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Final report

project

Poverty alleviation and food security through improving the sweetpotato-pig systems in Papua, Indonesia

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Contents

List of acronyms used in report

ACIAR – Australian Centre for International Agricultural Research, Canberra.

Balitkabi – Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbuan Malang (Research Institute for Legumes and Root Crops), Malang, Java, Indonesia (also ILETRI)

Balitnak – Balai Penelitian Ternak, (Research Institute for Livestock), Ciawi, Java, Indonesia

Balivet – Balai Penelitian Veteriner (Veterinary Research Institute), Bogor, Java, Indonesia.

BPTP – Balai Pengkajian Teknologi Pertanian Papua (Papua Assessment Institute for Agricultural Technology), Sentani, Papua, Indonesia

BPPH – Balai Penyidikan Penyakit Hewan (Disease Investigation Centre), Denpasar, Bali, Indonesia

CIP – International Potato Center, Lima, Peru

CIP-ESEAP – International Potato Centre – East South East Asia and Pacific

IAARD – Indonesian Agency for Agricultural Research and Development,

ILETRI – (Balitkabi) – Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbuan Malang (Research Institute for Legumes and Root Crops), Malang, Java, Indonesia

JLO – Jayawijaya Regency Livestock Office (Dinas Peternakan Kabupaten Jaywijaya, Wamena, Papua, Indonesia

KIPPK – Kantor Informasi Penyuluhan Pertanian dan Kehutanan (Information Office for Agricultural and Forestry Extension), Jayapura, Papua, Indonesia

SARDI – South Australian Research and Development Institute, a Division of Primary Industries and Resource South Australia (PIRSA) co-located on campuses of the University of Adelaide

Translations used in report

Dinas Peternakan – Department of Animal Husbandry

Dinas Peternakan Kabupaten Jayawijaya, Wamena – Jayawijaya Regency Livestock Office

Dinas Tanaman Pangan – Department of Crops and Vegetables (Agriculture)

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2 Executive summary

Food shortages and malnutrition and high levels of poverty are major problems in the mountain areas of Papua province where agriculture is dominated by sweetpotato cultivation and pig raising. Sweetpotato is the principal staple food for humans and main food for pigs. The overall objective of the project was the alleviation of poverty and the improvement of food security in the Papua province through increased production of consistently high yielding, nutritious crops of sweetpotato and improving pig production efficiency.

The project objectives, including those added as project variations in 2004 and 2006, were to:

- assess, characterise, and analyse the existing human-pig production
- improve sweetpotato production with emphasis on selection for dual-purpose and forage feed varieties
- enhance efficiency of pig growth by nutritional improvement and disease management
- improve the efficiency of indigenous, integrated, pig-raising systems
- obtain registration for the new clones of SP for both human and pigs
- build capacity of national programs and indigenous farmers through training programmes

Diagnostic studies to characterise sweetpotato cultivation and pig production were followed by several years of participatory action research. The project team was formed by the International Potato Center (CIP), South Australia Research and Development Institute (SARDI), Indonesian Legume and Tuber Root Institute (ILETRI, Balitnak), Balai Pengkajian Teknologi Pertanian Papua (BPTP) and Local Government Agencies (Dinas Peternakan and Dinas Tanaman Pangan) and increased by a group of participating farmers nominated by the Village Chief in selected villages. Farmers were involved in all planning and review processes.

Surveys showed that the importance of sweetpotato as human food was steadily declining, but its importance as a pig feed was increasing.

Three new clones of sweetpotato developed for human consumption were registered and named by the Indonesian President (Papua Solossa, Papua Pattipi and Papua Sawentar), and released in 2007. Two new clones and one local clone were also registered and released nationally for pig feed. Over 5000 F1 generation clones from Papuan parent stock are also stored at ILETRI for future research.

Improved sweetpotato-based diets for pigs were developed, including the use of pond snails which have potential in other pig production systems throughout Asia and the Pacific.

A modified pond fertilisation method was developed for fish production. The most important health problems detected in pigs were internal parasitism, ingestion of toxic plants and the presence of three important zoonotic diseases: which are transmitted to humans via eating under cooked pork.

Project and regional scientists received training within Indonesia and pig production training and visits were provided to most participating farmers. Training materials were developed and translated into Huburi (the Dani language), Bahasa Indonesia and English.

The project recommends that farmers require better access to more reliable markets for both sweetpotato and pigs; further research on pig-associated human infections is warranted; improved control programs for Classical Swine Fever and related infections

are required and that both government and non-government extension and training efforts need ongoing financial support.

3 Background

Food shortages and malnutrition were identified as major problems in Papua Province Indonesia, especially in the mountain areas, such as the Baliem Valley. The dominant agricultural activities of farmers in these regions are cultivation of sweetpotatoes and production of pigs. Sweetpotato (SP) is the principal staple food for humans and is also the main food source for pigs. Significant quantities were grown for both purposes. Pigs outnumbered all other livestock species by more than 30 to 1 and appeared to generate the major part of the small farm incomes. Pigs are also an integral part of the culture as well as the cultural-political organisations among many Papuan tribes. They are also extremely important for ceremonial and social activities.

The high levels of poverty recorded in the highlands of Papua Province, plus the dependence on the sweetpotato-pig system, were the main justifications for the development of this project in the Baliem Valley.

While sweetpotato is the main food for both people and pigs, it contributes only marginally to farm income. Sweetpotato varieties grown for human consumption can be sold in local markets, but sweetpotato grown for pigs has no market. In contrast, pork can be a significant protein source for people, and is often a widely traded commodity. As cash incomes become increasingly important in the local economy, with the encroachment of regional and national markets, pigs offered a good opportunity for income generation and pork production was considered as an important key to reducing poverty levels. However, although much had been written about pig production on the island of New Guinea, productivity has remained low and inefficient.

Prior to commencing the project, anecdotal evidence indicated several problems existed with the current SP-pig systems. These included low fertility rates and slow animal growth rates and these problems needed to be identified and defined before pig farming could become a sustainable source of farm income. Anecdotally, the main causes for the low productivity included diets low in nutrients, irregular feeding of pigs, sub-optimal husbandry and housing, poor management systems and parasitism.

After completing a scoping exercise in April/May1999, this region (the central highlands of Papua Province) was identified as the most appropriate site for a research project to improve the sweetpotato-pig system as a means to improve human nutrition, pig production efficiency and income generation.

In 2001, ACIAR[1] approved and funded a project that was developed by IAARD, CIP and SARDI and centred in the Jayawijaya District of Papua Province, Indonesia. The project commenced with diagnostic studies designed to characterise the production systems and this was followed by several years of participatory action research, once the data collected from a diagnostic study had been analysed. The research included the development and selection of new varieties of sweetpotato and improved pig-raising management techniques.

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[1] *IAARD is the Indonesian Agency for Agricultural Research and Development, CIP is the International Potato Center, SARDI is the South Australian Research and Development Institute based as the University of Adelaide, and ACIAR is the Australian Center for International Agricultural Research. The principal IAARD institutes involved in the project are the Balai Penelitian Tanaman Kacang-kacangan dan Umbi-umbuan (Balitkabi), Malang; Balai Penelitian Ternak (Balitnak), Bogor; Balai Penelitian Veteriner (Balitvet), Bogor; Balai Pengkajian Teknologi Pertanian Papua (BPTP Papua), Sentani; Balai Penyidikan Penyakit Hewan (Disease Investigation Centre), Denpasar; and Faculty Veterinary Science, Udayana University, Denpasar, Bali; as well as the Dinas Peternakan Kabupaten Jayawijaya, Wamena.*

4 Objectives

The overall objective of the project was the alleviation of poverty and the improvement of food security in Papua Indonesia and Vietnam through the introduction and adaption of technologies that produce consistently high yielding, nutritious crops of sweetpotato, satisfying household consumption, human and pig nutrition in Indonesia and Vietnam and improving pig production efficiency in Papua Indonesia. However, activities ended in Vietnam at the completion of the first 3 year phase.

The initial aim of the project was to study and characterise the existing human-sweetpotato-pig production system within the overall household economy, in order to understand the major constraints. Using a participatory research methodology, the major research objectives were:

- To assess, characterise, and analyse the existing human-pig production systems in Papua within the overall household economy in order to understand the various types of systems, their relative importance, and their major constraints.
- To improve sweetpotato production and stable food and feed supply with emphasis on selection for dual-purpose and forage feed varieties, drought and frost resisting varieties for pig feed in Papua and Vietnam, and vitamin–A rich varieties for humans in Papua.
- To enhance productivity and efficiency of pig growth by nutritional improvement with locally appropriate technology and disease management using various levels of confinement, which are acceptable to the local farmers in the Baliem Valley of Papua Province.
- To improve the efficiency of indigenous, integrated, pig-raising systems oriented to subsistence farming in Papua.

The project was extended in 2004 and the modified objectives for the second phase were:

- To obtain registration for the new clones of SP developed in the initial phase of the project for both human and pigs, by providing data to meet Indonesian requirements for registration and release within Indonesia.
- To enhance productivity and efficiency of pig growth by nutritional improvement with appropriate technology acceptable to the local farmers in Papua.
- To strengthen an indigenous, integrated, pig-raising system appropriate for subsistence agriculture in Papua with a view to enhancing the productivity and efficiency of pig production through the development of a laleken based foraging system for pigs
- To enhance the productivity and efficiency of pig production in the Baliem Valley by improving the management and nutrition of sows and boars.
- Capacity building of national programs and indigenous farmers in Papua through developing training programmes for Government Scientists and Extension Officers (JLO, BPTP, KIPPK), project staff and farmers directly (Train the Trainer) and through developing farmer groups (farmer-to-farmer extension) in using and preparing modified pig diets and production systems presented as packages to local communities

The projected was extended again in 2006 and the modified objectives for this final phase were:

- To improve food security through the introduction and adoption of technologies producing consistently high yielding nutritious crops of sweetpotato through the provision of disease-free planting material.

- To increase productivity and efficiency in pig growth through providing farmers with a range of alternative diets of varying cost and productivity. .
- To strengthen the SP-pig production system in indigenous communities in Papua through farmer-to-farmer training programs.

5 Methodology

A participatory approach was used throughout the project to ensure that farmers were involved in all facets of development and decision making.

Initially selected Dani villages were invited to participate in the project and the farmers nominated by the Village Chief were included in the planning process and paid for their time and labour, provided they followed agreed procedures. As the research activities commenced to produce results other villages requested to join the project. Regular visits were made to each project site by the Dani project staff 2 to 3 times/week and by the project team 3 to 6 times/year. Farmers participated in all project team review and planning meetings where farmers and project staff presented results to other farmers. This enabled farmers to question each other and the project team. Because different farmers were involved in different experiments, an annual visit was made to all project sites by the full project team and the participating farmers and their wives. This enabled all farmers to again knowledge and understanding of all facets of the project activities.

Socio-economic diagnostic survey:

The initial step was to complete a socio-economic diagnostic survey to provide data on a wide range of social and economic issues affecting residents of the Baliem Valley. The data included information on sweetpotato cultivation from harvest to sale or consumption, pig production, management, husbandry and marketing or slaughter, and a range of socio-economic and cultural activities that impacted on the overall household economy. This enabled identification of the major constraints to cropping and animal production. .

Disease survey and observational survey:

A survey of pig disease and health problems was undertaken by collecting 39 pigs of varying size and body condition from 10 villages, examining them post-mortem and collecting blood and tissue for further analysis. A total of 39 pigs were examined. An observational survey was also conducted in 5 villages to determine a baseline for growth rates and mortalities for pigs fed traditional diets. Six pigs weighing 10 to 15 kg were tagged in each village and three were treated monthly with an anthelmintic to remove internal parasites. All 6 pigs were weighed monthly for 4 months.

Development of new clones of sweetpotato:

A series of sweetpotato cultivars were selected and new clones developed and analysed for dry matter content and starch (energy) in roots, and higher protein content in leaves. The most promising clones were then trialled at several locations in the Baliem Valley, at varying altitudes (1500 to 2200 metres), for quantity and quality of yield of roots and vines, as well as performance in the dry and wet seasons. Roots and vines were collected at harvest and analysed for carbohydrate, protein and dry matter content.

Development of pig diets:

Initially a diet for pigs based on sweetpotato was designed and compared with the traditional feeding method used by most farmers as defined by the diagnostic survey. This diet was used as the base line for a series of other diets designed using locally available ingredients with increased levels of protein. The feeding experiments were conducted in two villages (Pisugi and Tulem) using facilities built for this purpose. These facilities enabled two groups of 5 to 8 pigs to be housed and fed, either individually or in groups, for periods of up to 5 months. Pigs were fed approximately 10% of their body weight on a daily basis and feed intake was monitored daily. They were weighed monthly and feed intake adjusted accordingly. Pigs were also medicated at regular intervals to eliminate parasites.

Source of pigs:

Pigs were obtained from the farmers in the village, examined by the JLO veterinarian, weighed and matched into pairs according to weight and sex. One of each pair was then randomly assigned to each group. Pigs were treated for parasites, using an anthelmintic, and injected with long acting oxytetracycline (a broad spectrum antibiotic) to eliminate infection. Pigs were placed in the facilities and fed either a test or control diet for a 2-week period of acclimatisation. Pigs were weighed again at the end the acclimatisation period (start weight) and then monthly until the end of the experiment 3 to 5 months later. Faecal samples were collected and examined for parasite eggs at the beginning and the end of each experiment and all pigs that developed clinical signs (became sick), or died, were examined by the JLO Veterinarian.

NOTE: Because the length of experiments varied from 3 to 5 months, and the weights and ages of pigs used in different experiments also varied, it was not possible to make comparisons in pig growth rates between experiments.

Improving fish production:

Two different pond fertilisation methods designed to increase fish production as a source of protein for pigs were designed. Treatment 1 consisted of 8 kg dried pig dung added once before the trial with 12 kg SP-vines (additional green feed) added every 10 days. Treatment 2 consisted of 8 kg dried pig dung added once before the trial with an additional 4 kg dried pig dung added every 10 days. Ponds were seeded with equal numbers of fingerlings and mature fish harvested and weighed at the end of the trial (8 weeks) and mortality rates calculated.

Modifying pig husbandry:

As a result of a farmer-project team discussion meeting, it was discovered that small enclosures called lalekens had been used traditionally by the Dani to confine pigs, thus limiting environmental damage and access to toxic plants and crops. However they were not planted with crops or grasses and they allowed pigs to have access to dog and human faeces. In the current traditional management system pigs were confined at night in houses and free-ranged during the day. However, in the morning and evening the pigs shared the family compound with dogs and children creating a high risk for cross infection with zoonotic parasites. Planning meetings with famers resulted in a decision to reintroduce lalekens as part of a modified management system that would enable farmers to supplement pig diets with high protein pasture, as well as reduce the pig's access to toxic plants and human and dog faeces. A number of species of grasses growing in the Baliem Valley were analysed and based on the results, three locally grown species, Sundaleka (Puerasia cephaloides; 17% crude protein), Wurikaka Baru (Centrosema sp15% crude protein) and Jirikpuruk (Calopogonium sp; 11% protein) were selected for further investigation. Similarly a number of tree species whose leaves could be used as a source of protein were also analysed. The two selected for further investigation were Dadap (Erythrina variegate; 29% crude protein)) and Gamal (Gliricidia sepium). The trees also had the advantage that they could be used for “live fences” around the lalekens. Experiments were designed to assess and validate the nutritional improvements to be gained by supplementing pig diets with high protein pastures and the foliage from fodder trees. A further modification was the incorporation of special “dunging areas” into the laleken management system to improve the control of internal parasites. Native pigs were observed to seldom dung inside their pen when housed overnight, with the majority of defecation occurring when they are first released each morning. It was hypothesised that by covering the “dunging area” with rocks, or a raised slatted platform to separate pigs from their faeces, exposure to parasite eggs contained in the faeces would be reduced and reinfection delayed. Experiments were designed to test this hypothesis and assess the potential of dunging areas for improved parasite control. The time required for pastures to regenerate following foraging, as well as the most productive rotational

programme, were also assessed and validated in a series of experiments where pigs were moved at varying times after access to forage crops.

Sow productivity:

Data collected in the initial diagnostic survey indicated that sows farrowed approximately once every 18 months and that litter size was small. Initially a survey was designed to assess sow fertility and productivity by recording individual sow productivity over a 2-year period. Fifteen sows in 7 villages were identified, examined every 3 months and the following data recorded: number of litters born/sow; pigs born/litter; and litters weaned within 3 months of farrowing. The data were used to calculate litters/sow/year and percentage of sows farrowing more than once per year.

Sow boar management to improve productivity:

Data from the diagnostic survey also confirmed that sows bred infrequently and few entire males were kept by farmers, Hence an experiment was designed to assess the value of boar contact post-weaning on sow productivity. Two sites for housing weaned sows were built in the village of Napua. One site (site 1) consisted of one small pig house with 2 pens, both connected to separate lalekens for daytime foraging. A small house, with only one pen connected to a laleken, was constructed 50 metres away behind a high mound. A boar was housed permanently at site 1 but not at site 2. Every sow that was weaned in the village was housed either at site 1 or site 2 and the date sows arrived at the site, the date sows were mated or remated (if it occurred), the date of departure, the date sows farrowed and the number of pigs born recorded.

Introduction and adoption of technologies producing consistently high yielding crops of sweetpotato:

A workshop was convened and a survey designed to collect data to identify the strengths and weaknesses of the seed supply systems, methods of seed selection, propagation, maintenance, and access to varieties. The way SP production/seed systems relate to the overall agricultural livelihoods of the farmers in the agro-ecological conditions in the Baliem Valley was also identified. This was followed by the introduction of new technology to provide clean disease free planting material. To avoid virus re-infection, initial multiplication of mother plants was carried out in protected environments and the planting material was transplanted and multiplied in screen houses to produce healthy mother plants for further seed multiplication. Different types of screen houses using local materials were constructed and compared to evaluate cost and efficiency. The planting material was obtained from healthy and vigorous mother plants free of pest and disease symptoms with high yields following the process of Positive Selection (PS). On-farm trial sites were then selected to compare the foliage and root yields obtained with PS planting material seed and non PS planting material of the same variety collected using prevailing farming practices (FS). The degeneration (virus re-infection) rate of PS planting material was also monitored.

Strengthening the SP-pig production system in indigenous communities in Papua:

Economic assessment of potential and cost-benefit ratios for modified diets

Data, already generated from earlier trials, was used to assess diets according to the cost of ingredients and production, and their potential in terms of pig production outcomes. This would enable farmers to make decisions based on the cost of diets and the potential outcome when pigs were fed the diet.

Capacity building through farmer-to-farmer training programs

Farmers already trained in the key facets of pig and sweetpotato production were selected as Trainers and received further training (Train-the-Trainer) to assist them in training other farmers. A training program was then designed and initiated to train farmers in villages

that have had no direct contact with the project to date, as well as other farmers in villages with previous contact. World Vision was also recruited to include villages where they have existing projects and established farmer networks. A set of training materials was published in English, Bahasa Indonesia and Huburi (the language spoken by the Dani). Outcomes generated during the first 5 years of the project were also presented at the BPTP National Seminar Series.

6 Achievements against activities and outputs/milestones

Phase 1 - Objective 1: To assess, characterise, and analyse the existing human-pig-pig production systems in Papua within the overall household economy in order to understand the various types of systems, their relative importance, and their major constraints.

no.	Activity	outputs/ milestones	completion date	comments
1.1.1	Diagnostic survey	Data collection completed	October 2001	
1.1.2	Data analysis	Data analysis completed	April 2002	The importance of SP is decreasing for humans but increasing for pigs. Over 600 varieties identified but farmers only planted 18 cultivars/plot on average. Root yields were 9.00.t/ha and vine yields were 7.5 t/ha. The cultivation period averaged 28.5 months. Pigs produced in the traditional system grew at 18g/day, with 40% mortality over 4 months.
1.1.3	Observational pig production and reproduction survey	Survey completed and data analysed	June 2002	Sows farrowed once every 12 to 18 months, with 5 pigs/litter; 0.7 litters/year; 48% pre-weaning mortality.
1.1.4	Disease survey	Survey completed and data analysed	August 2002	Key restraints for sweetpotato and pig production identified

PC = partner country, A = Australia

Phase 1 - Objective 2: To improve sweetpotato production and increase stable food and feed supply with emphasis on selection for dual-purpose and forage feed varieties, drought and frost resistant varieties for pig feed in Papua and Vietnam, and vitamin–A rich varieties for humans in Papua

no.	Activity	outputs/ milestones	Completion date	Comments
1.2.1	Review of SP varieties grown in Baliem Valley	Most common varieties identified	November 2001	
1.2.2	Development of new clones	New cultivars developed	September 2002	Over 5000 F1 generation clones from Papuan parent stock held at ILETRI.
1.2.3	Evaluation of new clones	Field trials to evaluate new clones commenced	October 2002	
1.2.4	Evaluation of new clones and comparison with most popular local varieties	Field trials to evaluate new clones completed	December 2004	Three new clones developed for human consumption and two new clones and a local clone selected for pigs.

PC = partner country, A = Australia

Phase 1 - Objective 3: To enhance productivity and efficiency of pig growth by nutritional improvement with locally appropriate technology and disease management using various levels of confinement, which are acceptable to the local farmers in the Baliem Valley of Papua Province.

no.	Activity	outputs/ milestones	completion date	Comments
1.3.1	Asses the value of regular feeding and cooking SP to improve pig growth	Cooking SP and regular feeding assessed validated	March 2002	Regular feeding and increased intake (10% body weight) resulted in significantly improved growth rates in pigs.
1.3.2	Develop and evaluate modified diets based on cooked SP (Wamena # 1) and evaluate	Wamena # 1 diet evaluated	July 2002	Cooking destroyed anti-nutritional factors in SP resulting in improved growth rates.
1.3.3	Develop and evaluate modified diets based on ensiled SP (Wamena # 2)	Wamena # 2 diet evaluated	December 2002	Ensilaging also appeared to destroy anti-nutritional factors in SP roots and improve digestibility and growth rates.
1.3.4	Feeding trials to compare Wamena #1 and #2 with raw and ensiled SP diet (Wamena # 3)	Wamena # 3 diet evaluated	July 2003	Diets consisting of a combination of raw roots and vines and ensilaged material were found to have a potential of approximately 50 to 70% of cooked diets.
1.3.5	Formulate diets based on Wamena #2 supplemented with corn, rice bran and tofu waste	Modified diets (Wamena #4, #5 and #7) evaluated	February 2004	Diets supplemented with corn, tofu waste and rice bran found not to be sustainable because of lack of supply in Baliem Valley. The commodities would need to be imported of the production base expanded.
1.3.6	Evaluation of traditional fish production	Fish production documented	February 2004	Traditional fish production in ponds was documented and reviewed by scientists at SARDI Aquatic Sciences Division

PC = partner country, A = Australia

Phase 1 - Objective 4: To improve the efficiency of indigenous integrated pig-raising systems oriented to subsistence farming in Papua.

.no.	Activity	outputs/ milestones	completion date	Comments
1.4.1	Review Dani pig husbandry methods	Use of lalekens reviewed and evaluated and modified model designed for evaluation	December 2003	

PC = partner country, A = Australia

Phase 2 - Objective 1: To obtain registration for the new clones of SP developed in the initial phase of the project for both human and pigs, by providing data to meet Indonesian requirements for registration and release within Indonesia.

No	Activity	outputs/ milestones	completion date	comments
2.1.1	Registration of SP clones for human consumption	3 new clones named, registered and released late 2007.	July 2006	Clone: MSU 99051-1– named Papua Solassa (after a previous Governor) Clone: BB 97089-12 – named Papua Patipi Clone: BB97256-9 – named Papua Sawentar

1.2	Registration of SP clones for pig consumption	3 new clones identified and one clone developed locally in Baliem Valley	July 2006	Clones were registered and released in mid 2008

PC = partner country, A = Australia

Phase 1 - Objective 2: To enhance productivity and efficiency of pig growth by nutritional improvement with appropriate technology acceptable to the local farmers in Papua.

No.	Activity	outputs/ milestones	completion date	Comments
2.2.1	Evaluate diets supplemented fish offal (Wamena #6)	Wamena #6 diet evaluated	July 2005	Pigs fed diets supplemented with fish offal grew from 250 to 300 g/day, up to 10 times the baseline figure for village pigs.
2.2.2	Evaluate pond fertilisation in improving fish production	Pond fertilisation evaluated in terms of fish production	December 2005	Fertilising ponds with dried pig dung and green leaf material increased production by more than 200%.
2.2.3	Evaluate diets supplemented with golden snails (Wamena #9)	Wamena #9 diet evaluated	July 2006	5 of the new diets developed proved to be sustainable and increased growth rates in parasite free pigs from 120 to 300g/day.

PC = partner country, A = Australia

Phase 2 - Objective 2: To strengthen an indigenous integrated pig-raising system appropriate for subsistence agriculture in Papua with a view to enhancing the productivity and efficiency of pig production through the development of a laleken based foraging system for pigs

No.	Activity	outputs/ milestones	completion date	Comments
2.3.1	Evaluate protein and amino acid profiles of selected pasture grasses available in Baliem Valley	Protein values and amino acid profiles determined	December 2004	Only limited amino acid analysis was available but both lysine and methionine were included.
2.3.2	Design and build small laleken model	3 small laleken models designed and built	July 2004	
2.3.3	Evaluate pig management and production in small laleken models	Pig growth and mortality evaluated in 3 small laleken models	December 2005	Pigs given access to pasture in small lalekens grew 80% faster than confined pig without pasture access.
2.3.4	Design large laleken model	2 large laleken models designed and built	December 2004	
2.3.5	Design pig housing models based on core principals for pig housing	Models designed and prototypes built	December 2005	Farmers were quite positive about the housing models developed and several volunteered to erect them for trials.
2.3.6	Evaluate pig management and production in large laleken models	Pig growth and mortality evaluated in 2 large laleken models	March 2006	Pigs given access to pasture in large lalekens grew around 80% faster than confined pig without pasture access.

2.3.7	Evaluate pig housing models for temperature control	Housing models evaluated for temperature control	July 2006	The housing model with a thatched grass roof provided a more even temperature over 24 hours. It was cooler during the day and warmer over night.
2.3.8	Develop sustainable method for generating fodder tree stocks from cuttings	Fodder tree cuttings successfully propagated	September 2006	Several groves of fodder trees were established to provide cuttings for farmers wishing the erect live fences.
2.3.9	Review and validate laleken and pig management	Final evaluation of laleken pig management system completed	March 2007	Lalekens demonstrated to be sustainable and valuable aid to pig management to improve production and health.

PC = partner country, A = Australia

Phase 2 - Objective 3: To enhance the productivity and efficiency of pig production in the Baliem Valley by improving the management and nutrition of sows and boars.

No.	Activity	outputs/ milestones	completion date	Comments
2.3.1	Review sow productivity	Sow productivity reviewed and constraints identified	December 2003	
2.3.2	Design sow-boar housing and management systems to improve sow productivity	Sow-boar housing and management system designed and validated	June 2004	
2.3.3	Evaluate sow-boar housing management system	Sow-boar management system evaluated and validated	July 2005	Sows managed in this system farrowed 2 more pigs per farrowing and farrowed 1.5 times per year compared with less than once/year for control sows.

PC = partner country, A = Australia

Phase 2 - Objective 4: Capacity building of national programs and indigenous farmers in Papua through developing training programmes for Government Scientists and Extension Officers (JLO, BPTP, KIPPK), project staff and farmers directly (Train the Trainer) and through developing farmer groups (farmer-to-farmer extension) in using and preparing modified pig diets and production systems presented as packages to local communities.

No.	Activity	outputs/ milestones	completion date	comments
9.1	Create opportunities for project team staff training	All staff allocated at least one training opportunity annually	December 2003 December 2006 December 2008	
8.2	Design and provide training opportunities for participating farmers	70% participating farmers provided with training opportunities outside of Papua Province	December 2003 December 2006 December 2008	
8.3	On-going training for participating farmers in all aspects of project activities	Farmer trainer program developed and executed annually	December 2003 December 2006 December 2008	Farmers invited to all project team review meetings (2 to 3 annually) and a yearly tour of all project sites.

PC = partner country, A = Australia

Phase 3 - Objective 1: To improve food security through the introduction and adoption of technologies producing consistently high yielding, nutritious crops of sweetpotato.

No.	activity	outputs/ milestones	completion date	comments
3.1.1	Survey famers in 10 representative villages (5 from uplands and 5 from valley floor) on SP selection and cultivation	Baseline data for sweetpotato seed system, and sweetpotato cultivation practice collected	July-August 2007	
3.1.2	Analyse survey data	The way farmers manage SP planting material documented	November 2007	Farmers obtained planting material from vines grown on both new and old land and from disease free 5 month old plants. Planting material was only purchased to obtain new varieties. Women did the planting.
3.1.3	Trial comparing two seed sources of Sweetpotato; positive selection (PS) and farmer practice (FS)	Sweetpotato production from each method assessed and compared	August 2008	
3.1.4	Prepare manual of the positive selection process for planting material	Manual prepared	March 2008	Farmers able to conduct an assessment of crops and selection of planting material
3.1.5	Prepared manual of rapid multiplication technique for sweetpotato cultivation	Manual prepared	March 2008	Farmers were able to prepare sweetpotato planting material in large quantities rapidly.

PC = Partner Country, A = Australia

Phase 3 - Objective 2: To increase productivity and efficiency in pig growth.

No.	Activity	outputs/ milestones	completion date	Comments
3.2.1	Estimate the potential outcome and cost of each diet validated	The 6 sustainable diets formulated costed and ranked in terms of growth rate potential	31 December 2007	The highest ranked diets, which are based on ensilaged sweetpotato roots and high protein pasture, with or without supplementation with golden snails were demonstrated to be cost effective and increased growth rates from 40g/day to 200 to 300 g/day

PC = Partner Country, A = Australia

Phase 3 - Objective 3: To strengthen the SP-pig production system in indigenous communities in Papua.

no	Activity	outputs/ milestones	completion date	Comments
3.3.1	Production of materials for farmer-to-farmer training programs	Materials written, reviewed and translated into Bahasa Indonesia and 100 copies printed	March 2008	The training materials will form the basis of a training document that can be adapted and used in other parts of eastern Indonesia.
3.3.2	Train selected project farmer collaborators as trainers for a farmer-to-farmer training program.	Farmer training programs conducted with all of the project farmer collaborators and a group of *Farmer Trainers* selected	December 2007	100% of the project farmer collaborators actively participated in the training program and provided useful feedback on the materials and training methods.

3.3.3	Select villages and farmers from those villages to participate in farmer-to-farmer training program.	Farmer-to-farmer training programs completed in selected villages	Continuing until October 2008	Farmers were selected from 7 key villages for training in the project outcomes and methodology. Selection was made with assistance from the Director of the Baliem Valley Co-operative Farmer Groups (KTNA), the Head of the Regency Livestock Office, and the Leader of World Vision Indonesia Papua. The training program ran over 3 days with a one day field trip and practical session demonstrating silage making, processing SP, and cultivating tree cuttings.

PC = Partner Country, A = Australia

7 Key results and discussion

Socio-economic diagnostic survey

Key results included:

- SP as human food is steadily declining, but its significance as pig feed is increasing.
- Sweetpotato selection should focus on varieties that are specifically targeted for pig feed.
- The number of SP plots varied between villages, with farmers in the upland areas having fewer and smaller plots than farmers on the valley floor. A high proportion of plots are located far away from the family compound or sili, which adds to the human input in SP production.
- While more than 600 varieties have been found in Papua Province, Musan and Tamue appear to be the only short-season varieties and Helaleke and Hupuk are the only long-season varieties consistently planted. On average farmers planted 18 cultivars/plot.
- Root yields in the valley floor averaged 9.58 t/ha compared with 8.3 t/ha in the uplands. Vine yields were 8. and 6.8 t/ha respectively.
- The cultivation period, including fallow period, varied from 27.7 on the valley floor to 30 months in the uplands.
- Growth rates for pigs in the traditional system ranged from 18g/day, with a mortality of 40% over 4 months in untreated pigs to 48g/day, with a 10% mortality in pigs treated regularly for internal parasites.
- Survey data indicated that on average sows farrowed every 2.5 years and pigs took 2.5 to 3 years to reach a mature weight. However, the data from the observational trial over a 2-year period indicated that although sows farrowed approximately once every 12 to 18 months, production was limited by small litter size and piglet mortality (5 pigs/litter; 0.7 litters/year; 48% pre-weaning mortality).
- The basic diet consisted of uncooked sweetpotato roots supplemented with vines. Supplementation with vegetables was irregular and unplanned. Pigs were generally fed daily but the amount provided was only 5 to 8% body weight. Pigs require approximately 10% per day.

Developing and breeding new varieties of Sweetpotato

Three new clones of SP developed for human consumption were registered and named by the Indonesian President (Papua Solossa, Papua Pattipi and Papua Sawentar). They have subsequently been released for use by Indonesian farmers in 2007.

An unexpected outcome was a Government decision to use of the new varieties to solve a food shortage problem resulting in malnutrition and death that occurred during 2006 in the neighbouring regency of Yahukima. The acute food shortage was caused by high rainfall, pests and poor tuber production. Dr Jusuf took the team investigating the problem to visit one of the our multiplication and demonstration trials at Holima and were impressed with the size of tubers and vines and the overall production. Material was taken from the trials and planted in demonstration plots in 17 locations in Yahukima and two high school graduates were selected for each site and trained in the theory and practice of SP crop production by Dr Jusuf. As a result, food drops to villages in Yahukima ceased the following April because food supplies were deemed sufficient.

Two improved clones developed for pigs were also registered and released nationally. A local variety, Musan, was also identified as being equal in energy and protein content, with high dry matter content. These three varieties are being promoted for use in pig diets.

A large amount of breeding material has also been accumulated from the project. This includes 40 clones in Wamena and over 5000 F1 generation clones from Papuan parent stock held in Malang. A selection of these will be screened for nutritional and physical traits required for processing, as part of a new project (AH/2007/106) to commence in 2009.

Providing clean planting material

Baseline survey

Data from the baseline survey conducted in 2007 indicated that farmers obtained planting material from vines growing on both new and old land, and in some cases purchased planting material if they wanted to plant new varieties. Farmers tended to select sweetpotato planting material from plants which were free from pest and diseases, which had large sized stems and fresh, healthy leaves. Most farmers used planting material from 5 months old crops, while only a small number of farmers used planting material from crops that were more than 5 months old. Planting material was collected by women and apical cuttings (around 40cm in length) were generally used and stored for three to four days prior to planting. Farmers in the upland areas planted sweetpotato in a slanting or horizontal position, whereas farmers on the valley floor planted it in an upright position. This was in accordance with soil texture in the two environments. None of the farmers in the villages surveyed prepared special land for a multiplication plot or renewed planting material with tubers, because planting material is always available. The same plant was used as a source of planting material for several growing season. Hence the need for planting material was not a constraint in the agribusiness system surveyed.

Comparison of Positive Selection PS and Farmer Selection FS

Although, the average yield for all varieties with PS material was 10.3% higher than from FS material (26.0 t/ha compared with 23.3 t/ha) the difference was not significant. There was also no significant difference either in the level of infection, or the storage of root yield. The mixed result was due to the unusual dry conditions during the first two months of the growing period, which increased the amount of replanting required. Also many cuttings from PS mother plants grew poorly in the nethouse, resulting in a shortage of cuttings.

However with Cangkuang, which gave the highest yield and was the earliest maturing variety, there was a significant yield difference between PS and FS material at all sites except two (Molima and Megapura). Major differences were also obtained with Musan.

In the second trial conducted, the average root yield from PS planting material was relatively higher for all varieties. Yields from PS material averaged 23.3 t/ha compared with 17.3 t/ha for the FS planting material, an increase of 25%. Cangkuang was again the highest yielding variety with 39.3 t/h for PS material compared with 26.3 t/ha for FS material at the same site. Average root yields were also higher from trial sites in the valley floor (23.3 t/ha) than upland sites (17.3 t/ha). While a mild form of scab disease was observed on leaves and stems of two varieties (Helaleke and Cangkuang), no roots were attacked by pests and diseases. Cangkuang produced 4 tubers/ plant, Musan produced 3 tubers/plant, and Helaleke 1 tuber/ but tubers from Cangkuang were irregular in shape and part of its skin surface was also cracked. By contrast Helaleke produced long and elliptic tubers with smooth skin, while Musan tubers were also long and elliptic in shape, but often had a cracked skin surface. Musan and Cangkuang were earlier maturing varieties (4-5 months) in both the valley and slopes while Helaleke matured later (>7months).

Positive selection was proven to be beneficial in this environment, producing superior planting material, with increased yields even in the relatively low disease environment of the Baliem Valley.

Development and modification of pig diets

Regular feeding and increasing the amount fed to10% of the pig's body weight improved growth rates dramatically. Pigs fed raw SP roots and vines twice daily grew approximately three times as fast as pigs sampled in the village survey, confirming that increasing feed intake and feeding pigs on a regular basis improve production significantly. Adding banana trunks improved growth rates marginally but increased mineral intake significantly.

Cooking sweetpotato roots and vines prior to feeding increased growth rates above that achieved with raw material ($P<0.05$). This was assumed to be due to cooking destroying antitrypsinases present in SP roots.

Ensilaging roots and vines was also found to improve growth rates and produced similar results to cooked diets. Older larger pigs fed cooked roots and vines supplemented with ensilaged SP roots and vines, grew at similar rates to pigs fed diets of cooked roots and vines. However smaller pigs (<15kg) fed ensilaged material tended to grow more slowly that pigs fed only cooked material. Pigs fed the silage material grew approximately 14% slower than small pigs fed only cooked diets. Based on these data it was recommended that pigs be fed only cooked material until they reach 15 to 20 kg liveweight when they can be changed onto diets containing ensilaged material. Pigs fed a diet containing ensilaged material, with cooked SP roots and vines 4 days/week and uncooked 3 days/week SP roots and vines, grew at similar rates to pigs fed diets where SP roots and vines were cooked daily indicating that cooking and the use of firewood could be further reduced by feeding ensilaged material. Farmers also liked using silage because they could produce enough feed over a 3-day period to last several months, whereas cooked diets had to be prepared daily.

Pigs fed diets supplemented with fish offal or snails as a source of animal protein grew significantly faster than pigs fed diets supplemented with either tofu waste or rice bran. In fact, growth rates in pigs supplemented with fish offal were approximately 10 times greater than growth rates recorded for pigs in the initial village survey, confirming the value of using fish products to supplement diets of village pigs. Healthy pigs fed these diets could be expected to grow around 250 to 300 g/day. Neither tofu waste or rice bran proved to be sustainable as supplies would need to be imported into the valley. Snails proved more sustainable than fish offal and are readily produced in small ponds and easily harvested.

Fish production was increased by 200 to 230% by modifying pond fertilisation by adding dried pig dung to ponds before seeding them with fingerlings and fertilising them with either dried pig dung or green leaf material regularly throughout the growing period. However, fish production was only viable in areas of the valley close to rivers with access to running water 12 months of the year.

Table 1: List of sustainable diets developed and validated for pigs and the expected growth rate in healthy pigs

Diet	Ingredients	Growth rate (g/day)
Wamena #1	56% cooked SP-vines + 33% cooked SP roots + 11% cooked banana trunk + 0.5% salt	160 – 220
Wamena #2	33% cooked SP-vines + 22% cooked SP roots + 34% ensilaged SP tubers and vines + 11% cooked banana trunk.	160 – 220
Wamena #3	33% raw SP-vines + 22% raw SP roots + 34% ensilaged SP-tubers and vines + 11% raw banana trunk.	120 – 170
Wamena #6	50% cooked SP roots + 30% cooked SP-vines + 20% cooked fish internal organs (gill etc).	250 – 300
Wamena #9	Wamena # 2 + 5 kg golden snails	230 – 280

The most sustainable and productive diets were Wamena #9, #2, #3, and #6.

Various combinations of ensilaged material were also being tested and validated. These included:

Silage A: 85% SP roots + 15% SP vines + 0.5 kg salt fermented for 14 days Silage B: 85% SP roots + 15% sundeleka grass + 0.5% salt fermented for 14 days Silage C: 85% SP roots + 15% dadap leaves + 0.5% salt fermented for 14 days

Four other diets, which proved to be unsustainable, either because drying of ingredients was impractical, or supply of ingredients could not be sustained, were also developed (Table 2).

Table 2: List of sustainable diets developed and validated for pigs and the expected growth rate in healthy pigs

Diet	Ingredients	Growth rate (g/day)
Wamena #4	33% sun-dried raw SP-vines + 22% sun-dried raw SP roots + 34% ensilaged SP-tubers and vines + 11% raw banana trunk	N/A*
Wamena #5	20% raw SP roots + 9.9% raw SP vines + 60% corn + 10% sundeleka grass (Puerasia cephaloides) + 0.1% salt	180 – 240
Wamena #7	50% cooked SP roots + 30% cooked SP-vines + 20% tofu waste	N/A
Wamena #8	40% cooked SP roots + 30% cooked SP-vines + 10% ensilaged SP tubers and vines* + 20% rice bran	N/A

**N/A - not assessed*

The five most sustainable pig diets that were formulated during the life of the project were costed and ranked in terms of growth rate potential (Table 1) and the economic impact evaluated. Using the improved pig husbandry and management system developed during the first 6 years of the project, and feeding cost-effective diets, was found to reduce the time taken for pigs to reach sale weight by 30 to 50%. Based on the cost of diet alone, the increased profit from feeding these diets from weaning to 60 kg for 324 days is approximately 0.7 to 1.0 million rupiah/pig. The sale price for a 60kg over the last 3 years has varied from 2.5 to 4.5 million rupiah. The cost of feeding a 40kg pig ranged from 0.4 to 0.6 million rupiah with a sale price ranging from 1.5 to 3 million rupiah. These figures indicate that a farmer with one sow, who invests in building a pig house and lalekens, will recover costs and make a profit within 3 years.

Disease survey

The most important health problems detected were internal parasitism, ingestion of toxic plants and the presence of three important zoonotic diseases.

All 39 pigs blood tested were negative for antibodies to Brucellosis, Leptospirosis (Leptopsira pomona and L. tarossovi), Porcine Parvovirus (PPV), Mycoplasma hyopneumoniae, Classical Swine Fever (CSF) virus (Hog Cholera) and Transmissible gastro-enteritis (TGE) virus. However, five pigs were positive for antibodies to Pseudorabies virus (Aujeszkey's disease). (Note: Outbreaks of Swine Fever have since been reported in the Province of Papua).

Internal parasite species identified included Trichuris suis, Metastongylus, Physocephalus sexalatus, Ascaris suum, Ascarop strongylina, Macracanthoryncus, Strongyloides ransomi and protozoa identified included Eimeria debliecki, E scabra, E suis, polita, Balatidium coli, Entamoeba sp, and Jodamoeba sp. Although no Trichinella sp was detected in muscle samples, 5 serum samples were positive for antibodies to Trichinella sp., and 7 were positive for Toxoplasma gondii. This was considered to be an important finding as both Trichinosis and Toxoplasmosis are zoonotic diseases transmitted to humans via eating under cooked pork. Evidence of consumption of toxic plants was also recorded. The results indicated the need to modify husbandry techniques to limit the impact of parasites and toxic plants on production and increase the sustainability of pig production.

Development of confinement system based on lalekens or large enclosures

After reviewing the disease survey data, it was decided that confining pigs in houses and fenced areas would assist in the control of parasitism, as well as reduce the pig's access to poisonous plants. It would also assist in reducing the risk of pigs being infected with zoonotic parasites important for humans. The other advantage was that it would enable the introduction of foraging into management and further supplement the pig's diet.

Assessing the value of dunging areas for parasite control

To assess the value of dunging areas in reducing parasite burdens, two groups of pigs were given access to dunging areas for 30 minutes each day prior to foraging. Group A were treated prior to the commencement of the experiment with Doramectin to remove parasites and parasite faecal egg counts were performed on all pigs monthly. Pigs pre-treated with Doramectin remained relatively free of parasites for up to 3 months (Table 3). Mortality rates in untreated pigs were between 32 and 50% (Table 4) compared with only 16% in treated pigs. Treated pigs also grew 64 to 70% faster than untreated pigs. These data validate the value of dunging areas in parasite control.

Table 3: Mean monthly faecal egg counts for pigs treated pre-experiment for parasites and untreated pigs

Months	Trichuris		Hyostrongylus		Storngyloides		Oesophogostomum	
	A*	B	A*	B	A*	B	A*	B
0	580	413	887	587	140	833	140	73
1	0	216	7	752	0	112	0	80
2	0	120	0	824	0	376	0	88
3	0	160	200	1528	64	120	0	0
4	120	920	528	1336	80	336	0	0
5	264	1040	400	1930	48	110	64	0

** all pigs in group A injected with Doramectin -7 days (1ml/33kg body weight)*

Table 4: Mean growth rate and mortality rates over 5 month period for pigs treated for parasites pre-experiment and given access to dunging areas (group A) and untreated pigs given access to dunging areas (group B)

	Experiment 1		Experiment 2	
	Group A	Group B	Group A	Group B
Mean ± SD (g/day)	132.8 ± 62.2	47.0 ± 45.5	112.2 ± 55.6	34.7 ± 31.8
Range (g/day)	118 - 166	-17 - 100	72 - 183	-11 - 56
Mortality %	16	50	16	32

Assessing the value of supplementing SP based diets with foraging high protein pasture:

Sundaleka (Puerasia cephaloides, which contained 17% crude protein, proved to be the most sustainable of the three pastures assessed [others were Wurikaka Baru (Centrosema sp) with 15% crude protein and Jirikpuruk (Calopogonium sp) with 11% protein]. Sundeleka grows well across the valley floor and along the slopes of the valley and regenerates readily. It also grows prolifically along the verge of roads, which enables supply to be augmented using cut and carry techniques. In a series of palatability trials, pigs were found to prefer sundelaka leaves to the other pastures, as well as sweetpotato leaves and the foliage of fodder tress assessed. The most sustainable fodder tree in terms of cultivation and regrowth was Dadap (Erythrina variegate with 29% crude protein. It was easier to cultivate than Gamal (Gliricidia sepium) but less palatable for pigs.

The most successful system for confining pigs was to divide the land into 8 equal areas and rotate the pigs though all 8 pens or small paddocks. In a series of foraging trials, pigs were removed from a pen when 100%, 75%, 50% and 25% of leaf material had been eaten and the time taken for the plot to recover recorded. It was found that the most

sustainable pasture management system was to move pigs when 50% of the leaf material had been eaten. Except in drier months, plots recovered in time for pigs to forage again after they had progressed through the other 7 pens. During these periods of the year farmers can use cut and carry to augment the supply of pasture.

The value of providing access to forage material was validated in a series of trials comparing the growth rates of two groups of pigs given regular treatment to remove parasites and fed Wamena #2 diet, with and without access to foraging. Pigs with access to pasture grew from 18 to 30% faster than the controls.

When pigs were not treated regularly to remove parasites, the pigs given access to pasture grew only 7 to 12% faster than those with no access to pasture, and both groups had significant infestations of parasites (Hyostrongylus sp) by the end of the third month.

However, when pigs were treated pre-trial with an anthelmintic and held in dunging areas for 20 to 30 minutes before being given access to pasture, they grew significantly faster than either untreated pigs with access to pasture (80%) or treated pigs with no access to pasture (32%), and remained relatively free of parasites for 3 months (Table 5).

Table 5: Mean growth rates pigs fed Wamena #2 diet with and without daily access to forage pasture and dunging areas

Treatment to remove parasites	Yes	Yes	No
Access to pasture	Yes	No	No
Access to dunging area	Yes	No	No
Mean ± SD (g/day)	235 ± 32.1	159.5 ± 26.7	47 ± 34.5
Range (g/day)	194 - 249	121 - 198	29 - 98

In a related project (AH/2006/038) regular feeding of papaya or betel nut was found to eliminate parasites over 2 to 3 weeks.

Hence a sustainable confinement system, where pigs were housed over night, fed Wamena #9 diet supplemented with either papaya or betel nut, and held in dunging areas for 30 minutes each morning before being given access to lalekens planted with high protein pasture, had been developed.

Fodder trees were also successfully cultivated from cuttings and these can be used to build live fences around lalekens. The trees can also provide another source of high protein foliage to supplement pig diets as well as provide wood for cooking.

Developing an appropriate housing model

Several housing models, based on the core principals for pig housing and adapted for the local environment, were developed and trialled. The final model was constructed from timber with a thatched roof. Thatch was compared with iron and was found to provide a more even temperature over a 24-hour period (Table 6). Thatch roofed houses were 3 to 4 degrees cooler in the hottest part of the day and 3 degrees warmer at night.

Table 6: Temperature control in houses with thatched roofs and tin roofs

Type of roof	Mean temperature		
	Day	Night	Day-night difference (C)
Thatch Roof	22.6 ± 0.92	19.1 ± 0.87	3.5
Tin Roof	26.2 ± 1.91	18.2 ± 0.92	7.9
Outside	24.8 ± 0.61	17.5 ± 1.33	7.3

Houses were designed with an opening along the back wall, which could be closed with wooden panels. Pigs were provided with a dry sleeping area, covered with dry grass, and a wet area for food and water (Figures 1 and 2).


Figure 1 and 2: Pigs were provided with a dry sleeping area and a wet area for feeding and water.

The value of providing boar contact for sows post-weaning on productivity

Ninety percent of sows given boar contact continuously following weaning came into oestrus and were mated within 10 days of arrival at the site. This compared with only 40% of sows with no boar contact. Sows that were given boar contact pre-mating also farrowed 82% more live piglets at the next farrowing. These data confirmed the importance of boar contact in increasing farrowing frequency and litter size. The economic advantage of using a boar to stimulate sows post weaning in a village farming system was also found to be quite significant. Even if a boar costs 10 million Indonesian Rupiah, an increase of 83% in pig sales at an estimated 5 million/pig will more than offset the cost.

Table 7: Number days between arrival at the experimental site and mating

	Sows housed next to boar (boar contact)	Sows housed away from boar (no boar contact)
Mean ± SD	7.3 ± 8.78	18.2 ± 17.70*
Range	1 - 31	4 - 22
% sows mated within 10 days	90	40

** 2 sows did not mate*

Table 8: Number pigs born/sow at next farrowing

	Sows housed next to boar (boar contact)	Sows housed away from boar (no boar contact)
Mean ± SD	5.1 ± 2.08	2.8 ± 2.25
Range	2 - 8	0 - 5

T test for piglets/sow = P > 0.05 (P = 0.06)

Farmer training and farmer-to-farmer training

Capacity building was an important part of the project and all the regional scientists involved in the project received a number of training opportunities within Indonesia and one was assisted in obtaining a Masters degree. The members of the project team also worked closely with scientists from two major Government Institutions (The Institute for Legumes and Root Crops in Malang and The Institute for Animal Husbandry in Bogor). Project members also worked closely with scientists and researchers from the University of Udayana in Denpasar and the University of Papua in Manokwari West Papua.

Participating farmers were included in all project team meetings and visited all project sites annually. Approximately 70% of the farmers were taken to another part of Indonesia (Bali, North Sumatera and West Java) to observe pig production and visit academic and training institutions.

Training materials were developed by the project team and have been translated into Huburi (the Dani language), Bahasa Indonesia and English. The material is designed to

facilitate the transfer of knowledge and to be used as the basis of a training document that can be adapted and used in other parts of eastern Indonesia. The manual introduces techniques developed on SP cultivation and seed production, identification of pests and diseases of SP, developing SP products post harvest for human nutrition, building and managing lalekens (small paddocks) and dunging areas, developing and managing pastures for rotational foraging for pigs, building and managing pig houses, prevention and control of parasites, examining pigs post-mortem, feed and feeding management, growing Dadap (Erythrina sp) cuttings, and sow and boar management. Manuals have also been developed for the positive selection process for selecting sweetpotato planting material, a rapid multiplication technique for sweetpotato planting material, how to make silage from sweetpotato roots and vines and how to undertake a post mortem examination of a dead pig. These have been published in book form and copies are available for distribution. The material is presented as a combination of dot points, photographs, drawings and explanatory notes.

A group of farmers, who have worked with the project for 3 to 7 years, were trained as trainers for a farmer-to-farmer training program which was completed in 2008. Training has also been provided to field staff from World Vision Indonesia (WVI), to enable them to work with their own farmer networks in villages in other locations within the Baliem Valley.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The production and registration of new varieties of sweetpotato, along with a large quantity of breeding material, has already had an impact in neighbouring regencies to reduce the risk of malnutrition. They will also provide cultivars for further research into the qualities and characteristics required for processing sweetpotato as part of a new project (AH/2007/106) to commence in 2009.

Although positive selection has been shown to be beneficial in areas where the prevalence of disease and pests is high, the results achieved in this project demonstrate its value in low disease prevalence areas as well. Although this had no immediate impact, it has potential to have impact over the next 5 years in other areas of low disease prevalence.

The confirmation that ensilaging will eliminate anti-trypsinases or anti-nutritional factors in sweetpotato roots provides a more sustainable alternative to cooking for eliminating anti-nutritional factors from sweetpotato roots to improve digestibility for monogastrics. Again while the immediate impact has been limited, the finding has potential to reduce the use of firewood over many regions where sweetpotato is a staple ingredient in pig diets, such as the Pacific region.

The chemical analysis of snails and the demonstration of their value in pig diets is a novel finding as they are regarded as a pest in many regions of the world. Hence these findings once published will have potential impact in similar pig producing regions across Asia and the Pacific.

Similarly the demonstration that papaya fruit, when fed to pigs that have access to dunging areas, will eliminate internal parasites provides is an important scientific result. This provides a sustainable method of pig production in areas where medicines are either too expensive or unavailable. Again while this has had no immediate impact, the scientific and practical results have been communicated via other projects to PNG and the Pacific

8.2 Capacity impacts – now and in 5 years

Significant capacity building has occurred throughout the life of the project and as stated earlier each scientist involved in the project was given several training opportunities.

The close working relationships that have been established between the participating scientists (Cargill, Jusuf, Putra, Soplanit, Ketaren), the CIP project co-ordinators (Tjintokohadi, Mahalaya and Asayhputra), the Dani Project co-ordinator (Kossay), and the local farmer collaborators, has meant that a significant amount of “unofficial training and capacity building” occurred during all visits and project team meetings. This occurred on each visit to the project sites, as well as during more official meetings. With 32 villages involved in the project this provided a strong network of knowledgeable farmers for farmer-to-farmer training programmes that operated during the final year of the project.

The major training received by regional scientists was in research methodology and designing experiments using groups of animals and ensuring the data collected is valid. At least 3 of the project scientists have designed and operated successful research experiments that were unconnected with this project.

One scientist (Mr Soplanit) has been awarded a masters degree based his studies of fish culture and while trained on the project, he has independently demonstrated his research capabilities in other projects.

Dr Made Putra who received training at the University of Udayana in Diagnostic Parasitology has established a small diagnostic facility in Wamena and trained other staff to in diagnostic procedures.

Two scientists (Soplanit and Syahputra) have been appointed as the local project coordinators in Wamena and Manokwari for the new project (AH/2007/106) to commence in 2009. The selection and appointments were based on their demonstrated capacities to undertake and supervise research activities during the current project.

Following the completion of a training program at University of Papua, Luther Kossay (Dani Project Coordinator) has been used by farmers as a resource for obtaining advice and information on pig husbandry, management and health problems. Many of these requests have been unrelated to project activities and demonstrates that the project has provided farmers with an important human resource to aid them in improving animal production.

Farmers have also been the beneficiaries of training, not only via a farmer training program but via visits to other regions of Indonesia. Evidence of the value of the training visits to activities unrelated to the project can be seen in the increased income recorded from the sale of other crops (40%) in project households compared with only 16% for non-project households. This indicates that contact with the project team and visits to other regions in Indonesia by project farmers also had an economic impact on family income in other ways.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Based on the initial survey in 2001 and data collected as part of a PhD thesis in 2008 (Sukendra Mahalaya pers com), income from the sale of pigs among project households increased by 87%, compared with 30% in non-project households. Much of the increase has been due to increased herd size and 2 project farmers have increased herd size from 2 sows and 7 growing pigs to 7 sows and up to 40 growing pigs. The relevant increases in income for sale of sweetpotato roots and vines were 18% and 11% respectively again showing a greater increase among project households. Interestingly, income from the sale of other crops also increased by 40% in project households compared with only 16% for non-project households, suggesting that contact with the project team and visits to other regions in Indonesia by project farmers had an impact on family income. As the project outcomes are extended through training programs and famer to farmer contact over the next 5 years, these increases are expect to flow to non project households in project villages as well as non-project villages.

It was also found that lifestyle assets owned by project households, as measured by such items as motorbikes, radios and mobile telephones, had increased by 50%, in the case of radios, and 250%, in the case of motorbikes, compared with 2001. By comparison the increase among non-project households ranged from 20% (radios) to 50% (motorbikes). While no households recorded cell phones in 2001, and this was still the case with non-project households in 2008, a significant number of project households had purchased them by the end of the project indicating an increase on the ability to improve communication and follow lifestyle choices.

An unexpected modification in household income was noted in the reduction of expenditure on firewood. Despite cooking pig diets to increase productivity, project households spent 70% less on firewood in 2008 than 2001 compared with a decrease of only 20% for non-project households. This was due in part to many households adopting ensilaging as the main diet preparation method, and possibly the use of fodder trees grown in lalekens.

Household incomes also changed through an increased emphasis on cropping and pig production with reduced reliance on wild animals harvested from forests (reduced by 87% in project households and 20% in non-project households) and forest tree products, which were reduced by 84% and 24% respectively.

8.3.2 Social impacts

Increased education opportunities for children in households connected with the project appeared to be one of the major social impacts recorded. Mahalaya (unpublished 2009) found that the children of several farmers were planning to complete high school, or had completed high school and were attending tertiary educational programs in 2008. All the families interviewed agreed that this was the result of increased income generated through their involvement in the project. In 2001 the figure was zero for all households interviewed and remained close to zero for non-project households in 2008.

Education measured in years per household had also increased from 7.2 to 9.3 (30%) in project households for men and from 5.1 to 7.5 (47%) for women. This compared with 6.8 to 7.8 (16%) for men and 5.2 to 5.7 (9.6%) for women in non-project households.

However, the time spent on pig production had increased from 7.2 to 13.7 hours/week for men (90%) and from 5.2 to 9.0 (73.1%) for women in project households compared with 6.5 to 8.3 (28%) for men and 4.7 to 5.8 (23%) for women in non-project households. Although time spent on sweetpotato cultivation and harvest was much greater than the time spent on pig husbandry, the increases were more modest. The time spent had increased from 19.1 to 22.2 hours/week for men (15%) and from 32.9 to 41.1 (25%) for women in project households compared with 27 to 30 (11%) for men and 38 to 54 (11%) for women in non-project households.

8.3.3 Environmental impacts

Although environmental impacts were not measured as such, when data collected in 2008 was compared with the 2001 data a definite trend was noted.

The finding that project households spent 70% less on firewood in 2008 than 2001, compared with 20% for non-project households, indicates that other alternatives to buying wood obtained by deforestation were being used. Also there was less harvesting of other products from the forest areas. While the confinement of pigs is expected to reduce environmental damage caused by free-ranging pigs, this will not have a significant impact until a significant number of households have adopted this method of husbandry.

8.4 Communication and dissemination activities

The major avenue for communicating and disseminating results to the scientific community was through participation at the BPTP National Symposium and Exposition held every second year in Jayapura, Papua Province. This symposium attracts scientists and agricultural technologist from across Indonesia, and especially eastern Indonesia.

Four papers were presented in 2004 and 8 papers in 2007.

Topics in 2004 included:

- The performance of promising sweetpotato clones in Jayawijaya Valley
- Pig disease survey in Jaywijaya Regency, Papua Province, Republic of Indonesia
- The importance of boar contact in improving sow fertility.

Topics covered in 2007 included:

- A multidisciplinary research approach.

- Improving the efficiency of sweetpotato-pig production in Jayawijaya Regency of Papua Province: Housing for sows, litters and growing pigs.
- Ibid: Reducing parasite infections in pigs
- Ibid: Developing modified sweetpotato based diets for pigs.
- Ibid: Confining pigs to improve productivity and health.
- Papua Solossa, Papua Pattipi and other sweetpotato varieties adapted for higher altitudes.
- New sweetpotato varieties with improved drought resistance for feeding pigs.
- Improving fish production to provide protein for pigs

Other papers were published at conferences in New Zealand (First International Symposium on Root and Tuber Crops, Food Down Under), Bangkok (FAO Pig Production symposium) and Lima (Annual Meeting and Annual Review of CIP) as well as an article published in the Commonwealth Veterinary Journal July 2007 on parasite control.

Training programs were developed and downloaded to NGO's such as World Vision Indonesia, farmer groups such as The Baliem Valley Co-operative Framer Group (KTNA) and a group of farmers trained to deliver farmer-to-farmer training programs in the Baliem Valley.

Opportunity will exist for further technology dissemination in the highlands of Papua and West Papua Provinces through a proposal by the International Fund for Agricultural Development to develop and support a community empowerment program. It is proposed that this national program will draw on the technology developed by the project for dissemination in the highland communities.

9 Conclusions and recommendations

9.1 Conclusions

A socio-economic diagnostic survey, together with technical and observational surveys, were used to identify constraints in both sweetpotato and pig production in the Baliem Valley of Papua. Based on the analysis of data from the survey, a participatory research approach was used to improve sweetpotato production and enhance the efficiency of pig production.

Three new clones of sweetpotato were developed for human consumption and registered for use by Indonesian farmers in 2007. These new varieties played an important role in solving a food shortage problem that resulted in malnutrition and deaths in a neighbouring regency. Two new varieties, together with a local variety (Musan) were also registered and released nationally for use in pig diets. The breeding program supported by the project resulted in 5000 F1 generation clones from Papuan parent stock being developed. A selection of these will be screened for nutritional and physical traits required for processing, as part of a new project (AH/2007/106) to commence in 2009.

Technology for creating clean planting material from existing gardens was also introduced and validated in a series of field trials and demonstrated to be beneficial in the region, producing superior planting material which resulted in increased yields.

Significant changes, such as regular feeding and adjusting the amount of ration fed to pigs daily to 10% of body weight, were made to the existing practices for feeding pigs. These resulted in pig growth rates up to 3 times greater than traditional practices. Adding banana trunks improved growth rates marginally but increased mineral intake significantly. Cooking and ensilaging of sweetpotato roots and vines were also found to improve growth rates and production efficiency and a series of diets based on these practices was developed. The most efficient and sustainable diets were based on ensilaged roots and vines supplemented with either fish offal or golden snails. The latter was the cheapest and easiest to produce. Ensilaged material was also supplemented with either high protein pasture or foliage from fodder trees. The most successful diet (Wamena #9) contained 33% cooked SP-vines, 22% cooked SP roots, 34% ensilaged SP tubers and vines, 11% cooked banana trunk and 5% golden snails. The ensilaged material contained 85 kg SP roots, 15 kg SP-vines or pasture or foliage, 0.5 kg salt and was fermented for 14 days. Healthy pigs fed these diets could be expected to grow around 250 to 300 g/day and reduced the time taken for pigs to reach sale weight by 30 to 50%. Calculations based on the cost of ingredients, labour and sale price for pigs produced a benefit cost ratio of between 2.5 and 5.0. Neither tofu waste nor rice bran proved to be sustainable as supplies would need to be imported into the valley or the production base expanded. Snails proved more sustainable than fish offal and are readily produced in small ponds and easily harvested.

A modified pond fertilisation method was developed for fish production, which resulted in a 200 to 230% increase in production compared with the traditional system. However, fish production was only viable in areas of the valley close to rivers with access to running water 12 months of the year.

The most important health problems detected in pigs were internal parasitism, ingestion of toxic plants and the presence of three important zoonotic diseases. The latter included Cystercercosis, Trichinosis and Toxoplamsomosis all of which are transmitted to humans via eating under cooked pork. The results indicated the need to modify husbandry techniques to limit the impact of parasites and toxic plants on production, reduce human exposure to pig manure to increase the sustainability of pig production.

As a result a sustainable management system, based on lalekens or large fenced areas for daytime confinement and housing to provide shelter at night, was designed. The lalekens were planted with high protein pastures so that pigs could forage when confined during the day, and pigs were held in a specially designed dunging area when released from the houses each morning for 30 minutes. This reduced the contamination of pastures with parasite eggs and pigs were moved to a fresh laleken when 50% of the foliage had been eaten. Fodder trees were also successfully cultivated from cuttings and these can be used to build live fences around lalekens. The trees provided another source of high protein foliage to supplement pig diets as well as wood for cooking. The final housing model developed was constructed from timber with a thatched grass roof and openings along the back and front walls which could be closed with wooden panels to control ventilation rates. Pigs were provided with a dry sleeping area, covered with dry grass, and a wet area for food and water. Pigs treated with an anthelmintic to remove parasites and fed the Wamena #9 diet, and managed in the confinement system with access to pasture grew significantly faster than pigs fed the same diet and not treated with anthelmintics or not given access to pasture.

Sow and boar management and housing were also modified to ensure that sows had contact with boars pre-mating. Sows given boar contact post-weaning mated within 10 days of weaning and farrowed 82% more live piglets at the next farrowing. This compared with only 40% of sows without boar contact mating within 10 days of weaning. Hence the economic advantage of using a boar to stimulate sows post weaning in a village farming system was quite significant.

Capacity building was an important part of the project and regional scientists received a number of training opportunities within Indonesia. Pig production training and visits to academic and training institutions outside the Baliem Valley was also provided for approximately 70% of the farmers.

Training materials were developed by the project team and translated into Huburi (the Dani language), Bahasa Indonesia and English. The manual covers techniques on SP cultivation and seed production, identification of pests and diseases of SP, developing SP products post harvest for human nutrition, building and managing lalekens (small paddocks) and dunging areas, developing and managing pastures for rotational foraging for pigs, building and managing pig houses, prevention and control of parasites, examining pigs post-mortem, feed and feeding management, growing Dadap (Erythrina sp) cuttings, and sow and boar management. Manuals have also been developed for the positive selection process for selecting sweetpotato planting material, a rapid multiplication technique for sweetpotato planting material, how to make silage from sweetpotato roots and vines and how to undertake a post mortem examination of a dead pig. A group of farmers as well as field staff from World Vision Indonesia (WVI) were trained as trainers for a farmer-to-farmer training program designed to train other farmers in both contact and non-contact villages within the Baliem Valley.

9.2 Recommendations

The major recommendations include:

- Farmers require better access to more reliable markets for both sweetpotato and pigs:
  - The sale of sweetpotato is limited to local markets around the Baliem Valley and no market exists for the varieties grown for pigs. However, developing storage and processing technology suitable for Dani farmers to use within local communities would increase storage and market options and enable improvements in household nutrition.

  - Development of a secure market chain for pigs is essential so that farmers can be guaranteed a fair price and have a regular outlet for the increased numbers of pigs being produced.

- Further improvements in pig health are required, especially in the prevention or elimination of zoonotic parasites from pigs. Although much has been achieved in reducing the impact of intestinal parasites on pig production, as well as reducing the risk of childhood infection with zoonotic parasites, the current situation and risk factors involved need further elucidation. The outcomes from such studies will assist animal and human health authorities to develop policies and programs to eliminate or greatly reduce the risk of human infection with diseases such as Cysticercosis, Trichinosis and Toxoplasmosis.
- Although the pig confinement system developed appeared to reduce the risk of pigs being infected with Classical Swine Fever, the diagnosis and epidemiology of the disease in the Baliem Valley, and the role of *Streptococcus suis* in pig mortalities needs further investigation. This would enable animal health authorities to develop more effective control programs.
- While there are encouraging signs that outcomes from the project are being taken up by farmers in non-contact villages, agencies such as BPTP, Dinas Tanaman Pangan and Dinas Peternakan need to be encouraged and funded to continue training and extension programs. Increasing the role of NGO's such as World Vision Indonesia and Farmer Groups, such at the Baliem Valley Co-operative Farmer Groups (KTNA), will enable this to happen.

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