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3. National Agricultural Research Institute, PNG
4. Trukai Industries Ltd, PNG

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3 Executive summary

Peanut is one among the top five crops that generate cash income for PNG's small holder communities. About 20,000t of peanuts are produced and consumed annually as fresh food in PNG. However, the domestic demand for peanuts outweighs the local supply which makes PNG a net importer of processed peanuts and peanut products (e.g salted peanuts, peanut butter and oil).

The precursor project on “Improving Yield and Economic Viability of Peanut Production in PNG and Australia; (ASEM 2001/55)” documented the critical role of peanut in PNG farming systems and evaluated a range of introduced peanut varieties on small plots, which resulted in the identification of promising varieties with a potential to yield significantly better than local land races.

The major aim of current project ACIAR SMCN 2004/041 "Productivity and marketing enhancement for peanut in PNG and Australia" was to expedite extension of varietal and management technologies to small holders to establish sustainable and profitable peanut production systems. The aim also included to explore new avenues to enhance marketability of peanuts and their products in collaboration with private sector agencies engaged in the development of the peanut industry in PNG and Australia.

The specific objectives of the project were:-

1. Ensure multiplication and supply of seeds of new high yielding peanut varieties to smallholders in the Morobe and Eastern Highland Provinces of PNG.
2. Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and farmer-participatory research approaches in PNG.
3. Develop and apply aerial Near Infrared Reflectance (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 and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia.

The project was commissioned by the former Queensland Department of Primary Industries & Fisheries (currently the Department of Employment, Economic Development and Innovation, DEEDI) and implemented in collaboration with the National Agricultural Research Institute, Ramu Agri-industries and Trukai Industries in PNG and Peanut Company of Australia. The geographic focus in PNG was the Morobe and Eastern Highland Provinces.

Multiplication of promising peanut varieties identified in the precursor project was undertaken at Ramu Agri-Industries for evaluation in the targeted regions. The promising varieties were evaluated on farmers' village gardens via a farmer participatory ‘seed village’ concept, where they were grown under local and new management practices to demonstrate yield benefits of improved varieties and practices. Satellite imagery technology was applied to quantify areas under peanut cropping in PNG and in Australia. The imagery research has focussed on the application of the technology in improving the real time management of peanut crops. The APSIM crop model, in conjunction with information on local weather and soil properties was used to assess the pod yield potential and aflatoxin risk profiles in major peanut growing environments of PNG.

Two market scoping studies were implemented, one each in PNG and Australia. The PNG scoping study focussed on the economic feasibility of a downstream processing industry, while the marketing study in Australia focussed on the feasibility of initiating a new hi-oleic peanut oil industry. In Australia, the APSIM crop model was used to assess suitability of non-traditional peanut growing environments for growing peanut as an oil-seed crop.

The project has resulted in significant outputs for the PNG and Australian peanut industries, which are summarized below:

A seed production system was successfully established and implemented in collaboration with the Ramu Agri-Industries which allowed large scale multiplication and supply of peanut seed to all trials, including progressive farmers in the Markham and Eastern Highland Provinces. This seed production facility will be an asset to sustain seed supply to the future peanut industry in PNG.

A series of on-farm trials (termed as 'seed village' trials') along with parallel on-station trials across the three focus regions have demonstrated that peanut productivity can be increased from the existing 1 t/ha to >3t/ ha using local or new varieties and by adopting improved management practices.

The superior performance of new varieties over local varieties was, however, inconsistent across locations, although new varieties were acknowledged as being superior in their early maturity, pod and kernel characteristics (i.e smooth shell texture, high kernel to shell ratio, uniform and larger kernel shape and size) and their suitability for processing (roasted and butter) market, compared to local landraces. It is expected that varietal improvements will continue to meet future market requirements.

The preliminary cost benefit analysis of management practices indicated that net profits of up to K2500/ha could be achieved by the adoption of new practices by growers. More location-specific research is, however, needed to identify and optimise key factors contributing to the yield benefits.

The collective experience gained by the collaborating scientists in PNG on the varietal and management practices, coupled with technical expertise of DEEDI researchers, led to the publication of the Best Management Practice Manual for growing peanuts in PNG. The manual was published by ACIAR as a 77-page monograph (No 134), which was launched by Queensland's Primary Industries Minister The Honourable Tim Mulherin on 30th October 2008, during his visit to a trade show in PNG.

The installation of aflatoxin analytical facilities and training of staff at NARI and Ramu Agri-Industries has enabled these institutions to independently monitor aflatoxin contamination in peanut samples. The results from the seed village trials showed that while the pre-harvest aflatoxin contamination was generally low (<20 ppb) in EHP, crops planted during February to July in the Markham region had a high frequency of aflatoxin contamination with levels of >200ppb recorded in some samples.

Understanding of climate variability, soil water dynamics, aflatoxin risk profile and the relative importance of results across a range of agro-climatic conditions has enhanced application of crop simulation modelling in PNG environments. There was a good agreement between pod yield and aflatoxin contamination observed in field trials and that simulated by the APSIM peanut model, suggesting that APSIM peanut crop model can be used as a tool to assess climatic effects and develop strategies to achieve high pod yield and quality in peanut production environments.

Satellite imagery technology has proved to be a cost effective tool for the in-season monitoring of spatial variability of peanut crops and peanut yield prediction in

Australia as well as in PNG. The results generated in this project have led to early adoption of this technology by the Peanut Company of Australia, as well as Trukai Industries and Ramu Agri-Industries in PNG, with all three agencies purchasing their own imagery. PNG project staff from Ramu Agri-Industries, NARI and Trukai Industries developed a strong understanding and competency in the use of hand held GPS units as well as processing of satellite imagery.

The two market scoping studies implemented in the project have provided an insight into the state of the art of markets for peanut and peanut products in PNG and Australia and in particular, peanut oil in the global market. The scoping studies suggested a potential for domestic and export opportunities of raw peanut kernel and oil for PNG and export opportunities of Hi-oleic peanut oil for Australia. It is expected that the scoping study reports will stimulate the thought process of commercial players to further explore economic viability of the new market opportunities suggested by the scoping study. It is hoped that tapping into new markets by the commercial players will increase the demand for domestic peanuts.

Through training, participation in annual review meetings and project team meetings, PNG project staff gained scientific expertise in maintaining quality of on-farm research, data analysis and reporting. Researcher managed trials have consistently shown improvement in crop yields, both with new and local varieties.

The project has been able to improve the scientific skills of the collaborating scientists in accurate recording of GPS coordinates, developing shape files of targeted paddocks and processing satellite images by applying appropriate processing tools.

In Australia, the remote sensing and satellite imagery work done in this project received a 'special' recognition by senior executives within DEEDI as "revolutionary" science. This research will see a large change to existing agronomic practices with remote sensing becoming a major tool for identifying in-season variability for a range of broad acre crops, allowing for coordinated agronomy to better manage constraints of economical concern.

The application of crop modelling followed by field validation has enhanced project scientists' understanding about the benefits of timing of planting and also the value of collecting daily weather data.

A total of 32 training activities/visits were implemented during the project (16 activities in PNG including PNG researchers' visits to Australia and 16 visits by Australian scientists to PNG). The training visits have been mutually beneficial to all parties involved, with officers developing a range of skills including, satellite imagery analysis, implementing on-farm research and the exchange of information on the project research and outputs.

A major environmental impact of utilising best management practices is that in PNG farmers will improve their production without the need for further land clearing. Ramu Agri-Industries has started seeing rotation benefits from using peanuts in their sugarcane rotations to break the sugarcane yield decline cycle.

Significant impacts of the project outputs are expected in the next five years at all levels of the peanut supply chain in PNG and Australia.

Given the growing demand for peanut, a declining "Buai" industry in the Markham region and demonstrated opportunity for significant yield benefits and favourable climate for growing the peanut crop year round, there exist temptations of mono-cropping of peanut, which can result in a build up of diseases leading to a rapid yield decline over a period of time. While there is a strong need to extend the package of improved practices to small holders, there is equally a strong need to raise the awareness about the negative effects of mono cropping. There are reports of decline in yield, quality and soil health in a range of mono-cropping systems in PNG (for e.g., sweet potato in EHP).

It is recommended that the future research and extension of BMP for peanut should be integrated into the prevailing cropping system(s) with the overall aim of achieving sustainable productivity and economic viability at the systems level. Such a research project would require exploring suitable food legumes that not only meet the needs of human nutrition and stock feed markets but also enhance economic and environmental performance of farm business as a whole at the small holders level.

4 Background

Peanut production in PNG was an important and viable commercial industry during the 1960s and 1970's, but has subsequently declined rapidly, due to the collapse of the peanut processing industry. Since then, there has been no significant R&D effort to sustain peanut production either by introducing new varieties or developing cost-effective agronomic packages for small holders. About 12,000t of peanuts are produced and consumed annually as fresh food in PNG. There has been no organised value addition to the product due to a lack of capacity, infrastructure and/or sustained supply of quality peanuts. Consequently, PNG is a net importer of processed peanuts and peanut products (eg salted peanuts, peanut butter and oil).

The precursor project on "Improving Yield and Economic Viability of Peanut Production in PNG and Australia; (ASEM 2001/55)" implemented during the 2002-2005 period documented the critical role of peanut in PNG farming systems. A comprehensive survey involving >400 small holders conducted in the four major peanut growing agro-ecological zones in PNG revealed that peanut ranked among the top 5 crops that generate income for the small holder communities (Wemin et al 2005).

The ASEM/2001/055 project also evaluated the potential of high yielding peanut germplasm lines introduced from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), in major peanut growing regions in PNG. These small plot trials resulted in the identification of promising varieties with a potential to yield significantly better than the local varieties.

The external review panel of the ASEM 2001/055 project recommended that:

1. "A new project should be undertaken for (3) years from July 2005 to June 2008 to establish the specifics of best management practices (e.g. seed treatment, density, fertility management, pest and disease control and post harvest handling)". "As an underpinning to the proposal, considerable emphasis must be placed on 'ownership' of the 'seed village' process and the considerable involvement on a sustaining basis of qualified and experienced extension agents. Thus, in promulgating the 'seed village' concept the emphasis on the detail outlined in the proposal must be subject to the wishes and acceptance by participating smallholders and villagers generally. There would be value in 'progressing slowly' but thoroughly, rather than spreading resources so thinly that the sustainable element of the process is lost."
2. "There must be a clear distinction between the specific responsibilities and roles of the public (NARI) and private sector (Ramu Agri-Industries and Trukai) in this project. Duplication should be minimised and NARI's focus should be in those areas within their capacity to deliver, where the profit motive of success is not high, difficult (or risky) to capture or very diffuse in impact. Successful collaborative activity of public and private sector operatives at common sites will rely heavily on reliable and satisfactory fail-safe communication procedures".
3. "The application and adoption of remote sensing technologies in a developed industry (Australia) and an emerging one (PNG) is strongly recommended and will provide an output of world-wide relevance. Appropriate training of relevant public and private sector personnel in this technology is critical"
4. "The incorporation of peanut as a legume crop into the 'slash and burn' subsistence gardening fallow systems in villages (coastal and highlands) should be investigated by NARI under the new project proposal". "The need for and

management of Rhizobium inoculum and the contribution to the system's nitrogen economy could be an important focus".

5. "The commercial stakeholders (Ramu Agri-Industries Ltd, and Trukai Industries Ltd) and Support Services Contract Facility should play important and clearly defined roles in promoting the peanut industry on a sustainable basis in PNG under the new proposed peanut project. There would be merit in leaders of the private sector component visiting and reviewing peanut industries in Australia and one other developing country where peanuts are an established industry"

In response to the ACIAR's recommendations on the external review panel recommendations (mentioned above), the DEEDI project leader held a series of group meetings with Australian Peanut Industry stake holders and PNG collaborating agencies, i.e. the National Agricultural Research Institute, Ramu Agri-Industries and Trukai Industries to develop the project proposal. The outcome of the group discussions is summarised below:-

- While new varietal and management technologies can lead to increased peanut production, the industry stakeholders in PNG are concerned that wide fluctuations in the fresh market price may eventually constrain the development of the industry.
- A feasibility study to examine alternatives to current peanut market practices and products (e.g. processing) would help private investors determine future industry directions to enhance the markets for, and marketability of, new peanut varieties in PNG.
- In Australia, increasing frequency of droughts (and hence aflatoxin contamination) and rapidly growing demand for cooking oil in the global oil market prompted a need for a market scoping study to assess the potential new markets for new peanut varieties and their products (i.e. especially high-oleic acid (mono-unsaturated) peanut oil).
- In Australia, spatial variability for yield and quality on broad acre farms are recognised as one of the major constraints to improving yield and profitability of commercial varieties. Recent work at DEEDI indicated that Near Infrared 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 enabling the implementation of novel in-season management and harvesting strategies.
- The Australian Peanut Industry as well as the NARI and private agencies including Ramu Agri-Industries Ltd and Trukai farms in PNG expressed their interest in learning and applying the imagery technology to monitor peanut crops in PNG.

The above discussion points are addressed in the current project SMCN 2004/041 "Productivity and marketing enhancement for peanut in PNG and Australia".

5 Objectives

The major aim of the project was to expedite the varietal and management technologies to small holders to establish sustainable and profitable peanut production systems and to explore new avenues to enhance marketability of peanuts and their products in PNG and Australia.

The specific objectives of the project and major activities under each objective were:-

1. Ensure multiplication and supply of seeds of new high yielding peanut varieties to smallholders in Morobe and Eastern Highland Provinces of PNG.
    - Multiplication of up to 15 most promising varieties at Ramu Agri-Industries to achieve up to 2 tons of pods per variety
    - Maintenance of nucleus seed of promising varieties at Bubia, NARI, using cold storage and multiplication (once in 2 years)
2. Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and farmer-participatory research approach in PNG.
    - Identify suitable sites and farmer groups in targeted regions, develop a technical work plan for each seed village
    - Implement the work plan and collect data on activities, weather, crop yields and quality, seed sales and aflatoxin contamination
    - Organise at least one field day in each of the regions
    - Conduct survey on role of women in peanut culture (Trukai Industries only)
    - Data analysis and reporting
    - Publication of Best Management Practices manual for peanut production 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.
    - Establish protocols for accessing to satellite imagery for target regions in South Burnett Dist in Qld and Markham Valley in PNG
    - Groundtruthing of peanut crops in target regions in PNG and Australia
    - Training workshop for project personnel on processing of multi-spectral aerial imagery
    - Investigate the scope for applying NIR technologies to assess peanut production in Markham Valley in PNG
    - Assess peanut crop’s area and performance in target regions using spectral reflectance properties derived from satellite and aerial imagery
    - Develop an appropriate decision support system package to extend the results of imagery to peanut growers in Australia

4. Assess the potential and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia.
    - Consultations with peanut industry stake holders in PNG and Australia to establish the scope of the market feasibility studies
    - Implement the feasibility study in consultation with peanut industry stake holders in PNG and Australia
    - Conduct scenario analysis using APSIM peanut model to assess likely adaptation of the new peanut varieties in dryland production regions.
    - Combine the outputs of peanut model and the market feasibility study to assess the economic potential for new processing industries in PNG and Australia

6 Methodology

The methodology varied for each objective as described below:

1. Ensure multiplication and supply of seeds of new high yielding peanut varieties to smallholders in Morobe and Eastern Highland Provinces of PNG.

A large-scale seed multiplication program was implemented at the Ramu Agri-Industries site under the supervision of Dr Lastus Kuniata. The project was fortunate to access and supply a second hand planter and peanut thresher free of cost in order to assist Ramu Agri-Industries in the seed multiplication effort. The Ramu Agri-Industries staff were trained in using a peanut planter and thresher. Access to land and infrastructure including irrigation facilities at Ramu Agri-Industries facilitated the large scale seed multiplication of new peanut varieties. The centralised seed multiplication strategy allowed seed supply of improved varieties to cater to the needs of the 'on-farm' research program in the Upper Markham, Lower Markham and EHP regions as well as progressive farmers who were keen to adopt new varieties and practices.

2. Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and farmer-participatory research approach in PNG.

A major thrust of the objective was 'recipe' research (varieties and optimizing management inputs). The value of the recipe component is expected to be fairly site specific for some practices such as variety, nutrition and planting time but less so for others such as seed treatment and plant spacing which are relatively risk free.

Farmer-participatory trials conducted on their own land were termed as a "seed village". The project staff at NARI, RS and TI selected appropriate sites for seed village trials in EHP, Upper Markham and Lower Markham Valley regions respectively, in consultation with landowners and local government agencies where appropriate. Typically, a seed village trial was laid out as a split plot design with improved and local practices as main plots and varieties (i.e. 2 or 3 selected new varieties and local check variety) as sub-plots, with 3-4 replications.

The treatments and operation details of seed village trials are thoroughly discussed in the annual review and planning meetings, and finalised in consultation with the collaborating farmer groups. The project staff developed an operational schedule for implementation of each seed village, in consultation with seed village owners.

The improved management practices varied across locations and covered four main aspects (a) plant spacing and row configuration, (b) seed dressing and need based plant protection, (c) remediation of major nutrient disorders by application of appropriate basal and/or foliar fertilizers and (d) appropriate harvesting and post harvest practices (to maintain seed quality). All the farm inputs were accessed from local stores. Specific details of the improved practice varied between the seed village trials depending on the situation but more details are presented in the individual progress reports of NARI, Ramu Agri-Industries and Trukai Industries (**Appendix 11.0, 11.1, 11.2 and 11.3**).

General conditions for implementing seed village trials were as follows:-

The project supplied the seed for planting free of cost.

Land was freely supplied by farmer(s) and the cost of land preparation was met by the project. Project contributed labour for improved management practices including planting, weeding, spraying, harvesting, threshing and storage, while local practice plots were managed by land owners.

Fertilizer, chemicals and other supplies for improved practice were provided by the project.

After yield sampling by the project staff, the farmer took ownership of the remaining produce of the local check variety.

The proceeds from the seed sale of produce were offered to the land owner(s) as a token of appreciation of their co-operation in the on-farm adaptive varietal trials.

Seeds of improved varieties were protected and stored by growers for further sale to local farmers or back to the project for further use.

The project staffs were responsible for timely supply of necessary seed and farm inputs, crop and weather monitoring, and timely implementation of improved management practices.

The seed village sites acted as platforms for demonstrating new varieties and management practices, organising field shows and extending these technologies to local farming communities. In addition, seed village trials also served the purpose of being the source for multiplying seeds of new varieties. One-page handouts containing information about varieties and management practices were prepared by the project teams and distributed to growers.

Best Management Practices Manual

Considerable time was devoted to developing a clear understanding about the focus, target audience, content and format including photos for the best management practice manual. A series of consultations involving PNG collaborators and peanut experts at DEEDI, Kingaroy were held while developing the content of the manual. Special attention was paid to management of pest and diseases particularly, in using chemical control. A detailed section on workplace health and safety practices on the use of agricultural chemicals was also included in the manual.

Extensive field testing of the draft manual was undertaken under the guidance of Mrs Barbara Tomi, NARI publication Unit. The project staff in the Upper and Lower Markham and Eastern Highland Provinces were involved in field testing the manual with farmer groups, researchers and extension officers in their focus regions. Comments were sought from the target audience, on the style, content and format including photos or figures used in the manual. The Project team also debated about the option of publishing the manual in Pidgin. As a wide range of target audience were able to read and understand English and that the translation process (particularly, sorting out common names of pests and diseases which vary from place to place) would not only cause delay in publication but also might compromise scientific accuracy of the manual and hence, a decision was made to publish the manual in English.

3. Develop and apply satellite 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.

In Australia ‘creative’ research was undertaken in developing satellite/aerial imagery as a fundamentally new way of managing many aspects of peanut production. Although collaborating agencies in PNG expressed considerable interest in the imagery technology, it was expected that the PNG project staff would need considerable training in understanding the value of the technology and ability to process the imagery for the monitoring of their own cropping systems.

Accordingly in PNG, the thrust of the remote sensing research was on assessing scope for its application to monitor peanut cropping systems and skilling up of NARI and Ramu Agri-Industries staff in processing and interpretation of satellite imagery. The imagery targeted the Markham valley as this region provided a higher frequency of seed village trials and general peanut cropping area as well as a lower risk of continued cloud cover compared to EHP. Care was taken to ensure that the coverage areas 'shape files' of satellite images encompassed the 'seed village' trial sites.

Once acquired, the multi-spectral satellite images of up to 100 km2 area were ‘geo-rectified’ using GPS coordinates collected from trial sites and neighbouring peanut cropping areas. The peanut crops and seed village trials were sub-setted from the images and transformed with a Normalised Difference Vegetation Index (NDVI) to remove image noise errors associated with shading and differences in crop geometry. The crops were then segregated into a number of classes based on the reflectance characteristics of the crop canopy, using unsupervised classification with “ENVI” software. This classification provided an indication of the spatial variability in crop vigour across the crop. Coordinated ground-truth samples were collected from each of the crop vigour classes, using hand held GPS units, to quantify the variability in terms of plant health, pod yield and pod quality. Data collected during ground-truthing was correlated with spectral reflectance parameters to distinguish crops and particularly, performance of peanut crops. This analysis led to identifying main drivers of plant vigour variability and differences in pod yield from each of the crop vigour colour zones.

In Australia, the remote sensing activity was focussed on peanut production systems of the South Burnett region, and to a more limited extent in the high input production systems of coastal Queensland and Northern Territory. Satellite Images of rainfed and irrigated peanut fields were acquired approximately 1 and 2 months prior to harvest, and processed using the methodology described in the previous paragraphs. Rigorous ground-truthing of selected fields was carried out to determine the agronomic factors associated with poor growth in low vigour regions. NDVI (crop vigour) maps were produced and distributed to growers during the last 2 months of crop growth, along with suggestions on possible management intervention to overcome the constraints (e.g. high foliar/soil borne disease pressure, poor infiltration of irrigation water etc…).

4. Assess the potential and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia

Two market scoping studies, one each in PNG and Australia were carried out to determine the potential for peanut and value added peanut products within domestic and export markets. Two separate Terms of References (TOR) were developed for the scoping studies in consultation with industry stake holders in PNG and Australia.

Two private consultants with relevant experience in global commodity markets (i.e. Dr Sandra Martin, Associate Professor, Lincoln University, New Zealand for the PNG scoping study and Mr Bob Hansen, Managing Director, Peanut Company of Australia for the Australian scoping study) were contracted to implement scoping studies.

In PNG the peanut market scoping study evaluated the market size for peanuts and peanut products with a view to identifying potential market segments that could be expanded in the future and various production and processing scenarios within the context of the potential market segments that were identified. The methods used to achieve these two outputs were exploratory preliminary market surveys, rapid market appraisal and interviewing key informants.

The APSIM peanut crop model in conjunction with seasonal weather and soil data was used to assess yield potential of peanut in PNG. However, the accuracy of this activity was severely constrained by the limited availability of quality weather data for various locations and hence simulations were confined to Markham and Eastern High Lands environments.

In Australia, the market scoping study focussed on:

a. Assessment of the domestic and export market potential for Australian high oleic peanut oil and peanut meal in intensive livestock operations throughout Australia and for export.

b. Assessment of infrastructure, physical constraints and processing economics for potential Australian peanut oil Industry.

c. The likely adaptation of the new GRDC-DEEDI bred ultra-early maturity varieties with high oleic oil content in a range of Australian farming systems, achieved by conducting a detailed peanut crop modelling study and economic analysis to assess agronomic suitability, yield (oil) and profitability.

The likely adaptation of DEEDI-bred short duration high oleic acid varieties in selected non-traditional cotton, cereal based farming systems of Queensland and Northern New South Wales was assessed using the APSIM peanut crop simulation model. A selected set of peanut varieties were evaluated in a field trial at Tamworth, NSW to assess the varietal adaptation and the data were used in validating the peanut model. The peanut model in conjunction with daily weather data was used to generate yield potential and aflatoxin risk maps for various regions in Queensland and Northern NSW, using a GIS framework.

7 Achievements against activities and outputs/milestones

Objective 1: Ensure multiplication and supply of seeds of new high yielding peanut varieties to smallholders in Morobe and Eastern High Land Provinces of PNG.

no.	activity	*outputs/* milestones	completion date	Comments
1.1	Multiplication of up to 15 most promising varieties at Ramu Sugar to achieve up to 2 tons of pods per variety	*Sustainable seed multiplication strategy* *An effective mechanism for small holders to access seeds of new peanut varieties* **ml-1** Model output on predicted yield and aflatoxin risk at different planting dates under irrigated and RF conditions developed for Ramu Agri-Industries site. (PC) **ml-2** Field sites selected, prepared and irrigation equipment installed where necessary (PC) **ml-3** Varieties planted, crop managed, harvested, pods stored safely in labelled bags after drying down to safe moisture (PC)	2006	Application of APSIM-peanut model in conjunction with climate and soil properties of Ramu Agri-Industries site suggested that peanut crops planted after Feb are likely to experience end-of season droughts resulting in low yield and high aflatoxin risk. As a result, of the new knowledge, necessary adjustments were made in planting window for peanut to ensure high yields During the last four years Ramu Agri-Industries has been able to supply up to 6 tons of seed for 'seed village' trials in lower Markham and Eastern Highland provinces, in addition to meeting their own requirements. This activity resulted in establishing a large scale sustainable seed multiplication strategy at Ramu Agri-Industries.
1.2	Maintenance of nucleus seed of promising varieties at Bubia, NARI, using cold storage and multiplication (once in 2 years)	*Peanut germplasm maintained in cold room at NARI for future use.* *Multiplication of nucleus seed once in two years will maintain viability* **ml-4** About 250g of pure seed accessed from the field trials and stored in cold storage moisture (PC) **ml-5** Field multiplication planted, rouged if necessary & harvested, kernels cleaned, bagged and labelled and stored in cold storage moisture (PC)	2006 2008	The National Agricultural Research Institute (NARI) has procured pure seed of short and medium duration peanut varieties from Ramu Agri-Industries for long-term storage at Bubia and Aiyura research stations. NARI has undertaken seed multiplication of peanut germplasm at the Aiyura research station.

PC = partner country, A = Australia

Objective 2: Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and farmer-participatory research approach in PNG

no.	activity	*outputs/* milestones	completion date	Comments
2.1	Identify suitable sites and farmer groups for implementing seed village programs in targeted regions.	*Successful collaboration between public and private institutions and grower groups* **ml 6**. Sites suitable for seed village trials identified (PC) **ml 7** Appropriate contract agreements finalised and signed by concerned parties (PC)	2006, -09	The trial sites were identified by the researchers in consultation with the grower groups who are also land the owners of the trial site. Where necessary, appropriate contract agreements were signed by R&D agencies and grower groups, specifying the roles responsibilities and duties of parties involved. A total of 42 on-farm seed village trials (19 in EHP, 10 in LMV and 13 in UMV) were successfully conducted.
2.2	Develop a work plan for each seed village.	*Hands-on experience for collaborating agencies and growers in evaluating new peanut varieties and management practices.* **ml 8**. *Details on treatments (varieties and management), experimental design, field lay out, data collection finalised* (PC) **ml 9.** *Work schedule for each seed village is prepared and circulated to all concerned staff and grower groups at least 2 weeks prior to planting.* (PC)	2006, -09	Each year the technical plans were thoroughly discussed in annual review meetings followed by small group meetings involving DEEDI, Queensland and project teams in PNG The work schedule for the trials was developed by project staff in consultation with the collaborating farmer(s).The trials surrounded by farmer-managed blocks allowed comparison of varieties and practices.

2.3	Implement the work plan and collect data on seed village activities, weather, crop yields. and quality (aflatoxin and seed size)	*A multi-location data base on seed village trials including the farmer's views on new technologies* **ml 10**. Seed village diaries maintained and weather data downloaded at monthly intervals during the season by project staff(PC) **ml 11**. Seed village farmers are trained to record daily rain fall data in the record books supplied by the project staff(PC) **ml 12**. Data from seed village trials collated and structured in a format amenable for analysis.(PC) **ml 13**. Trials data analysed using appropriate statistical procedures(PC) **ml.14**. Information on the views and opinion of growers on new varieties and management generated(PC)	2006, -09	Project staff maintained a daily log of "seed village"' trials operations. Rain gauges were installed at each trial site and farmers were trained in recording the rainfall. The air temperature was recorded at one or two sites in each region using Tiny-Tag loggers. The project staffs were trained in operating the loggers. The project staff collected, compiled and analysed tria.ls data using appropriate statistical procedures (i.e. SAS by Ramu Agri-Industries and TI, and Genstat by NARI). Results from the 'seed village" trials over the last 3 years trials revealed significant yield benefits (up to >100%) from improved practices in all the target regions However, the impact of new varieties was not consistent across locations and seasons. While pod, kernel characteristics and shelling% of new varieties were better than local varieties (e.g. local varieties have 5-10% more shell), there seemed to be a perception amongst some growers that the new varieties may not be attractive as fresh product (on taste preference) and smaller pod size. However, there appear to be a change in consumer preference lately with new varieties being preferred for processing (roasted, butter) compared to local variety. NARI and Ramu Agri-Industries agencies developed extension material for their grower groups on improved varietal and management practices.
2.4	Collect samples at harvest, after drying and in storage and conduct aflatoxin analysis.	*Base line information from all seed village trials on the effect of improved management on aflatoxin levels at all critical points through the production chain* **ml 15**. Data on aflatoxin contamination under improved local practices collected and analysed (PC)	2006, -09	Installation of Mini-Column facility at NARI and Ramu Agri-Industries followed by training of staff in aflatoxin analysis, in Year 1, strengthened capacity and skills of the institutions to undertake aflatoxin analysis with minimum supervision from DEEDI Over the last 3 years >350 peanut samples collected from the seed village trials were analysed for aflatoxin at Ramu Agri-Industries and NARI Aiyura with minimum supervision from DEEDI Queensland. The results are presented in Section 7.

2.5	Organise at least one field day in each of the regions	*Field days will help exchange of information on new technologies involving wider range of grower communities* **ml 16**. Field days advertised and extension material prepared and published(PC) **ml 17** Field day conducted at the best performing seed village each season(PC)	2006, -09	Project staff from NARI, Ramu Agri-Industries and Trukai Industries held project management meetings at bi-monthly intervals to exchange information about project research activities including seed village trials management. A total of 20 field days and a number of grower group meetings were conducted by the three collaborating agencies over the last 3 years. The field days provided good opportunity for exchange of information about varieties, practices.
2.6	Collect information on seed sales from each seed village	*Information on the demand for and spread of new varieties* **ml 18**. Labelled seed bags, stationary, sale receipt books are distributed to seed village farmers(PC) **ml.19.** Data on seed sales from each seed village is recorded(PC)	2006, -09	Contrary to our expectations, it was difficult to track the movement of seed from seed village trials. Although project staff knew that seeds have changed hands, accurate information on seed movement could not be collected because farmers either gave away the seed of new varieties freely to their 'one-talks' without noting the details or mixed it with the seed of local variety and sold in local markets. In some specific cases the project bought the seed back from growers for use in the project work. Ramu Agri-Industries recorded sale of large quantities (>800 kg) of improved varieties to their nucleus estate farmers and small scale butter processors. From the sale transactions, it was observed that the demand for improved varieties is rising due to their better roasting and butter qualities compared to local varieties. However farmers prefer local varieties for fresh food markets.
2.7	Conduct survey on role of women in peanut culture (Trukai Industries only))	*A report on the apparently important role of women in peanut production* **ml 20**. Final survey questionnaires are developed (PC) **ml 21**. Survey completed in stipulated time(PC) **ml. 22.** Survey report finalised and circulated to project leaders(PC)	2007	Two surveys were conducted to assess the "role of women in peanut culture" by Ms Julie Kolopen of Trukai Industries. The surveys examined the role of women in peanut culture in two peanut growing settlements, in the Lower Markham valley. The surveys revealed that contribution of peanut to total household income varied from 39 to 75% across sites and identified specific peanut production and marketing activities that women are involved in and their training needs. The full report is included as part of Trukai Industry progress report (**Appendix 11.3).**

2.8	Finalise the material for publication of Best Management Practices manual for peanut production in PNG	*Best Management practices manual for peanut production in TokPisin* **ml 23**. Best Management Practice manual published as ACIAR technical bulletin (PC,A)	2008	Considerable time was devoted to developing clear understanding of the focus, target audience, content and format including pictures for the best management practice manual. The draft manual was field-tested extensively under the guidance of Mrs Barbara Tomi, NARI publication Officer involving the project staff in the Upper and Lower Markham and Eastern Highland provinces. The teams consulted farmer groups, researchers and extension officers about the style, content and format including figures and photos presented in the manual. After incorporating comments of target audience the manual was published by ACIAR as a 77-page monograph (No 134) **(Appendix 11.5).**
2.9	Collate and analyse data collected form seed villages	*Improved understanding of the adaptation of new varieties and effects of management practices, possible constraints including soil nutrient disorders and ways to overcome them.* **ml.24** A comprehensive report on seed village trials including extension activities produced for each region and sent to QDPIF with in with in 6 weeks after harvest of trials (PC, A)	2006-09	The project staff compiled weather and crop data of all trials and analysed using appropriate statistical procedures. The annual review and planning meetings, followed by separate group meetings allowed joint inspection of field trials and procedures followed for data analysis. NARI, Ramu Agri-Industries and Trukai Industries and Agri-Science, Queensland prepared comprehensive progress reports each year. The annual reports prepared by the collaborating agencies for the 2007-08 and 2008-09 seasons are attached **(Appendix 11.1, 11.2 & 11.3).**

PC = partner country, A = Australia

Objective 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

no.	activity	*outputs/* milestones	comp letion date	Comments
3.1	Establish access to Quick bird satellite imagery (from US-based Digi Globe) for target regions in S. Burnett Dist in Qld and Markham Valley in PNG. Airborne imagery acquisition for S Burnett in Qld and Morobe (depending on cloud cover)	*Capacity to access aerial imagery on a regular basis* **ml.25.** Digi Globe satellite imagery and/or aerial imagery data files for target regions acquired (A)	2006-09	Effective linkages have been established with a range of image providers (e.g. GeoImage :SPOT IKONOS, QuickBird). Landsat, SPOT 5, QuickBird and IKONOS satellites were assessed for their spatial and spectral resolution as well as ability to obtain timely acquisitions. For PNG work, both QuickBird and IKONOS were identified to have the appropriate spatial resolution, 0.6m and 1m respectively, to define peanut crops within village gardens. In Australia QuickBird imagery identified as the best image source in regards to spatial resolution, minimum area required and cost per hectare, however on a large commercial scale, SPOT5 imagery may prove more cost effective. In regards to aerial imagery, constant hardware and software issues with the recently purchased TerraHawk multispectral aerial camera system prevented the collection of any useable data. The progress in getting the system repaired is further hampered by resignation of technical personnel followed by a change of company ownership in the USA.
3.2	Groundtruthing of peanut crops in target regions in PNG and Australia	*A data base on crop identification parameters along with GPS references to help interpret imagery* **ml.26** Crop information at targeted GPS coordinates collected and stored for further use in interpretation of imagery (PC&A)	2006-09	The project staff of Ramu Agri-Industries, NARI and Trukai Industries have been trained in the use of hand held GPS units and as well as to locate ground truthing locations for plant sampling and testing the positional accuracy of the imagery. In Australia historical database of satellite images of the focus regions has also been used to identify the inherent variability of some peanut cropping paddocks allowing for improved management decisions such as the use of short duration varieties in regions prone to stress, as well as identifying homogeneous locations to position trials. The database of GPS coordinates generated for the focus regions in PNG and Australia would help in future imagery work in cropping systems.

3.3	Workshop for project personnel on processing of aerial imagery and developing spectral reflectance parameters for peanut crops	*Ability to process aerial images and derive information on spatial and temporal changes in peanut production systems and their performance in target regions* **ml.27** NARI and Ramu Agri-Industries access, process and interpret imagery maps (PC&A) **ml.28**. NIR data validated in targeted regions in PNG and Australia (PC&A)	2006-08	Hands-on training courses on the use of GPS meters, ground truthing the images in 2006, 2007 and 2008, additional training on the use of the remote sensing software ENVI, as well as the Geographical Information System (GIS) software Arc-view were conducted for Trukai, NARI and Ramu staff, in PNG as well as in Australia. A manual describing the processing steps required for the sub-setting of imagery as well as for applying vegetation indices such as NDVI transformations and classifications has been compiled and distributed to the trainees. Ramu Agri-Industries and Trukai are now are able to use this technology to various crops and pastures including impacts from weeds, disease and pests, as well as for the prediction of yield and quality.
3.4	Investigate scope for applying NIR technologies to assess peanut production in Markham Valley in PNG Assess peanut crop's area and performance in target regions using spectral reflectance properties derived from aerial imagery	*Capacity building of NARI and Ramu Agri-Industries staff in using remote sensing technologies and their potential application in PNG* **ml.29**. Techniques to distinguish peanut from other crops standardised for use in PNG (A) **ml 30.** Peanut crop performance maps developed for targeted fields in South Burnett district of Qld (A)	2006-09	Satellite imagery was identified as an accurate tool for estimating yield of a peanut crop at paddock level as well as estimates of lost production from the regions of underperforming growth. This information enabled management decisions regarding the feasibility of applying remedial action to correct under performing areas to be made. The prediction of total peanut cropping area with an intensive cropping system through imagery was also shown to be possible, however 'feature recognition' software is required to greatly improve the accuracy and is therefore recommended for future research.
3.5	Develop an appropriate decision support system package to extend the results of imagery to peanut growers in Australia	*A web-based decision support system for peanut growers in Qld to access the crop performance maps generated from imagery.* **ml 31.** In Australia NIR derived information extended to collaborating farmers with in 4 weeks before harvest (A)	2007-08	The DEEDI's web-based decision support system (AFLOMAN) has been enhanced to provide access to processed imagery of the paddocks on the internet. This will enhance growers' capability of assessing spatial variation in crop vigour that may be related to drought or disease stress. A further ground truthing in conjunction with aflatoxin risk predicted by 'AFLOMAN' program will assist them in making better harvest management decisions. See DEEDI (DPIF) report (**Appendix 11.4**) for more details.

PC = partner country, A = Australia

Objective 4: Assess the potential and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia

no.	activity	*outputs/* milestones	completion date	Comments
4.1	Hold consultations with peanut industry stake holders in PNG and Australia to establish scope of the feasibility study	*Strategic document outlining the peanut industry needs and expected outcomes of the proposed feasibility study* **ml.32**. The scope of the feasibility study established and contract agreement developed (PC&A)	2006	TORs for the PNG and Australian scoping studies were developed and a contract agreement for implementing the market scoping studies of both Australia and PNG were signed off with Mr Bob Hansen (MD, Peanut company of Australia) in 2006. However, as Bob Hansen expressed inability to do PNG part of the study in 2007, which led to seeking assistance of well-experienced Dr Sandra Martin (Lincoln university, NZ) to conduct the PNG market scoping study and accordingly a separate contract was initiated.
4.2	Implement the feasibility study in consultation with peanut industry stake holders in PNG and Australia	*A feasibility report on the potential for domestic and export market and value adding (via peanut oil, butter and live stock feed) of locally produced peanuts in PNG* *In Australia, a report including the export market potential for Australian high oleic peanut oil and potential economic and environmental benefits to a number of farming systems (cereal, cotton and sugar).* **ml. 33**. The final report on the market feasibility study for PNG and Australia completed (PC&A)	2008	The two separate market scoping studies were completed in PNG (by Dr Sandra Martin) and Australia (by Mr Bob Hansen) (**Appendix 11.6 and 11.7).**

4.3	Conduct scenario analysis using APSIM peanut model to assess likely adaptation of the new varieties and validate the model in targeted regions in Australia Use APSIM Peanut model to defining risk profiles of growing peanuts including aflatoxin risk in main peanut production regions.	*Information on adaptation and likely yield potential of DEEDI bred short duration lines in Australia* *A database of model derived outputs on yield potential, dates of planting, aflatoxin risk scenarios for major peanut production systems in PNG* **ml.34.** Model outputs on the likely adaptation and genetic potential of new varieties in new environments in Australia (A) **ml 35.** A "Whopper Cropper" software package developed to enable user-friendly access to the model predicted outputs on predicted production potential, aflatoxin risk scenarios of peanut varieties in major production areas (EHP, Markham) and other regions of interest (ENB and Madang) (PC&A)	2008	The APSIM peanut model was used for simulating rainfed yield potential and aflatoxin risk of ultra-early (short-duration) peanuts for 32 locations below latitude of 31oS in Australia. Seventeen locations where pod yield of ultra-early peanuts exceeded 1.5 t/ha in 3 out of 4 years were identified. The APSIM model was also used to develop a Whopper Cropper database for PNG locations including Aiyura, Ramu Agri-Industries, and Bubia (Lae) using their updated historical climatic data This database of simulations in conjunction with Whopper Cropper Software (developed by the Agricultural Production Systems Research Unit (APSRU)) can assist growers in making agronomic decisions to maximize peanut production and quality. The crop simulation output database along with Whopper Cropper software has been loaded on to a CD and distributed to the project collaborators **(Appendix 11.8).**
4.4	Combine the outputs of peanut model and the market feasibility study to assess the economic potential for new processing industries in PNG and Australia	*The outputs from feasibility study and peanut model will allow assessing prospects of investing in new Industry* **ml. 36** A comprehensive report on the feasibility and viability of a new processing industry completed (PC&A)	2008	While the outcome of the PNG peanut market scoping report is still being examined by the industry partners in PNG (Ramu Agri-Industries and Trukai Industries), Peanut Company of Australia has moved ahead and initiated an in-depth in-house review to assess economic viability of high-oleic peanut oil industry in Australia. Depending on the outcome of this review DEEDI may initiate a new project aimed at growing peanuts for oil markets.

PC = partner country, A = Australia

8 Key results and discussion

Objective 1: Ensure multiplication and supply of seeds of new high yielding peanut varieties to smallholders in Morobe and Eastern High Land Provinces of PNG.

(*a) Sustainable seed multiplication strategy*

Large scale seed multiplication of a selected set of short and medium duration varieties was undertaken at Ramu Agri-Industries (RAI) Sugar estate which has excellent infrastructure facilities, land and equipment to grow crops on a large scale. The project has been able to assist the seed multiplication effort at RAI by importing a peanut planter and thresher from Australia as well as providing the relevant training to RAI staff to operate the peanut machinery. Application of the APSIM-peanut model in conjunction with climate and soil properties of RAI site suggested that peanuts planted after February are prone to end of season droughts and hence low yields and high aflatoxin risk. The yield and aflatoxin risk simulated by the model was found to be consistent with the performance and aflatoxin contamination in late sown crops. This improved understanding resulted in changing planting window of peanut crops by RAI to achieve high yield and quality and included in the best management practice for Upper Markham region.

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Fig 1: Left: Dr Lastus Kuniata inspecting crop emergence in the seed multiplication blocks. A Peanut thresher in operation at Ramu Agri-Industries (right).

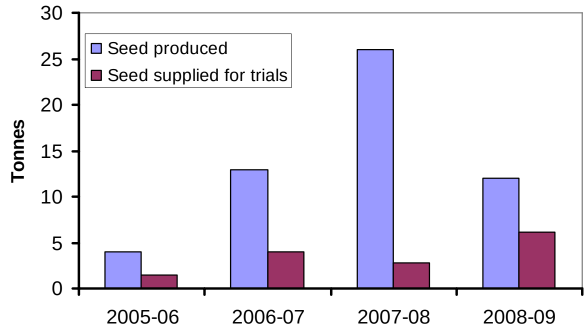


Fig 2. Peanut seed production and supply at Ramu Agri-Industries

Over the last four years Ramu Agri-Industries suppled >6 tons of seed for 'seed village' trials in lower Markham and Eastern Highland provinces, in addition to meeting their own trials requirements (Fig 2).

While meeting the project requirements, Ramu Agri-Industries has been able to further capitalise on the experience gained in broad-acre peanut production and improved their peanut production from <5 t in the year 2006 to >25 t in 2008, demonstrating sustained capacity and skills to produce and deliver quality peanut seed beyond the current project period (Fig 2). However, recent changes in Ramu Agri-Industries business priorities has resulted in increased investment in oil palm and reduced emphasis in peanut work.

(b) Peanut germplasm maintained at NARI for future use.

The National Agricultural Research Institute (NARI) has procured pure seed of 16 short duration and 11 medium duration peanut varieties from Ramu Agri-Industries for long-term storage at Bubia and Aiyura research stations.

(c) *An effective mechanism for small holders to access seeds of new peanut varieties*

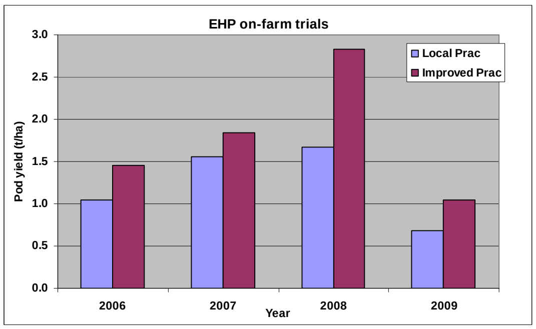
According to the project scientists more than 1500 farmers in the EHP and Markham regions requested for seed of new varieties and expressed interest in participating in peanut on-farm trials during the 2006-08 seasons. Some of the seed produced at Ramu Agri-Industries has been supplied to other organisations, for e.g., Citi mission, Pelgens, Dept Trade and Commerce and Oro Disaster Help (as humanitarian aid) and selected grower groups for further evaluation. The training and skilling up of staff in seed multiplication activity has resulted in shaping up of Ramu Agri-Industries as a large scale commercial seed producer and distributor of new varieties in PNG. In addition to meeting seed requirements of the research trials Ramu Agri-Industries supplied large quantities of seed (>2tons) to progressive farmers in Markham region who are keen to adopt new varieties and practices. It is possible that the progressive farmers in Markham will be able to undertake large scale commercial seed production.

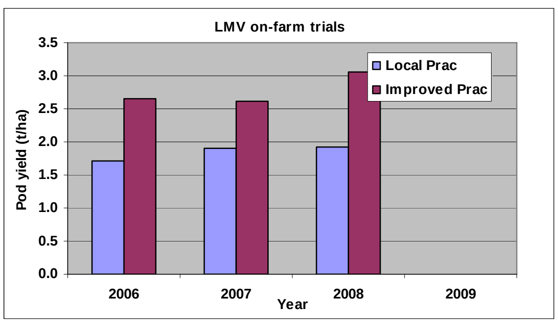
Objective 2: Demonstrate and monitor improved productivity of peanut using varietal, management, modelling technologies and farmer-participatory research approach in PNG

A total of 42 'seed village' trials were conducted, all rain-fed, in the last four years, 19 in the Eastern Highlands Province (EHP), 13 in Upper Markham Valley (UMV) and 10 in Lower Markham Valley (LMV) regions. As described in the 'Methods' section, the seed village trials were designed and implemented by the project staff in consultation with the participating grower communities who were the land owners. In each trial, up to 5 varieties including 1-3 selected new varieties and 1 or 2 local check varieties were grown under either improved or local practice. While the local practice represented the conventional system, the recipe of improved practice varied across sites depending on the situation, mainly comprising of practices to overcome local constraints for peanut crop production i.e. seed bed preparation, basal fertilization, seed treatment, timing of planting, planting in rows, plant protection and harvest management.

Demonstrating improved productivity

The seed village trials have successfully demonstrated yield increases of >100% from improved practices in all regions and years (Fig 3).





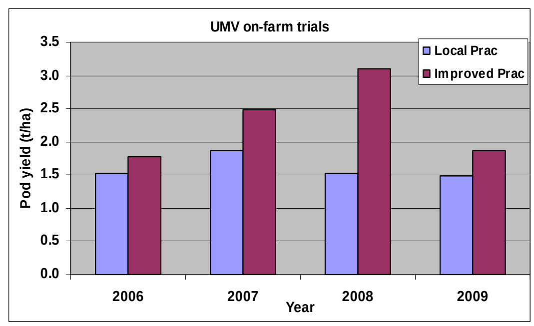


Fig3. Effect of local (blue bars) and improved (dark red) management practices on yield harvested in the 2006,to 2009 seasons in the Eastern Lands (EHP), Upper Markham Valley (UMV) and Lower Markham Valley (LMV) seed village trials

A general increase in trial yields from 1 t/ha in 2006 to >3t/ha in 2008 in all regions demonstrates enhanced skills and confidence gained over time by the collaborating researchers and growers in managing peanut crops to achieve high yields. The results suggested that planting time, plant stand (spacing and row configuration), functional leaf area during seed filling phase (by disease protection) and harvest management (timing and windrows to prevent harvest loses) were the main contributors for the yield response in improved practices.

However, the varietal responses were inconsistent with new varieties yielding either on par or only marginally better (by up to 15%) than the local check varieties. However, there was a trend for better performance of new varieties under improved practices (Fig 4).

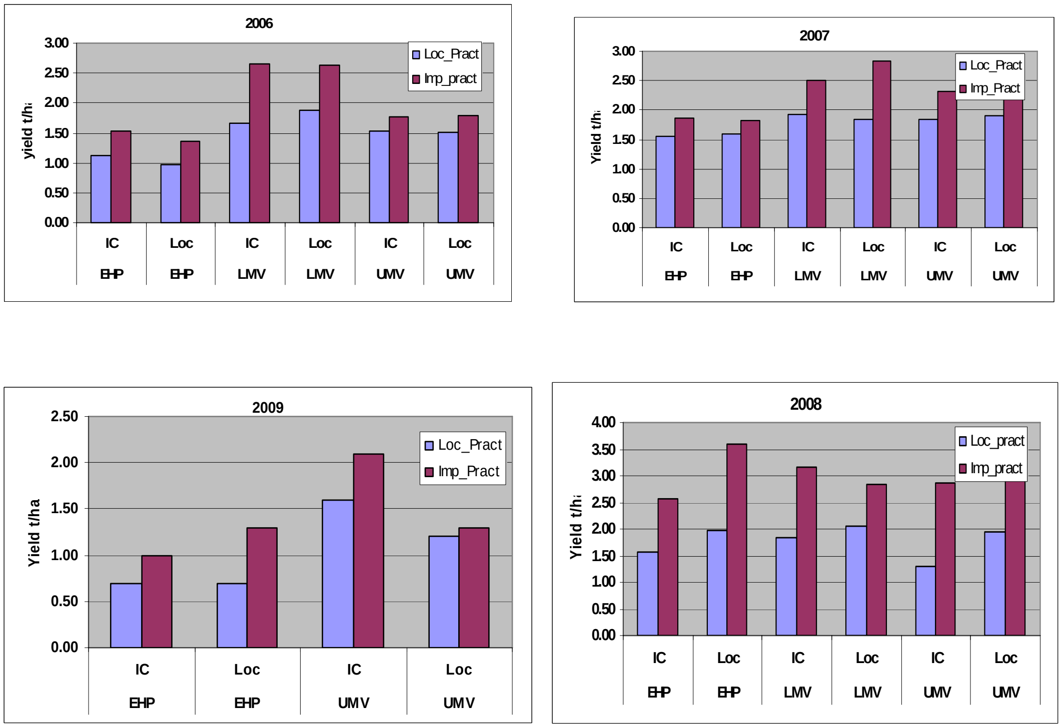


Fig 4. Average pod yield of new (IC) and local (Loc) varieties harvested under local (blue bars) and improved (dark red) practices in the 2006,2007, 2008 and 2009 seasons in the Eastern Lands (EHP), Upper Markham Valley (UMV) and Lower Markham Valley (LMV) seed village trials.

Although performance of new varieties has not been significantly better than the local checks consistently, there is a growing perception amongst some growers-processor's that kernel quality of the new varieties is better suited for processing (butter and roasted) compared to local cultivars, which are preferred for fresh food markets. This situation should present growers with a choice of varieties to meet different (future) market requirements.

Monitoring aflatoxin

Over the last 3 years >350 peanut samples collected from the seed village trials were analysed for aflatoxin at Ramu Agri-Industries and NARI Aiyura with minimum assistance from DEEDI. Results showed significant site effects with aflatoxin positive samples varying from being 'nil' in the Eastern Highlands to >40% in the Upper and Lower Markham regions. While low temperature and high rainfall contributed to low aflatoxin risk in EHP, hot and dry weather in the Upper and Lower Markham regions contributed to high aflatoxin contamination in Markham. Further the results also showed that crops planted after February in the Markham region had a higher frequency and levels of aflatoxin contamination because of high probability of dry and hot weather towards the end of the season. This finding has led to improved understanding of the effects of planting time on aflatoxin.

Best Management Practice Manual

The experience gained by the collaborating agencies on the varietal and management practices, coupled with technical expertise from DEEDI researchers led to the publication of Best Management Practice Manual for growing peanuts in PNG. Considerable time was devoted to developing clear understanding of the focus, target audience, content and format including pictures for the manual. The draft manual was field-tested extensively under the guidance of Mrs Barbara Tomi, NARI publication officer involving the project staff in the Upper and Lower Markham and Eastern Highland provinces. The teams consulted farmer groups, researchers and local extension officers about the style, content and format including figures and photos presented in the manual. The manual was published by ACIAR as a 77-page monograph. (No 134) The monograph was launched by the Queensland's Primary Industries Minister The Honourable Tim Mulherin on 30th October 2008, during his visit to a trade show in PNG.

Farmer participation

There has been active and functional collaboration between researchers and participating grower communities through all phases of on-farm trial conduct, i.e. site selection, designing and implementing practices in 'seed village' trials. Comparing new practices and varieties with conventional practices on their own paddocks provided a learning experience for participating growers, which also enabled improved understanding of crop management required to achieve high yield and quality. Field shows and short training courses organised by R&D agencies have attracted large number of growers who received relevant information about the crop husbandry and also the health and safety measures to be followed in implementing crop protection measures.

On-station *Agronomy Trails*

In addition to the on-farm 'seed village' trials NARI, Ramu and Trukai collaborators conducted a number of on-station agronomy trials to address local specific issues such as planting density, nutrient management, pest & disease, and weed management etc. As recommended by the external review panel, a peanut scientist from NARI (Humphrey Saese) visited Australia for 4 weeks and worked with the Australian project leader to collate, analyse and interpret all the agronomic data generated in the project. Major findings of the agronomy studies are summarised below and detailed results of all trials are reported in the individual progress reports **(Appendix 11.0, 11.1, 11.2 & 11.3)**.

- Effects of planting density on dry matter and pod yield of peanuts in the lower Markham valley

A fixed row spacing of 40cm effects of four inter-row spacing i.e. 10, 20, 30 and 40cm were assessed under on-station trials in the lower Markham to optimise plant population for tractor operated planting conditions. The results showed that 20cm plant to plant spacing was superior in pod yield compared to other three spacings.

- Peanut variety x foliar disease management interaction in EHP

The trials are aimed at quantifying losses due to foliar diseases and explore genotypic variation in resistance to foliar diseases and yield response to fungicide application. Field trails were conducted at the NARI research station, Aiyura. Fourteen genotypes introduced from ICRISAT and two local checks were grown out in field with or with out foliar disease protection.

Protecting crop from foliar diseases resulted in a 43% and 45% increase in pod and kernel yield respectively. Yield losses in the two local checks due to fungal diseases ranged from 50% to 100%. However, there was a significant variation among genotypes in yield losses due to foliar diseases, as evidenced by kernel yield response to fungicide application which ranged from 0 to >100%. The lines ICGV 95256, 95271 and 95179 were lest affected by diseases and had very little response to fungicide application suggesting that these varieties need to be further evaluated

- Assessing optimum weeding interval of smallholder peanuts crops in the lower Markham valley of PNG

The aim of the study was to determine the best combinations of weed intervals that produce the highest dry matter and yield of peanut crops planted in rows. Two field trials were conducted at Gabmatsung and Tanam sites located in the Huon district in the lower Markham.

It was evident that weed-free control treatments produced the highest yields. However, it was interesting to note that the current practice of weeding after crop emergence (21 DAS) and during pod filling (63 DAS) produced lower yields. It appears minimizing weed competition during pegging stage (around 42 DAS) is more critical than weeding at late pod fill stage (63 DAS) to increase availability of resources (light, water and soil nutrients) for young pods.

- Micro nutrient management trial

This study was conducted at Ramu Sugar during the 07-08 season. Four rates of foliar (0, 1, 2 and 3 kg ha-1) micronutrient (Librel®) was applied at 40 DAS. The composition of the 'Librel' consisted of micronutrients B (0.875 %), Cu (1.70 %), Fe (3.35 %), Mn (1.70 %), Mo (0.023 %) and Zn (0.60 %).

Although, statistically non significant ($P<0.05$) yield differences were observed, with pod yield increasing from 0.8t/ha in control to 1.2 t/ha as foliar nutrient application rates increased. Significant differences were observed for pod filling. Percent pod filling increased from 83% to 95% as foliar application increased from zero to 3 kg ha-1. Plots receiving zero micronutrient had more empty pods than plots receiving micronutrients which suggest deficiency of important micronutrient such as Ca. Pod yield improvement of up to 0.3t/ha were observed as application rate increases.

Objective 3: Develop and apply satellite and 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

PNG

Accessing satellite imagery for target locations

Satellite imagery from four commercial providers (Landsat, SPOT 5, QuickBird and IKONOS) was assessed with comparisons made between spatial and spectral resolutions as well as the ability to obtain timely acquisitions. All commercial providers experienced some capture delay as a result of cloud cover and therefore, in regards to reliability, could not be separated. However, this will only be improved with the launching of more satellites in the near future that will offer a faster rate of repeat capture. For the PNG research, both QuickBird and IKONOS were identified to have the appropriate spatial resolution, 0.6m and 1m respectively, to define peanut crops within village gardens. However, the IKONOS imagery displayed greater geo-referencing inaccuracies (in excess of 40m) as well as ‘edge blurring’ following the transformation of imagery with vegetation indices such as NDVI.

For the Australian conditions, QuickBird was identified to have the best image quality, but in the event that a large area (3600km2) was required to be imaged, SPOT 5 was a more feasible option(3c/ha AUS compared to 23c/ha AUS) even though its spatial resolution was inferior (2.5m pan sharpened from 10m).

In regards to aerial imagery, constant hardware and software issues with the TerraHawk system, that involved lengthy repair delays with the shipping of components to the United States and back to Australia, prevented the collection of any useable data. This system is repaired and does offer great possibility for the future.

Developing crop identification parameters along with GPS references to help interpret imagery

Project staff based at RAI, NARI and Trukai Industries developed strong understanding and competency in the use of hand held GPS units, which were used to provide locations of seed village trials so that satellite imagery could be acquired accurately, as well as to locate ground truthing locations for plant sampling and testing the positional accuracy of the imagery. Strong correlations were observed between the spectral data (NDVI) and ground truthing measurements of biomass production, pod yield and maturity.

Skilling up of PNG project staff in using remote sensing technologies

Project staff developed a good understanding and skills in the ordering and processing of satellite imagery, as well as the use of handheld GPS units to ground truth imagery. Software training using basic software user manuals compiled for this project (**Appendix 11.13**) has enabled the staff to adopt these technologies as part of there agronomic processes, particularly at RAI and Trukai Industries for the improved management of their own farming land as well as for the surrounding villages. Unfortunately NARI staff member Mark Tinah resigned midway through the project to use these skills at an oil palm company.

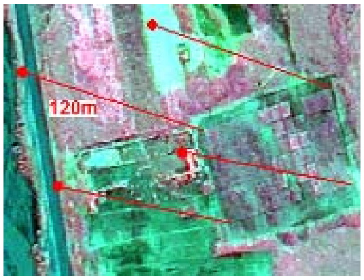
Key results from satellite Imagery work in PNG

Satellite imagery was successfully used for the monitoring of ‘seed village’ trials identifying varietal performance, overall trial condition and impact of abiotic and biotic constraints such as soil type, foliar disease, poor drainage etc on replicates. A total of 8 satellite images were captured since 2006 and applied for monitoring peanut crops. A case study describing the results from a seed village trial is outlined below.

The 'seed village' trial conducted at Wampuai location in the Upper Markham valley revealed strong correlations (up to R= 0.85) between the Normalised Difference Vegetation Index (NDVI) image pixel values with pod yield (Table 1). The improved management practice plots, in most cases identified to display higher IR reflectance and ultimately higher yields.

Photos: Wampuai seed village trial site and processed images.

Wampuai Seed village trial site



Geo rectification accuracy of the trial site

Classified Image of the trial site

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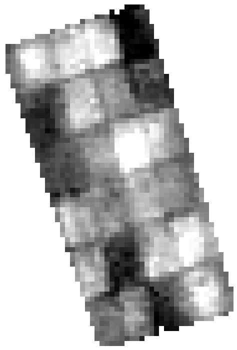
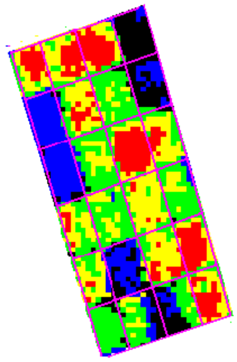


Infrared image representation



Classified image

Pseudo colour representation overlaid with variety and practice

Wampuai Seed Village Trial - 5 - 06
Date planted: 29th December 2006
Date harvested: 18th April 2007
Trial Area: 0.144ha
Plot Size: 10m x 6m = 0.006ha

Practice A = Local
Practice B = Improved

Variety 1 = ICGV 94 - 299
Variety 2 = ICGV 94 - 341
Variety 3 = Yarang(Local check)

Yield	Practice	Rep1	Rep2	Rep3	Rep4	ave
94 - 299	Local	0.7	1.1	1	0.6	0.9
94 - 341	Local	1.3	1.5	1.1	1.3	1.3
Yarang	Local	0.6	0.6	0.4	0.4	0.5
94 - 299	Improved	1.4	1.8	1.4	1.3	1.5
94 - 341	Improved	1.7	1.5	1.8	1.3	1.6
Yarang	Improved	1.6	1.4	1.9	1.5	1.6

	Correl Yld with
IR	0.81
Red	-0.02
Green	0.53
Blue	0.40
NDVI	0.85
SAVI	0.85

Table 1. Pod yield (t/ha) measured for each replicate versus colour class and correlation between measured yield and vegetation index

The above figures and Table 1 demonstrated yield variation for each variety as evidence by the spectral reflectance captured by imagery and correlation between measured yield with management practice each colour band and two vegetation indices (Normalised Difference Vegetation Index (NDVI) and Soil Adjusted Vegetation Index (SAVI).

These results demonstrated the potential of this technology as an accurate method not only for ensuring the integrity of field trials, but also identifying non-treatment related effects such as drainage, poor germination, disease etc, as well as an accurate predictor of yield at paddock level. Initial supervised spectral classifications identified that the majority of 'village garden' peanut crops within an image region could be identified. However to increase the accuracy of area predictions it is recommended that additional feature recognition software, that uses both spectral, textural and proximity analysis be assessed.

A major early impact from this imagery work and associated project staff training is that both RAI and Tukai Industries have undertaken their own image ordering, processing and ground truthing (GPS operation), for yield prediction, weed and disease monitoring, as part of their commercial operation. For this technology to be successfully adopted in PNG as a part of an improved agronomic management system for both larger companies and village growers, it requires these larger entities such as RAI, NARI and Trukai to drive it, and this has been achieved to a large extent.

Australia

In Australia imagery and the associated processing protocols developed over the last three years in both dryland and irrigated conditions, have been used to accurately identify disease, irrigation inefficiencies and inherent spatial variability resulting from constraints such as soil type and drainage. Targeted yield and maturity sampling guided by imagery has enabled accurate predictions of crop yield to be determined on real time basis as well as improved management decisions such as harvest segregation to minimise aflatoxin risk to maximise profitability. Temporal images have enabled inherent trends, such as those from soil type, that transcend peanut cropping systems, including rotational crops to be identified.

More specifically, research over the last three years has identified satellite imagery as an effective method for predicting

- Peanut yield and crop maturity,
- Incidence and extent of damage by diseases such as aflatoxin, Fusarium, leaf rust and net blotch.
- Growth constraints such as poor drainage, soil nutrition, irrigation efficiency, erosion.
- An understanding of the inherent variability a paddock within a peanut cropping system may exhibit irrespective of the rotational crop.

Satellite imagery was identified as an accurate tool for estimating the total yield of a peanut crop by multiplying total crop area (via the remote sensing/GIS software) by pod yield estimates measured at strategic locations (zones of varying crop vigour) specified by classified imagery. By comparing the calculated crop yield with those produced if optimum production occurred, estimates of lost production was determined from those regions of underperforming growth (Table 2). This information enabled management decisions regarding the feasibility of applying remedial action to correct under performing areas to be made. A case study on applying imagery technology to predict yield at paddock level is described for a fully irrigated crop in the Texas region of Queensland (Fig 5).

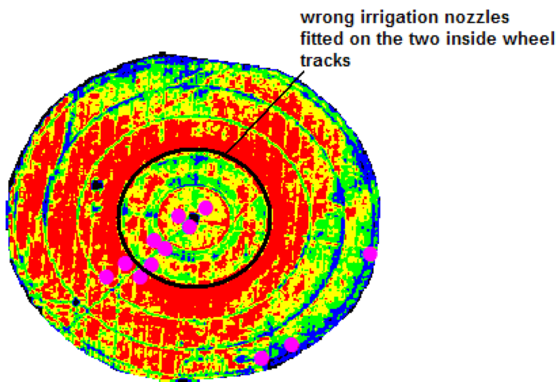


Fig 5. Classified NDVI image indicating spatial variability of IR reflectance and GPS sample points

Area = 21.9 ha (cv. Holt).

Table 2: Estimation of spatial variability and under performing regions in a peanut paddock

	Red	Yellow	Green	Blue	Black	Total
area (%) of pivot of each zone	38.8	31.5	20.5	7.8	0.3	100.0
area (ha) encompased by each zone	8.5	6.9	4.5	1.7	1.4	21.9
Yld (t/ha) (calc. from hand samples)	12.68	10.31	9.18	4.31	n/a	
Total Yld (t) per zone (area of each zone* hand sample yld)	107.79	71.17	41.33	7.34	n/a	227.64

From Table 2, it can be seen that 39% (8.5ha) of this irrigated pivot grew at an optimum level (Red zones- 12.7t/ha) producing an est. yield of 107.8t, whilst the remaining 61% (13.8ha) (Yellow- 10.3t/ha, Green- 9.2t/ha, Blue- 4.3t/ha zones), produced only 139.8t.

Table 3. Assessing potential loss of production using satellite Imagery technolgy.

Total Area of Pivot	21.9 (ha)
Total predicted yield from all colour classes	227.64 (t)
Average yield for all colour classes	10.4 (t/ha)
Average yield for Red colour class	12.68 (t/ha)
Total predicted yield if pivot all Red	277.7 (t)
Yield Difference	50.1 (t)

If the entire crop had optimum growth (Red) then the predicted total pivot yield would have been 278t, 50t more than the total predicted yield based on the measured variation within each colour zone. In monetary terms, the ineffective irrigator as well as other smaller regions of under performing areas could have resulted in a potential loss of production of $50,000 (at $1000 per tonne) (Table 3). This information is highly beneficial to both growers and consultants as the financial impact of underperforming areas can be determined, allowing for well informed decisions regarding the feasibility of correcting these zones to be made.

In regards to regional predictions a strong correlation was identified between NDVI and crop yield from a number of dryland peanut crops of various varieties grown over the three years (R= 0.82**). This correlation indicates the possibility of making future yield estimations of dryland peanut crops directly from the classified imagery with a reduced need for ground sampling. The prediction of total peanut cropping area with an intensive cropping system through imagery was also shown to be possible, however 'feature recognition' software is required to greatly improve the accuracy and is therefore recommended for future research.

A web-based decision support system for peanut growers in Queensland to access the crop performance maps generated from imagery

The possible delivery of processed satellite imagery and the resultant classifications to registered growers has been investigated through both e-mail and internet based forums both of which have received positive feedback. The initial inclusion of imagery as a component in the web- based decision tool 'AFLOMAN' has shown promising results. These images can now be accessed on the internet at www.apsim.info/afloman by its password protected account holders (Appendix 11.4b). These images can be used to segregate the stress affected areas that have a high probability of aflatoxin contamination. The internet access to imagery by subscribers creates an additional dimension to the existing 'AFLOMAN' program in assessing crops spatial variability in conjunction in-season aflatoxin risk to make informed decisions about harvest management of their crops. However, timely availability of imagery and the cost involved in acquiring the imagery are seen as key constraints for uptake of imagery technology by growers.

Objective 4: Assess the potential and feasibility to enhance marketability of new peanut varieties and products in PNG and Australia.

Two independent market feasibility studies, on each in PNG and Australia, were conducted to assess scope for enhancing marketability of new peanut varieties and products.

a. Market scoping study in PNG

This consultancy was commissioned by RAI Ltd, in consultation with the project leader in Australia and implemented by a private consultant, Dr Sandra Martin, Associate Professor and Director, LUCID, Lincoln University, Canterbury, New Zealand.

The TOR for the consultancy addressed under two objectives. The first objective was to evaluate the market size for peanuts and peanut products in PNG with a view to identifying potential market segments that can be expanded in the future. The second objective was to evaluate various production and processing scenarios within the context of the potential market segments that were identified. The methods used to achieve these objectives were exploratory preliminary market surveys, rapid market appraisal and interviewing key informants. The major findings of the scoping study is outlined below and the full report is attached (**Appendix 11.6).**

The wider context within which the PNG peanut industry operates will have an impact on its development. The demand side features of the macro-environment provide a positive base for any up-scaling of the PNG peanut industry and rising world food prices herald good price prospects for peanuts and peanut products in international markets. However, any foray into peanut markets must recognise the existence of the large, and probably efficient, players in those markets. The growth of the PNG economy and the transformation of internal markets signal greater disposable income within PNG, and thus opportunities for expansion of the peanut industry.

There have been previous attempts to commercialise the peanut industry in PNG. In 1976, the Atzera Rural Cooperative peanut factory was established in the Markham Valley, primarily for the production of peanut butter. However, this earlier initiative failed. From a marketing perspective, key factors in its failure appear to have been uncertain supply of peanuts from smallholders, resulting in uncertain supply of peanut butter and variable prices on the shelf, management problems, and of key concern, high levels of aflatoxins reported in product samples.

The vast majority of current peanut production in PNG, which is estimated to be in the range between 15-20,000 t/pa and growing, consumed locally, although significant quantities of peanuts are internally traded through informal road-side markets. A key feature of this informal trade of fresh peanuts is its marked seasonality in terms of peanut availability and prices. By contrast, virtually the only peanut products sold in the formal sector are imported processed products and volumes traded, estimated at 520 t in 2007, are very small.

Management of the aflatoxin risk has some key implications for the up-scaling of the peanut industry in PNG. Fresh peanuts in informal markets have been found to have aflatoxin levels that are generally low, though some dried samples of peanuts tested in major markets showed alarmingly high levels. Peanuts grown in the peak season using proper crop management techniques are likely to exhibit low aflatoxin levels at the production phase, but the level of aflatoxin is likely to rise if peanuts are planted during the off-peak season. However, this impact can be ameliorated through good crop husbandry including irrigation. At the post-harvest level, aflatoxin contamination can increase in storage due to poor drying and storage practices.

Market Size and Segments

Within PNG, there are two distinct market segments – the informal peri-urban markets and the formal urban markets. Peanuts are predominantly sold in the urban markets soon after harvest as a fresh product with little or no product enhancement, with local varieties preferred.

The formal urban (super) market for imported peanut products in PNG has changed markedly in recent years. Peanut butter is the dominant product traded in this market, while quantities of confectionary products traded are very small. Some very interesting trends are observable in peanut butter imports, the most obvious of which has been a collapse in the market share of imported Australian peanut butter, and the corresponding rise in the market share of peanut butter sourced from China. Associated with this has been a dramatic increase in the volume of peanut butter imported from China, rising from virtually nothing in 2005, to over 300t in 2007.

The most striking feature of this phenomenon has been the penetration of this Chinese sourced peanut butter to the market segments that service grassroots consumers. A well-functioning distribution system has aided this process with the rise of supermarkets and Cash N Carry stores servicing these lower income market segments. At the Chinese end of the distribution chain, there appears to be an efficient, reliable and well-functioning distribution system.

Consistent with this successful penetration of the lower-end market segment has been the introduction of an appropriate product for these consumers. Small sized 200g containers of peanut butter are on the shelf and move quickly. They are packaged in simple plastic containers with a simple label, which is usually a distributor brand. The pricing of the product reflects the needs of consumers in this market segment.

Because the domestic market for processed peanut products is very small, export markets need to be considered in any evaluation of a commercial peanut processing industry within PNG. Current export markets for confectionary products are unlikely to be accessible to PNG processors, but there may be scope of exporting peanut butter to other Melanesian Spearhead Group (MSG) countries. The total market for peanut butter products in these other MSG countries is likely to be around170 t/pa. Peanut oil is another product that might offer export opportunities. Peanut oil has a reputation as healthy oil with excellent cooking properties, which could be make it an attractive market proposition in Asian markets. A further export market possibility is the sale of dried (raw) and roasted peanuts directly to overseas markets. International demand for peanut products is likely to be rising, particularly in the emerging economies of South and South-East Asia, and buyers in these countries may try to source raw peanuts on the international markets in order to maintain their processing capacity.

Marketing Scenarios

Cottage Processing of Peanut Butter

Financial analysis showed that the return from cottage processing of peanut butter is relatively low and so this option is unlikely to be a solid commercial proposition. Cottage level processed peanut butter produced seasonally could not compete on the supermarket shelf, since it could not meet the requirements of continuity of supply and consistent and low shelf price over the year, while the distribution system would be higher risk for supermarkets than distribution systems for imported product.

It might be possible for cottage processors to find a market niche in isolated areas outside the current supermarket distribution areas where they would not be in direct competition with imported product. However, this option would bring with it the potential for increased aflatoxin risk that would be difficult to monitor and control.

Improving Smallholder Returns from Fresh Peanuts

There may be some simple ways of improving smallholder returns without resorting to cottage processing with its relatively meagre returns and increased food safety risks. Financial analysis showed that one small initiative that could improve smallholder returns through the traditional informal marketing system by using improved production practices. An associated initiative could be an improvement in food safety through education on post-harvest practices that can reduce aflatoxin risk. Financial analysis also indicated that it might be possible to encourage a greater increase in smallholder returns through the adoption of improved varieties and their sale in the informal markets, particularly if the price of the improved varieties is discounted to encourage its uptake.

Company Managed Buying Point

Qualitative analysis suggests that there is little scope for a company managed buying point that would do limited value adding and supply the domestic market. Currently, there is no outlet for this type of product in the formal markets and no indication that this activity would create value for consumers in the informal markets. There may be opportunities to export peanuts as an industrial raw material, but it could prove difficult to cement in such opportunities in the longer-term.

Commercial Peanut Butter Processing

Market and financial analysis shows that there could be scope for a commercial peanut butter industry in PNG if it is established by a company with peanut raw material secured through the use of a nucleus estate out-grower system. This would minimise food safety risks associated with aflatoxin contamination, and risks associated with lack of supply continuity to the market. However, an industry structured in this way would be much smaller than that initially envisaged for up scaling the peanut industry in PNG because of the size of the domestic market and the risks of operating in the wider export market. It would also have much lower smallholder involvement than more risky co-operative business structures.

Peanut Oil Processing

Preliminary financial analysis suggested that peanut oil processing might be commercially viable if markets can be secured. The scale to be considered would be much smaller than originally envisaged for up-scaling the commercial peanut industry in PNG if the core peanut supply came from a nucleus estate growing peanuts as a fallow crop. There would be relatively low smallholder involvement with the preferred nucleus estate:outgrower option than with other more risky options, such as smallholder co-operatives.

b. Market Scoping study in Australia

The market scoping study in Australia concentrated on assessing the market potential and industry feasibility of establishing a peanut oil industry in Australia. The study was implemented by Daniel Cook, Market Development Manager in consultation with Bob Hansen, Managing Director and Graeme Wright, General Manager, Breeding and Crops, at Peanut Company of Australia. The major outcomes of the scoping study are outlined below. The full report is attached as **Appendix 7**.

The current size of crude peanut oil in the Australian domestic market is about 2500mt and price of the crude oil has gone up from $1150/mt in 2003 to $2900/mt in

2008. There is an existing niche market for premium cold pressed high oleic peanut oil in Australia, only marketed to the food service sector, the current Value of which is about $5000/mt.

There are two major supply chain players in the Australian Peanut Oil industry i.e., Peanut Company of Australia and Goodman Fielder / Meadow Lea Ltd.

The world's consumption of peanut oil is about 4.2million mt and this is small compared to other oils for e.g. palm oil (23.6million, rape seed/canola, (13.6 million tons) and sunflower (8.3million tons).

In Australia the majority of peanut oil is now high oleic, except for imported oil which is normal oleic. Based on PCA customer information and sales, the benefit of high oleic oil does not seem to have been accepted by many customers due to the high cost compared to other oils such as canola. The market size and value is the same as above due to PCA having majority supply of the market. Currently there is no exporter of high oleic peanut oil on the world market due to very few shellers maintaining pure high oleic crushing feed stocks. It is not expected to fetch more than USD100-200/mt premium over normal oleic peanut oil due to peanut oil already being at the premium end of the market.

However, there is room to market peanut as specialty oil having similar properties as olive oil, thus opening the market and value to that of average olive oil prices. Contacts within China have suggested there will be a large market for high oleic peanut oil in future years as higher income consumers demand quality cooking oils.

The peanut meal is a valuable product in oil extraction and has a role to play in stock feed rations. The fat content in peanut meal is relatively low (~10%) and along with the fact that the levels of protein meals useable in feed rations are also quite low (<20%) means that a 1-2% change in saturated vs mono-saturated fats would have minimal impact. This is especially the case in comparison to monounsaturated canola meal (which makes up 25% of the meal industry in Australia).

The single largest restriction on peanut meal in Australia is aflatoxin content. The legislative requirement <200ppb B1and above this limit, the value of meal should be considered $nil for an industry viability study.

There is potential for value adding through protein meal extracts based on preliminary research done in the USA (Dr Tim Sanders, N. Carolina State University). Additionally further work could be undertaken on clay binders and their ability to bind aflatoxin in stockfeed rations.

The total protein meal market in Australia is ~600,000mt. The predominant usage is in the poultry and mono-gastric animal industry. The legislative requirement for aflatoxin for poultry and mono-gastrics is much lower (~10ppb) than for ruminants, which means that the aflatoxin level detected in peanuts for oil crushing would be equivalent to the aflatoxin level of Seg 1 (<8ppb) peanuts in the Australian peanut industry. Outside of this level the meal is essentially limited to non-lactating ruminants.

In general it is considered that the economic viability of peanut oil into bio-diesel to be at best marginal, especially considering peanut is a premium grade oil and will always attract a better price for refined oil relative to other commodity grade oils such as palm.

Based on the information derived from cost analysis, it is suggested is that only a small industry would be sustainable on a long term basis – 20,000mt total Farmer Stock basis. It should be expected that business operations would also be highly variable from year to year based on drought and lower productivity potential on more marginal land production thus causing supply variations – as is common in the commercial (edible kernel) peanut industry today.

Due to the variable nature of the business (and the virtual shutdown/start-up mentality that is required based on variable industry supply) it would not suit a stand alone enterprise. It is best suited to a large existing company who has a complementary business (peanut shelling / oil crushing / corporate farms) or a supplier owned co-operative and operated as a business unit which can run at zero or low profitability if required without impacting on overall parent company viability.

At a grower level, for the peanut for oil concept to work, farmer stock peanuts will have to be grown under a very low input/cost structure, such that significant improvements in gross margins would be achieved. We believe this should be possible, with significant savings possible in herbicides (use of low cost formulations), fungicides (using high foliar disease resistant and ultra early maturity varieties), no-till, and harvesting costs (i.e windrow drying (no drying costs), using corn type thrashers to shell peanuts on the fly, no pre-cleaning). It should be possible to reduce variable costs to around $6-800/ha using such an approach. Further work can also look at effect on pulling peanuts early due to aflatoxin risk to ensure by products are at their highest values to reduce the value of oil crushing kernels – lower oil content and meal value would be altered (perhaps even higher dependant on analysis).

Peanuts under this type of production system offer grain growers in the Northern Region the option of including a relatively high value, drought tolerant grain legume in the summer cereal/cane/cotton based farming system. Peanuts can offer significant benefits for N contributions to the following cereal crop, which will become increasingly important with rising N fertiliser prices.

Additional issues beyond this include high levels of aflatoxin in meal and the lack of a high volume peanut oil market in Australia. Large scale operations would be largely dependent on the export market for short to medium term sales, and would require large scale marketing investment to reach the targets identified earlier.

Future carbon trading schemes and tax benefits has not been included in this report due to the infancy of the market, and additionally the market viability should not rely on the existence on these market influences. They may however boost profitability where companies have the ability to claim carbon credits as part of their overall profitability.

Scenario analysis using the APSIM peanut model to assess likely adaptation of new varieties in Australia and PNG

The APSIM peanut module (version 6), was validated for a range of Australian and Papua New Guinea environments. The R2 of the relationship between observed and predicted pod yields was 0.9 (P<0.01) and the root mean square error (RMSE) was 5.5% of mean pod yield in environments that were relatively free from biotic stresses (Fig 6).

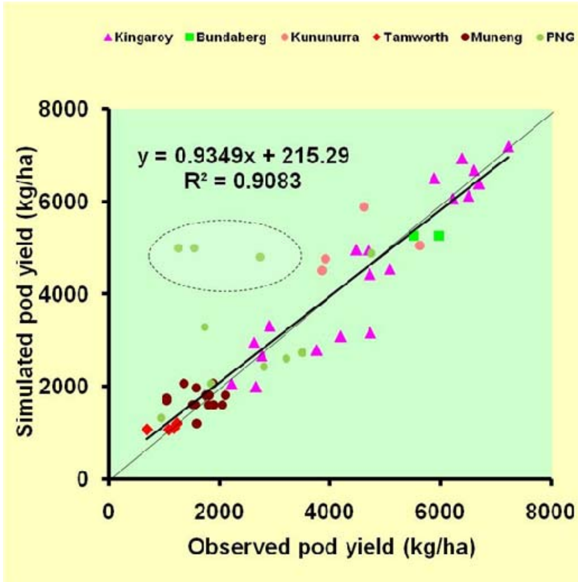


Fig 6. Validation of APSIM model for locations of Australia (▲), Indonesia (·) and PNG (●,·). The encircled PNG locations are those of Aiyura which were due to yield potential not being realized in this environment. The encircled points were not included in the regression equation depicted in the chart.

Australia

In Australia, peanuts are mainly grown in the Burnett and coastal regions on Red Ferrosols and sandy soils. Lack of adaptation of traditional full season peanut varieties to other environments and cropping systems seems to be the reason for their limited adoption elsewhere. High risk of aflatoxin under rainfed conditions could be another factor preventing their large scale cultivation in other areas. Given that peanuts can make substantial nitrogen contributions to the following cereal crops, which will become increasingly important with rising N fertiliser prices, and possess high levels of drought tolerance, it will be prudent to increase their adaptation to cereal-based broad acre farming systems. The development of ultra early varieties (Walter) that escape terminal drought and thus on-farm aflatoxin risk could provide an avenue for inclusion of peanut into non-traditional cropping systems.

The APSIM peanut module was used for simulating rainfed yield potential and aflatoxin risk of short-duration variety 'Walter' (<100 days duration) for 32 locations below latitude of 31oS in Australia. The simulated pod yield of 'Walter' ranged from 1.5t/ha at Emerald to 3.7t/ha at Bundaberg when grown at a narrow (50 cm) row spacing and a 50% higher plant population than used for traditional type peanuts (>140days). This assessment was for soils of very low water holding capacity, which could be considered marginal for growing high value crop under rainfed conditions. The yield potential of ultra-early peanuts was comparable, though not higher, to traditional long season varieties, which were more adversely affected by terminal drought in most environments. At a 75% probability of exceedance (chance of 3 in 4 years) pod yield at different locations varied from 0.4 to 3.3t/ha. Seventeen locations where pod yield of ultra-early peanuts exceeded 1.5 t/ha in 3 out of 4 years were identified and subjected further economic analysis for oil production. These simulations suggest that to sustain a small oil industry with an annual crushing capacity of 20,000mt, which has been highlighted in the scoping study discussed above, about ~13,000ha of additional peanuts will be required assuming a productivity of about 1.5t/ha.

The strategy of growing peanuts for oil will not only increase the income generating potential of peanuts but also accrue rotational benefit though greater diversification of broad acre farming systems. Substantial rotational benefits of peanuts to sugarcane in coastal farming systems are now well recognized by growers leading to greater inclusion of this crop in rotation with sugarcane. It is envisaged that inclusion of peanuts in broad acre farming systems in central south east Queensland and Darling Down regions can similarly benefit a number of broad acre cereal crops including wheat planted in winter or sorghum in the following summer season.

PNG

The APSIM module was used to develop a database of predicted yield and aflatoxin risk scenarios for PNG locations, including Aiyura, Ramu Agri-Industries, and Bubaia (Lae) using their updated historical climatic data. The results suggest that all the three locations permitted year round sowings with reasonable yield potential in Aiyura and Bubia environments. (Fig 7a) The overall yield potential of short duration peanuts at Aiyura location was lower, about 3t/ha, compared to other locations.

Further, Aiyura and Bubia had very low pre-harvest aflatoxin risk whereas only February to July sowings at Ramu Agri-Industries were prone to high probability of pre-harvest aflatoxin risk (Fig 7b).. Analysis of samples collected from the different seed village trials conducted in EHP and UMV regions confirmed the aflatoxin risk simulated by APSIM. model Incidentally March-July sowings were had lower yields as well due to severe dry spells and thus suggesting irrigation strategy during March-July sowings might result in high yields with low aflatoxin risk. The model has thus identified relatively safe planting times for achieving high yields of rainfed peanut crops while minimizing the pre-harvest risk of aflatoxin contamination in the upper Markham Valley (Ramu Agri-Industries).

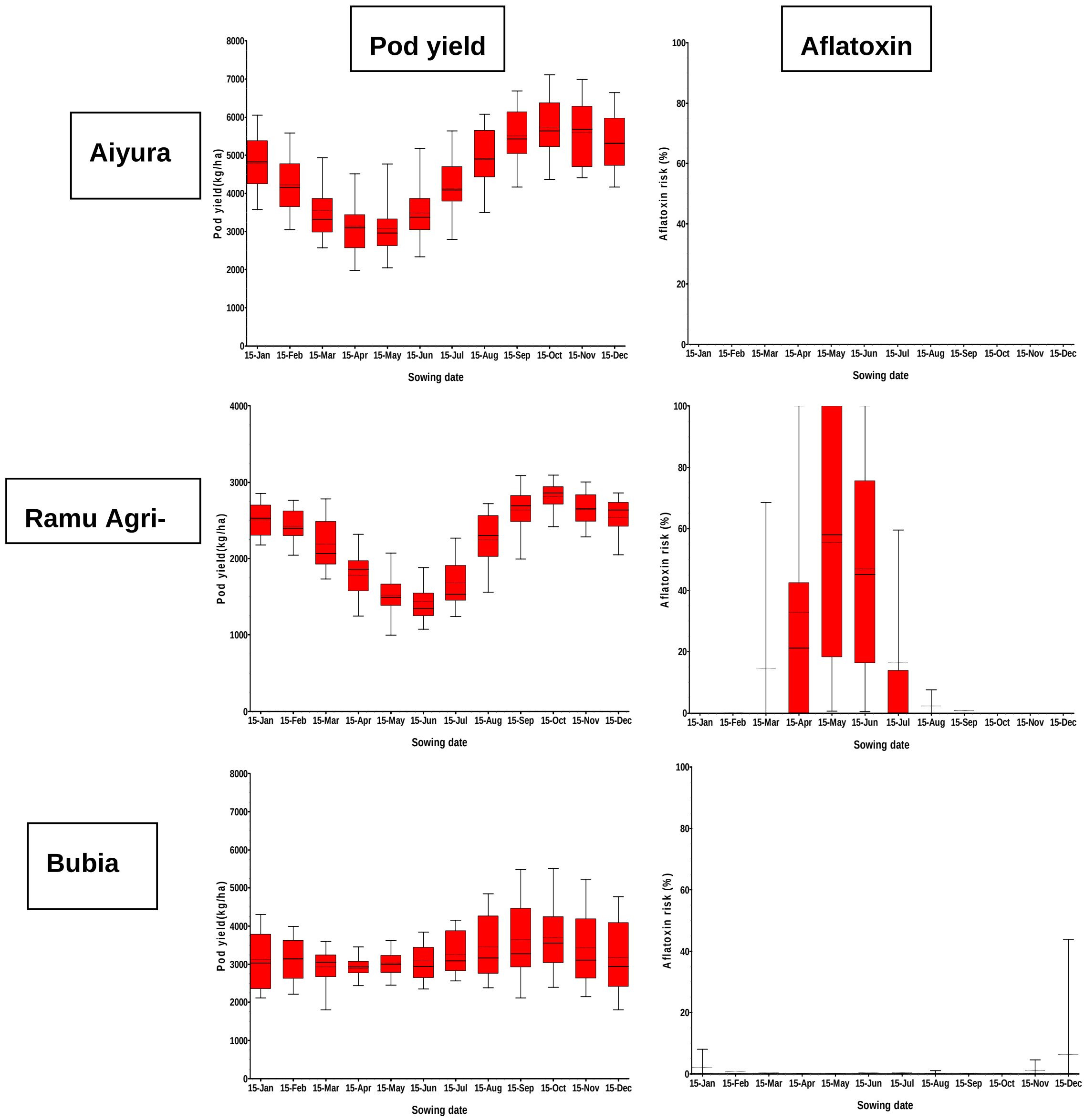


Fig 7 Time of planting scenarios for pod yield and aflatoxin risk at Aiyura, Ramu Agri-Industries and Bubia.

The risk of post-harvest aflatoxin can also be serious in all locations. Severe incidence of foliar diseases causing pre-mature harvests leading to immature kernels which are more vulnerable to A. flavus infection, wet harvests, as well as inappropriate storage and marketing practices could contribute to this risk. In many experiments the observed maturity was about a month earlier than simulated by the model which suggests that crop may been subjected to foliar diseases. Managing foliar diseases either through fungicides or genetic means and avoiding sowings that are more prone to wet harvests are the key for improving productivity in PNG.

The simulated yield and aflatoxin databases generated for limited peanut growing environments by the ASPIM model, in conjunction with the 'Whopper Cropper' software was used to develop a decision support tool to assess environmental effects on yield and aflatoxin risk and make appropriate management decisions to maximize peanut production and minimize risk of aflatoxin (**Appendix 8** & CD distributed at the review meeting). Whopper Cropper databases for other locations of PNG could not be generated due to un-availability of quality daily climatic records.

The use of APSIM-simulated database of yield and aflatoxin risk profiles will assist the collaborating partners in not only assessing the potential yields at various locations but also to appreciate the value of quality climatic data and how it could be useful to them in improving agronomic management of peanut.

9 Impacts

9.1 Scientific impacts – now and in 5 years

Through training, participation in annual review meetings and project team meetings, project staff gained scientific expertise in maintaining quality of on-farm research, data analysis and reporting Presentations by the PNG peanut project team at various field shows and grower meetings have generated significant awareness amongst small holders about new peanut varieties and management practices, including the harmful effects of aflatoxin contamination.

Researcher managed trials have consistently shown improvement in crop yields, both with new and local varieties. These improvements have generally been in the range of 39-155%. It is expected that varietal refinement will be continued by the National Agricultural Research Institute beyond the life of this project.

At the start of the project many of the farmers including researchers believed that senescing of leaves was a sign of plant maturity. They now understand that most of the leaf senescence they were seeing was caused by leaf disease (rather than sign of crop maturity) and that these diseases can be controlled by using appropriate fungicides. This knowledge will continue to be disseminated through the rural communities as learning from these trials sites is extended.

The project has been able to improve scientific skills of the collaborating scientists in accurate recording of GPS coordinates, and developing shape files of targeted paddocks, processing satellite images by applying satellite imagery processing tools.

In Australia, the satellite imagery work done in this project received a 'special' recognition by the DEEDI management as "revolutionary" science. The remote sensing technologies and applications identified through this project has seen a large amount of positive feedback and interest from both the Australian peanut and sugarcane industries. Under their direction and collaboration, additional project proposals have been submitted to both the Sugar and Grains Research and Development Corporations (SRDC and GRDC) for increasing the adoption of remote sensing in Australian cropping environment. This research will see a large change to existing agronomic practices with remote sensing becoming a major tool for identifying in-season crop variability, allowing for coordinated agronomy to better manage constraints of economical concern. It is hoped that the maximisation of productivity and a reduction in input costs (pesticides, fertiliser, water etc) will result from this technology. This application also has great potential of being adopted by Ramu Agri-Industries and Trukai Industries as part of their management practices.

The application of crop modelling followed by field validation has enhanced project scientists' understanding about the benefits of appropriate time of planting and also the value of collecting daily weather data. As a result of this knowledge Ramu Agri-Industries has changed time of planting of peanut in cane rotations. It is expected that the knowledge of these benefits, will diffuse into the neighbouring small holders, who are only partially implementing the planting time practice. Probably this is because their traditional production system often centres on cash flow requirements and lack of awareness how it affects quality of their produce.

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9.2 Capacity impacts – now and in 5 years

The project has been able to build the capacity of NARI and RAI agencies in aflatoxin analysis by installing the mini-column facility in the NARI, Aiyura, in the Eastern High Lands and Ramu-Agri-Industries in the Markham Valley in PNG. As peanut production expands, the economic impact of aflatoxin contamination could become a significant issue in PNG with quality deterioration and spoilage, carcinogenic effects on humans, livestock health and possible loss of export markets due to aflatoxin regulations restricting international trade in aflatoxin contaminated peanuts. It should be noted that aflatoxin contamination has been the prime cause for decline of the peanut industry in PNG in the1980's. The ability to monitor aflatoxin combined with enhanced on-farm research capacity should present the collaborating institutions with an opportunity to take a lead role in developing and implementing management practices to minimise economic impact of aflatoxin contamination in peanut supply chain beyond the project.

Through this project public and private sector staff have improved their peanut agronomy skills such as,

- varietal and site selection
- seed treatment
- time of planting
- crop growth monitoring
- pest, disease and weed management
- maturity assessment and harvest management to minimize aflatoxin risk.

The officers have also developed both extension and research skills in the processes of participative farmer research. Alongside this these officers have developed improved capacity in high quality research (trial layout, timeliness of operations record keeping etc). The development of these skills is evident in progressive yield increases of crop yields in all trial treatments during the project life.

A total of 32 training activities/visits have been implemented during the project (16 activities in PNG including researchers' visits to Australia and 16 visits by Australian scientists to PNG) (**Appendix 11.9**)

The training visits have been mutually beneficial with officers developing a range of skills including, satellite Imagery analysis, quality on-farm research, scientific and extension writing skills as evidenced by the attached report on satellite imagery analysis training by RAI staff at Kingaroy (**Appendix 11.12**).

The publication "Growing peanuts in Papua New Guinea: a best management practice manual" has been commended by scientists, extension officers and the public as a high quality informative and readable publication. In addition to PNG requests for the manual have been received from Australian peanut industry, Torres Strait Regional Authority, Solomon Islands, Indonesia and Cambodia.

In PNG the partners have developed a successful teamwork ethic by holding regular meetings to exchange information on technical and project management issues, which has further strengthened collaboration between public and private sector research and development programs.

Similarly to the partners, project staff, farmers and interested villagers have developed agronomic and peanut production skills through the participatory research approach taken throughout the project life.

Ramu, Trukai & NARI staff are trained in acquiring, processing, interpreting satellite imagery and started applying the technology to peanut and other crops (sugarcane). The RAI and Trukai agencies are keen to develop further skills in using the technology to livestock pasture management and land use to identify constraints and potential amelioration for future productivity gains to assess spatial variability in their broad acre cropping systems. Skilling up of the officers will have future impact in improving the productivity of PNG cropping systems.

The project has supported a postgraduate Masters program at the University of Queensland for Mr. Amos Topi from the University of Goroka under the guidance of Associate Professor Rob Cramb. Amos Topi 's work focussed on the socio-economic constraints for adoption of improved peanut practices by smallholders in PNG, a topic which has direct relevance to the project (**Appendix 11.10**)

9.3 Community impacts – now and in 5 years

9.3.1 Economic impacts

A survey on 'Role of Women in peanut culture', conducted in the Markham valley by the Trukai Agribusiness Ltd has shown that peanut provide 39-75% of the smallholder cash income. RAI conducted preliminary economic analysis of peanut production which indicated 50% of their surveyed peanut farmers are earning between K1000 -K5000 per year from peanut sales. This analysis also noted that the fresh market peanut supply is still inadequate to satisfy wholesale buyers and consumers requirements.

The preliminary cost benefit analysis of management practices conducted by collaborating agencies (table 3) showed that adoption of improved practices would result in greater cash income to small house holds.

Table 3: Summary of yield benefits and potential net profits from improved practices

Focus region (collaborating agency)	% Average yield increase/decrease by the use of best management practices	Net profit from the improved practices
Lower Markham (Trukai Agribusiness)	39% increase	Not available
Upper Markham (Ramu Agri-Industries)	103% increase	K2625/ha #
NARI -Aiyura (Eastern Highlands)	59 - 155% increase (with exception of a trial at Kabiufa that showed no effect of improved practices)	K3951/ha #

*# The figures were drawn from the progress reports (**Appendix 11.1 & 11.2**)*

An industry market study in 2008 recommended that there should be a focus by agencies such as NARI to improve smallholder returns through encouragement of the improved production practices demonstrated in this project.

Although farmers are aware of these benefits there are still some hurdles smallholder growers have to overcome, such as,

- having the initial capital to implement some of the improved practices (e.g. fungicides & micronutrients).
- physically being able to obtain required crop inputs (seeds, fungicides, fertilizers etc)
- paradigm change from receiving some small benefit from a minimal input crop to investment for crop maximisation to obtain a much improved benefit.

While the Ramu Agri-Industries survey showed there is sufficient market demand for peanuts, there is an issue with seasonality and price fluctuations. There are no processing facilities or large bulk buying points because some farmers do not see need or incentive for investing in improving productivity unless there is consistent demand for medium-large volume of product. Through this project and the best management practice manual, they now have the technology to implement improved crop production techniques if required.

The crop modelling supported by aflatoxin testing aspects of the project has decisively shown that yields can be increased and aflatoxin levels reduced by utilising correct planting and harvesting schedules. This information will be of critical importance for any future development of the industry especially in the area of downstream processing.

The use of satellite imagery with ground truthing in both Australia and PNG has shown and allowed producers to identify crop vigour, foliar disease sites, irrigation efficiency (when used) and crop maturity enabling them to maximise there crop return potentials. Both private and public sector partners have already seen the benefit of this imagery and are incorporating it into their overall farming systems.

9.3.2 Social impacts

Peanut is important cash and food crop to remote villagers as the commodity is 'ready to eat' and easy to transport to markets compared to other heavier and perishable commodities such as sweet potato, Irish potato, banana, yam or taro. Larger agricultural enterprises see a role for peanut as a rotation legume crop with the potential to provide a cash return (Wemin et al, 2005).

The utilisation of best management practices enables producers to improve yield by up to 155% without the need for any extra land. A NARI cost benefit analysis of local and improved practices identified improved practices requiring only 5% more man-days than local practice. While the initial work showed almost 50% extra man-days were required to sow seeds under the improved practice as compared to the local, this figure has substantially reduced with proper skilling. By adopting row planting, farmers have quickly noted that 60% less man-days were required for weeding under the improved practice. Because of this a number of villagers outside of the trial sites have already taken to planting of peanuts in straight rows (pers comm Wemmin, Saese 2008). In the Kolopen et al (2005) study on the role of women in peanut production in the lower Markham Valley, the interviewed women ranked weeding as one of their main activities in producing the crop. A 60% reduction in the man-days by use of row planting will be of great benefit.

Even considering the extra man-days required the economic analysis shows a benefit of between K63 and 247 per extra man-day. The Kolopen study indicated that 64% of women in the lower Markham receive income from the peanut crops. Wemin et al (2005) found that in the Eastern Highlands and National Capital District, 100% of their survey respondents indicated that only women did the marketing and controlled money earned from peanuts, while in East New Britain 75% of the marketing was done by women. From this data it could be expected that an increase in crop income would benefit families.

Field days and presentations by the project team have generated significant awareness amongst smallholder growers and customers of the harmful effects of aflatoxin contamination. Lowering aflatoxin contamination in human food is necessary to reduce the severity of the HIV (AIDS) disease. A recent study by Jiang et al. (2008) suggests that high aflatoxin intake may facilitate HIV associated immune hyper-activation and lead to a more severe disease. The capacity of the project partners to analyse for aflatoxin has been timely and necessary for the development and implementation of management practices to minimize its impact on the health of consumers and livestock.

Skills developed such as pest and disease identification, understanding of timeliness of agronomic operations while resulting in improved peanut production will also have spinoff benefits for other crops being grown.

In 2006 the PNG Rural Development Bank opened a credit facility at Mutzing, Morobe Province. The bank listed the participation/training in peanut technology (through the "seed village" trials) as one of the criteria for eligibility to apply for crop or agricultural loans which demonstrated the impact of the project at community and industry development level.

The use of satellite imagery in Australia has enabled growers to gain an effective handle in monitoring crop conditions including disease incidence and areas of low vigour which needs attention. This informed knowledge enables forward planning and implementation of appropriate crop management strategies to minimise resource input and maximise profits

The project has developed strong professional (& social) linkages between the project partners, DEEDI, Ramu Agri-Industries, Trukai Agribusiness and NARI with regular flow of information, emails and phone contact. These linkages will extend well beyond the life of the project.

9.3.3 Environmental impacts

A major advantage of utilising best management practices is that in PNG farmers will improve their production without the need for further land clearing.

Ramu Agri-Industries has seen benefits from using peanut in their sugarcane rotations to break the sugarcane yield decline cycle. Dr. Kuniata believes that the effect of peanut rotation can even be seen in the ratoon sugar crops. The main benefits seen to date from the use of peanut in the sugarcane rotation is a reduction in need for inorganic fertilizer, increase in soil organic matter and a very large reduction in weed competition resulting in faster emergence and canopy cover. However, in contrast, there is need to rise the awareness among small holders about the negative effects of mono cropping of peanuts.

Dr. L . Kuniata showing the benefit a sugarcane crop receives from a legume crop (right) compared to mono cropping of cane (left)

The crop modelling and subsequent validation of the model outputs has revealed opportunities to minimise on-farm aflatoxin by adopting optimum planting time in the Upper Markham valley. The knowledge of aflatoxin risk and its on-farm management meant reduced aflatoxin contamination in human food. The environmental benefits that remote sensing and satellite imagery can offer to cropping systems has been well demonstrated in Australia as described in earlier sections.

9.4 Communication and dissemination activities

The project outputs are promoted through a range of communication and dissemination activities which included field shows, VIP field visits and information bulletins, radio interviews etc. As part of the project >100 communications were delivered in various media to target audiences in PNG and Australia. The detailed list of the communication activities implemented in PNG and Australia are listed in **Appendix 11.11**

10 Conclusions and recommendations

10.1 Conclusions

1. The project has successfully demonstrated that productivity of dryland peanut can be increased from the existing 1 t/ha to >3t/ ha using local or new varieties and by adopting a set of improved practices in all the three focus regions, i.e. EHP, UMV and LMV. More research is needed to identify and optimise the key factors contributing to the yield benefit, but it is likely that optimum planting time, basal fertilization, and maintenance of plant stand, row spacing, foliar pest and disease control particularly during the seed filling phase, as well as appropriate harvest management are significant factors responsible for the observed yield responses.
2. The performance of new varieties over local check varieties was inconsistent, with yield benefits varying from marginal to 15% across locations. However, new varieties were superior in their kernel characteristics (i.e smooth shell texture, high kernel: shell ratio, uniform/larger kernel shape and size) and suitability for processing (roasted and butter) market. It is expected that the R&D agencies will continue to evaluate new varieties to identify foliar disease resistant lines and match varieties to future market requirements.
3. The project has established a sustainable peanut seed production system which enabled Ramu Agri-Industries to take a lead role as a commercial producer and distributor of peanut seed, a capacity which will be an asset for the future peanut industry. However, the recent decision by the new RAI management not to pursue peanut cropping (in spite of demonstrated peanut rotation benefits to sugar cane) meant that commercial peanut seed production will remain as an issue for the PNG peanut industry.
4. Installation of aflatoxin analytical facilities and training of staff at NARI and Ramu Agri-Industries has enabled these institutions to implement monitoring of aflatoxin contamination in peanut samples independently. It is expected that this capacity will play a key role in monitoring peanut and peanut product quality for the future PNG peanut Industry. The results from the seed village trials showed that while the pre-harvest aflatoxin contamination was low (<20 ppb) in EHP, crops planted during February to July in the Markham region had high frequency of aflatoxin contamination with levels of >200ppb recorded in some samples. However, risk of post harvest contamination exists at all locations due to combination of favourable climate conditions (for aflatoxin production), poor storage and market practices (as fresh food).
5. An important task was to validate the APSIM peanut model for PNG peanut growing environments. An understanding of climate variability, soil water dynamics, aflatoxin risk profile and the relative importance of results across a range of agro-climatic conditions has enhanced the application of crop simulation modelling in PNG and Australian environments. There was a good agreement between yield and aflatoxin contamination observed in field trails and that simulated by the APSIM peanut model, suggesting that the APSIM peanut crop model can be used as a tool to assess environmental effects and develop strategies to achieve high yield and quality in various environments. However, access to quality weather data for PNG locations is seen as a major impediment to extend the application of modelling to other peanut growing environments. Successful application of modelling approaches allowed appreciation of the value of collecting such data for better management of peanuts and other crops.

6. Satellite imagery technology has proved to be a cost effective tool for the in-season monitoring of spatial variability of peanut crops and peanut yield prediction in PNG and Australia. The results generated by this project have led to the commercial adoption of this technology by the Peanut Company of Australia, as well as, Trukai Industries and Ramu Agri-Industries, with all three agencies purchasing their own imagery. PNG project staff from Ramu Agri-Industries, NARI and Trukai Industries developed a strong understanding and competency in the use of hand held GPS units as well as processing satellite imagery.
7. The two market scoping studies implemented in the project have provided a detailed assessment of the state of art of market for peanut and peanut products in PNG and Australia and in particular, peanut oil in global markets. Both scoping studies suggested potential export opportunities of raw peanut kernel and oil for PNG and Hi-oleic peanut oil for Australia. It is expected that the scoping study reports will stimulate the thought process of commercial players to further explore economic viability of the new market opportunities suggested by the scoping studies.

10.2 Recommendations

1. It is recommended that project results, particularly improved practices, be made available to local extension agencies. While is it expected that the research and extension agencies will find great value in the BMP manual published by the project, there is need to extend the BMP information to other major peanut growing provinces in PNG such as East New Britain. There also remains a need for location-specific research to explore avenues to optimize crop inputs by sourcing local products, while maintaining high yields from improved practices.
2. Given the recent change in business priorities of Ramu Agri-Industries (RAI), it is unlikely that RAI will pursue peanut seed production vigorously, and thus there is a need to develop alternate strategies for commercial seed production and supply systems. It is recommended that selected large-scale and progressive growers are trained in commercial seed production of peanut and supply to local small growers. It expected that seed production and distribution will play a key role as growers seek seed of new varieties to match with to future market requirements.
3. The project demonstrated that the crop modelling and satellite imagery technologies are useful tools to assess and enhance peanut productivity and quality in PNG and Australia. The public and private R&D agencies in PNG and Australia have acknowledged the benefits of the technologies and started applying the tools to enhance productivity of their crops/land use. It is recommended that the crop modelling and satellite imagery tools be further developed and applied to monitor and enhance productivity, profitability and sustainability of the previously envisaged cropping systems involving grain legume rotations.
4. The two market scoping studies implemented in the project suggested potential export opportunities of raw peanut kernel and oil for PNG and Hi-oleic peanut oil for Australia. While the potential for new market opportunities are being examined by the commercial players in PNG, the economic viability of the Hi-oleic peanut oil industry in Australia relies on sustained supply of product at processors level and growing peanut crops with minimal farm inputs to enhance profitability at growers' level. It is recommended that research be undertaken in

Australia to explore new varietal and management practices to produce peanut as an oil seed rotation crop in non-traditional cropping systems.

5. Given the high value of peanut in the local markets, declining "Buai" industry in Markham and demonstrated opportunity for significant yield benefits and favourable climate to grow peanut crop year round, there exist temptations of mono-cropping peanut, which can result in the build up of diseases which may lead to rapid yield decline over a period of time. Research done elsewhere has amply demonstrated the negative impacts of mono-cropping, for example sugarcane (Garside et al 1999, Garside and Bell 1999). In order to reduce economic impact of peanut mono-cropping, it is recommended that new research is initiated to integrate peanut as a profitable rotation crop (rather than a monocrop) to enhance cropping systems productivity as a whole and also achieve economic and environmental benefits.
6. While acknowledging the successful outcomes of the peanut project, PNG public and private sector agri-business agencies have recommended that there is a great need for a new research to explore potential of a range of high value tropical food legumes and develop BMPs for the candidate crops, to not only meet the growing demand for food, feed and fodder in farming communities but also enhance economic and environmental performance of private farm businesses as well as improve livelihoods of economically poor farming communities by generating to new income streams.

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Yi Jiang, Pauline E. Jolly, Peter Preko, Jia-ShengWang, William O. Ellis,Timothy D. Phillips and Jonathan H.Williams 2008. Aflatoxin-Related Immune Dysfunction in Health and in Human Immunodeficiency Virus Disease. Clinical and Developmental Immunology Volume 2008, Article ID 790309, 12 pages

11.2 List of publications produced by project

A total of 24 peer reviewed publications (6 Technical reports, 18 journal articles and conference papers) were produced in the project and six Journal articles are under preparation.

a. Technical reports -

Martin, Sandra. 2008 The PNG peanut industry: Domestic market segments and evaluation of alternative processing scenarios. Report to Ramu Agri-Industries, Gusap, Morobe Province PNG. (August 2008)

Cook D. 2008 Potential Peanut Oil Industry in Australia. Report for Productivity and marketing enhancement for peanuts in Papua New Guinea and Australia (project No. ASEM 2004/04l) produced by Peanut Company of Australia. (July 2008)

Rachaputi R.C.N. 2008. Productivity and marketing enhancement for peanut in Papua New Guinea and Australia. Project year 3 Annual report, Jun 2008-31 May 2009 (ACIAR project SMCN 2004/041)

Rachaputi R.C.N. 2008. Productivity and marketing enhancement for peanut in Papua New Guinea and Australia. Project Pre-final report for the External review, Feb 2009 (ACIAR project SMCN 2004/041

Rachaputi R.C.N. 2008. Productivity and marketing enhancement for peanut in Papua New Guinea and Australia. Project year 2 Annual report, Jan 2007-31 May 2008 (ACIAR project SMCN 2004/041)

Final Report: Productivity and marketing enhancement for peanut in Papua New Guinea and Australia

Rachaputi R.C.N. 2008. Productivity and marketing enhancement for peanut in Papua New Guinea and Australia. Project year 1 Annual report, Jan 2006-31 Dec 2006 (ACIAR project ASEM 2004/041)

b. Publications and Conference papers (Refereed)

Chauhan, Y.S., Wright, G.C., Holzworth, D., Rachaputi, R.C.N., and Payero, J.O. 2010. AQUAMAN – a web-based decision support system for irrigation scheduling in peanuts. Irrigation Science (in review).

Chauhan Y.S. 2010. Potential productivity and water requirements of maize–peanut rotationsin Australian semi-arid tropical environments—A crop simulation study. Agricultural Water Management 97; 457–464

Chauhan, Y.S., Wright, G.C., Rachaputi, Rao C.N., Holzworth, D., Broome, Alan, Krosch, S. and Robertson, M.J. 2010. Application of a model to assess aflatoxin risk in peanuts. Journal of Agricultural Science 148:1-11.

Rao C N. Rachaputi, Graeme C. Wright, Shyam N. Nigam, M. S. Basu, and Alan W. Cruickshank (2009) More Efficient Breeding of Drought Resistant Peanuts. p65, In Proc.3rd InterDrought Conference, 11-16, 2009, Shangai, China

AmosTopi. 2009. Socio-economic factors affecting the uptake of improved practices and varieties by peanut growers in Markham and EHP provinces. (M.Sc dissertation, UQ)

A.J. Robson., G.W. Wright., M.J. Bell., J. Medway., P. Hatfield., and R.C.N. Rachaputi. (2009). Practical remote sensing applications for the peanut, sugar cane and cotton farming systems. Poster abs. In Proc. of the 13th Annual Symposium on precision Agriculture in Australia. University of New England, Armidale, NSW. AUS. 10- 11th September 2009.

Chauhan Y.S., Rao.C.N. Rachaputi, and Wright, G.C. 2008. Climate change impacts on peanut quality in the sub-tropical Australia. Presented at the 5th International Crops Science Congress, 13-18 April, Jeju, Jeju Island, Korea 2008

Chauhan, Y.S., Rao.C.N. Rachaputi, Wright, G.C., Dharmaputra, O.S., and Rahmianna, A., 2008. Climatic risk of pre-harvest aflatoxin contamination to rainfed peanuts in Indonesia. In Proceedings of the 5th International Crops Science Congress, 13-18 April, Jeju, Jeju Island, Korea (Abstract).

Chauhan, Y.S., Rachaputi, Rao., Kuniata, Lastus., Ramakrishna, A. and Wright, Graeme. 2008. Assessing climatic risk of aflatoxin contamination to rainfed peanuts in Papua New Guinea. In Proceedings of the 5th International Crop Science Congress, 13-18 April, Jeju, Jeju Island, Korea. (Abstract)

Hughes,M., Rachaputi R.C.N., Kuniata L and Ramakrishna A. (2008) Growing peanuts in Papua New Guinea: a best management practice manual. ACIAR Monograph No 134, 77pp.

Saese H. 2008 "Studies on the impact of foliar diseases on the crop biomass and pod yields of peanuts in the lower Markham valley of Papua New Guinea". Poster for University of Goroka, Science and Technology Conference. 22-25 July 2008

Wright, G.C., Chauhan, Y.S., and Rao .C.N. Rachaputi. 2008. Climate Change Impacts on Aflatoxin Contamination in the Australian Peanut Crop. American Peanut Research and Education Society Conference. Jul 2008, Oklahoma, USA. (Abstract)

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Under preperation

Chauhan, Y.S. R.C.N. Rachaputi, Graeme C. Wright, A. Ramakrishna, Humphry Saese, and Lestus Kuniata (2010). Yield potential and risk of aflatoxin contamination to peanuts grown in Eastern Highland and Morobe Provinces of Papua New Guinea (under preparation)

Robson, A., Rachaputi, Rao, C.N. Lastus Kuniata and Humphrey Sasese (2010). The potential application of Satellite Imagery technology for remote sensing crop variability in food and tree crops and for monitoring pest and disease incursions in Papua New Guinea (PNG) (under preparation)

Humphrey Sase, Spencer Poloma, Juilie Kolopen and Geoff Fahey (2010). Effects of plant density on dry matter and pod yields of peanuts in the lower Markham valley. (Under preparation)

Rachaputi, Rao C.N., Ramakrishna, A., Humphrey Saese, Lastus Kuniata, Jhonny Wemin, and Spencer Poloma (2010). Best management practices to improve productivity and profitability of peanuts in the Eastern Highlands, Upper and Lower Markama valley regions of Papua New Guinea (PNG). (under preparation)

Lastus Kuniata and Johnny Wemin (2010). Foliar disease management of peanut in Upper Markham region of Papua New Guinea (under preparation)

Lastus Kuniata and Johnny Wemin (2010). Insect pest management of peanut in Upper Markham region of Papua New Guinea (under preparation)