Annual Research Report
2010

Seeds of Life
Fini ba Moris

Seeds of Life (Fini ba Moris) is a program within the Timor-Leste (East Timor) Ministry of Agriculture and Fisheries (MAF). The Governments of Timor-Leste and Australia collaboratively fund the program. Australian funding is through the Australian Agency for International Development (AusAID) plus the Australian Centre for International Agricultural Research (ACIAR) and is managed by ACIAR. The Centre for Legumes in Mediterranean Agriculture (CLIMA) within The University of Western Australia (UWA) coordinates the Australian funded activities.

Table of Contents

List of tables and figures

Tables

Figures

Foreword

It is my pleasure to release the fifth Annual Research Report prepared by the Seeds of Life (SoL) program within the Ministry of Agriculture and Fisheries (MAF). The SoL research program has made significant progress in selecting, evaluating and releasing crop varieties to improve food security in the Democratic Republic of Timor-Leste.

SoL research activities in 2009-2010 were centred in the seven districts of Manufahi, Aileu, Baucau, Viqueque, Liquica, Bobonaro and Ainaro. These districts were selected to represent the six agro-ecostystems of Timor-Leste ranging across low altitude, low rainfall to high altitude and higher rainfall environs. However, it is pleasing to see that the products of the program have been far reaching. In my travels around Timor-Leste, I have seen our varieties being grown in the districts of Ermera, Manatutu and Lautem in addition to the core districts. We expect to see further spread of SoL/MAF techologies across the entire nation in the future.

The on-farm trials, where new material is evaluated on farmers fields under farmer conditions, is the main conduit for information exchange regarding new technologies. In addition, farmers are invited to field days held at research stations and on farmers fields. Here they are able to debate the attributes of each new technology and discuss their experiences under different conditions with both researchers and other farmers. At the field days, farmers assist harvest the trials and taste tests are a regular event to ensure the most suitable varieties are released. Some varieties have been particularly successful and there are an increasing number of reports from farmers who not only grow these varieties but are able to sell their surplus product. Farmers have made considerable income from selling SoL/MAF sweet potatoes over a number of years as have rice farmers in several districts. Maize seed producers in Viqueque have recently commenced selling Sele seed. Extending successful technologies further will require extra effort in seed production and technology transfer activities.

MAF continues to strengthen agricultural research, seed production and technology transfer in Timor-Leste. During the year a new shed and fence was constructed at Loes Research Station, national seed multiplication was expanded and nearly 400 Suco Extension Officer (SEOs) are now operating in the districts. Training of MAF personnel, farmers, NGOs and other organizations working in agriculture received strong assistance from SoL during the year. On each work day, at least ten persons attended a training course. Training and other support to these agriculture sectors will expand further through the planned Seeds of Life 3 program. We look forward to signing an agreement early in the year to commence the program.

The Australian Government is gratefully acknowledged for its financial support through the Australian Centre for International Agricultural Research and the Australian Agency for International Development.

H.E Mariano ASSANAMI Sabino
Minister of Agriculture and Fisheries
Democratic Republic of Timor-Leste

December, 2010

Abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research
AEZ	Agro-Ecological Zone
ALGIS	Agricultural Land Geographic Information System
ANOVA	Analysis of Variance
ANU	Australian National University
APC	Australian Program Coordinator
ARP	Agriculture Rehabilitation Program
ATL	Australian Team Leader
AusAID	Australian Agency for International Development
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CLIMA	Centre for Legumes in Mediterranean Agriculture
CRIFC	Centre Research Institute for Food Crops (Indonesia)
EAS	Early Adoption Survey
FPR	Farmer Participatory Research
g	gram
GPS	Global Positioning System
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICM	Integrated Crop Management
ILETRI	Indonesian Legume and Tuber Root Research Institute (see RILET)
IRRI	International Rice Research Institute
LYDMR	Late Yielding Downey Mildew Resistant (Released as Sele)
M&E	Monitoring and Evaluation
MAF	Ministry of Agriculture and Fisheries
masl	Metres Above Sea Level
MTR	Mid Term Review
NGOs	Non-Governmental Organizations
OCAP	Oecussi Ambeno Community Activation Programme
OFDTs	On-Farm Demonstrations and Trials
PSC	Program Steering Committee
RA	Research Assistant
R/EA	Research and Extension Advisor
RDUs	Research and Demonstration Units
REML	Restricted Maximum Likelihood
RILET	Research Institute of Legumes and Tuber Crops (Indonesia)(see ILETRI)
SOL1	Seeds of Life 1
SOL 2	Seeds of Life 2
SOL 3	Seeds of Life 3
SoL	Seeds of Life
SOSEK	Social Science and Economics
SRI	System of Rice Intensification
t/ha	Metric ton per hectare
TAG	Technical Advisory Group
TL	Timor-Leste
UN	United Nations
UNTL	National University of Timor Lorosae
UWA	University of Western Australia
VRC	Varietal Release Committee

Personnel

Ministry of Agriculture and Fisheries

H.E Mariano ASSANAMI Sabino	Minister, Ministry of Agriculture and Fisheries
Mr. Marcos da Cruz	Secretary of State for Agriculture & Forestry
Mr. Eduardo de Carvalho	Secretary of State for Fisheries
Mr. Valentino da Costa Varila	Secretary of State for Livestock
Mr. Lourenço Borges Fontes	Director General
Mr. Gil Rangel da Cruz	National Director, Agriculture and Horticulture and Director for Food Crops and SoL Co-Leader
Mr. Adalfredo do Rosario Ferreira	Director of Research and Special Services and SoL Co-Leader
Mr. Joao dos Santos	District Director, Aileu
Mr. Lucio Nunu	District Director, Viqueue
Mr. Donato Salsinha	District Director, Same
Mr. Domingos Savio Cabral	District Director, Baucau
Mr. Gregoriu dos Santos	District Director, Liquica
Mr. Jose Orlando	Regional Director , Maliana
Mr. Moises Lobato Pereira	Research Manager, Fatumaca
Mr. Abril Fatima Soares	Research Manager, Aileu
Ms. Maria Fernandes	Research Manager, Betano
Mr. Teleforo Fernandes Moniz	Research Manager, Loes

Name	*District*	*Sub-District*
Mr. Luis De Almeida	Dili (to December 2009)	
Ms. Armandina Marcal	Dili	
Ms. Anita Ximenes	Dili	
Mr. Modesto Lopes	Dili	
Ms. Dorilanda da Costa Lopes	Bobonaro	Maliana
Ms. Deonisia Raquela Soares Brito	Aileu	Aileu Villa
Mr. Cipriano Martins	Aileu	Aileu Villa
Mr. Salvador de Jesus	Aileu	Remexio, Liquidoe, Laulara
Ms. Odete Ximenes	Baucau	Baucau Villa
Ms. Juliana de Jesus Maia	Manufahi	Betano
Ms. Ermelinda M.L. Hornai	Maliana	Maliana Villa
Mr. Antonio Pereira do Rego	Baucau	Venilale
Mr. Rojino Da Cunha	Baucau	Vemasse
Mr. Joao Bosco Pedro C.R. Belo	Baucau	Baucau Villa
Mr. Basilio da Silva Pires	Baucau & Viqueque	Venilale &Ossu
Mr. Marcos Vidal	Manufahi	Betano
Mr. Felisberto Soares	Manufahi	Betano
Mr. Rafael Feliciano	Manufahi	Betano
Mr. Jose da Costa Ronal Freygen	Liquica	Maubara
Mr. Jorge Amaral	Manufahi	Alas
Mr. Armindo Moises	Manufahi, Ainaro	Turiscai, Maubisse
Mr. Leandro C.R Pereira	Liquiça	Maubara
Mr. Mario Tavares Goncalves	Liquiça	Liquiça Villa
Mr. Luis da Costa Patrocinio	Bobonaro	Balibo
Mr. Luis Pereira	Dili	
Mr. Paulo Soares	Liquiça	Liquiça Villa
Mr. Mario da Costa	Viqueque	Viqueque
Ms. Maria Martins	Aileu	Aileu Villa
Ms. Isabel Soares Pereira	Baucau	Baucau Villa
Ms. Julieta Lidia	Baucau	Baucau Villa
Mr. Luis Fernandes	Manufahi, Ainaro	Same Villa, Hatudu
Mr. Amandio da Costa Ximenes	Viqueque	Ossu

Mr. Inacio Savio Pereira	Viqueque	Uatulari
Mr. Tobias Monis Vicente L. Agm	Liquiça	Maubara
Mr. Joao Paulo	Dili	
Mr. Agostinho Alves	Manufahi	Betano, Same, Alas

National University of Timor Lorosae	
Mr. Osorio Verdial	Head of Agronomy Department, UNTL
Mr. Acacio Guterres	Agronomy Lecturer
Mr. Antonio da Costa	Agronomy Lecturer
Mr. Adao Berbosa	Agronomy Lecturer

University of Western Australia
Dr. Harry Nesbitt. Australian Program Coordinator, Seeds of Life
Dr. William Erskine, Director CLIMA
Dr. Neil Turner, climate change specialist

Australian National University
Prof. Andrew Mc William, Research Anthropologist

Seeds of Life Office in MAF, Timor-Leste	
Mr. Robert Williams	Seeds of Life Team Leader
Dr. Asep Setiawan	Seed Production Advisor
Ms. Myrtille Lacoste	Research/Extension Advisor: Manufahi, Aileu (from September 2009)
Ms. Rebecca Andersen	R/E Adviser for Baucau, Liquiça &Maliana & Climate Change Advisor (to February 2010)
Mr. Martin Browne	R/E Adviser for Baucau, Liquiça &Maliana (from October 2009)
Mr. Nick Molyneux	Climate Change Advisor (from March 2010)
Ms. Frances Barnes	Social Research Advisor (from March to July 2010)
Mr. Rowan Clarke	Australian Volunteer – MAF Loes Research Station (to February 2010)
Ms. Sally Bolton	Australian Youth Ambassador – Communications Officer (to March 2010)
Mrs. Carla Da Silva	Office Manager (from November 2009)
Mr. Joaquim J.M.R da Cruz	Finance Officer (to July 2010)
Mr. Marcelino da Costa	Data Entry Specialist (to December 2009)
Mr. Apolinario Ximenes	Data Entry Specialist (from March 2010)
Mr. Aquilles Barros	Translator / Interpreter
Ms. Miguelina Ribeiro Garcia	Administrative Assistant
Ms. Alexandra Araujo	Administrative Assistant (from April 2010)

Collaborating Organizations		
National / Local NGOs	*Contact Person*	*Position*
Caritas Baucau	Mr Nelson da costa Freitas Pr.	Program coordinator
OISCA	Mr. Mirandolino A. Guterres	General Coordinator
	Mr. João da Silva Sarmento	Program Coordinator
Fundasaun Halarae	Mr. Angelino Lemos	Field staff
	Mr. Manuel Ati	Field staff
Santalum	Mr. Helio Jose Antonio da C.	Secretary
Loda	Mr. Ancelmos Mau	Field staff
International NGOs and UN	*Contact Person*	*Position*
Care International	Mr. Buddhi Kunwar	Project Manager LIFT
OXFAM Hongkong	Ms. Maria dos Reis	Program Officer for Timor-Leste
OXFAM Australia	Mr. Marcelino Belo	Project Officer
UNOPS (OCAP – Oecusse)	Mr. Koen W. Toonen	Int'l Program Coordinator (Ocap –Oecusse)
World Vision	Ms. Fiona Hamilton	Projects Manager
	Mr. Try Laksono	Bobonaro Area Manager

CCF	Mr. Carlos S. Basilio	Team Leader
Portuguese Cooperation	Mr. Hugo Trindade	Agronomist
GTZ	Mr Mathias Braun Mr. Benjamin Guterres	Country Representative Farming System Coordinator
Concern	Mr. Pedro Laranjeira Mr. Bonifase	Component 3 Coordinator Field Staff
PADRTL	Mr. Mario Assis Tavares	Ermera Component Coordinator
FAO	Mr. Chana Opaskonkul Mr. Peter Jarvis	Representative Food Security Advisor
Mercy Corps	Mr. Paul Jeffrey	Country Director
HIVOS	Ms. Maryanne Maerza	Program Manager Food Security
World Neighbors	Mr. Wayan Tambun	Program Coordinator
ETEA Foundation for Development & Cooperation	Ms. Magda Duarte Mora	Country Director
RDP III Same	Mr. Phillipe de Poole	Country Representative
Susu Been for Timor-Leste Domestic Dairy Industry Initiative Program (TLDD II)	Mrs. Luisa Goncalo	Program Manager

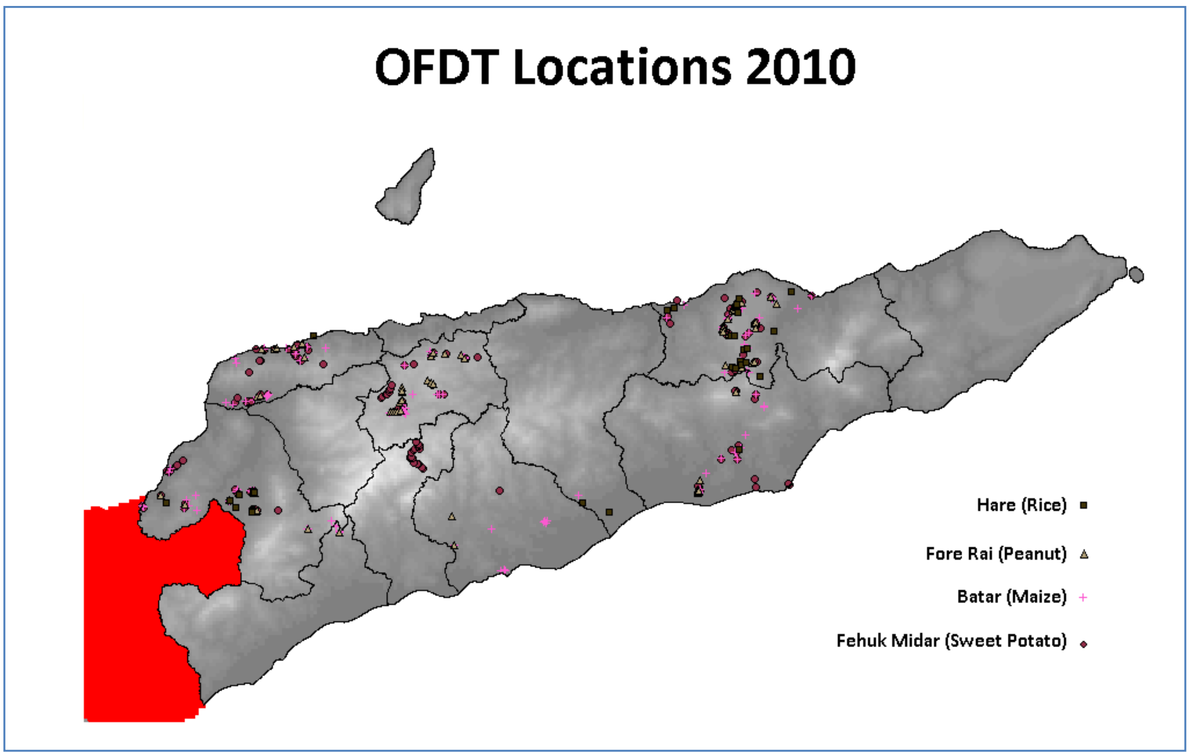


Figure 1. OFDT sites in Timor-Leste (Oecussi excluded) 2009-2010.

1. Overview of the Seeds of Life program

1.1. Introduction

Seeds of Life (SoL) is a program within the Ministry of Agriculture and Fisheries (MAF) of Timor-Leste (also referred to as East Timor). The program addresses food security in the rural areas through the release and seed production of improved food crop varieties plus capacity building to continue these activities. The program includes on-station and on-farm research, on-station and on-farm seed production, research station infrastructure improvement, training and assistance with policy development. It is implemented under the bilateral assistance program for Timor-Leste and is jointly funded by the Governments of Australia and Timor-Leste. Government of Australia funding is from the Australian Agency for International Development (AusAID) and the Australian Centre for International Agricultural Research (ACIAR). ACIAR manages the joint funding from AusAID and ACIAR through the executing agency, the Centre for Legumes in Mediterranean Agriculture (CLIMA) at the University of Western Australia (UWA).

SoL commenced in 2000 with the installation of replicated trials of improved maize, rice, sweet potato, peanuts and cassava. That phase (SOL 1) was fully funded from Australia as an ACIAR project. The current phase (SOL 2) which includes both on-station and on-farm trials and an increased amount of capacity building is co-funded by AusAID and MAF. SOL 2 commenced on 01 September, 2005. SoL research conducted during the previous year is summarized in Annual Research Reports (ARR). This report is the fifth in a series and describes the SoL activities conducted over the period from 01 September, 2009 and 31 August, 2010. A summary of capacity building and other non research SoL activities is also included.

The goal of SOL 1 was the "identification and release of new varieties of food crops suitable for cultivation in Timor-Leste". Highly productive varieties were identified during this phase and needed to be evaluated under farmer conditions. The goal of SOL 2 is identified as "improved food security in Timor-Leste" through the "use of improved crop varieties and associated technologies which result in increased food production".

The draft (2010) research policy for MAF states "That inclusive and consultative processes be established for project initiation and development. Priority should be given to adaptive and applied research that will benefit the farmers of Timor-Leste and improve livelihoods". SoL supports this approach and it is considered that sufficient good genetic material is available from other parts of the world for use in Timor-Leste. In both phases of the program, the main source of improved genetic material was through crop centres belonging to the Consultative Group on International Agricultural Research (CGIAR). Rice is sourced from the International Rice Research Institute (IRRI); maize from the International Maize and Wheat Improvement Centre (CIMMYT); cassava and beans from the International Centre for Tropical Agriculture (CIAT); sweet potatoes from the International Potato Centre (CIP) and the International Centre for Research in the Semi-Arid Tropics (ICRISAT) has provided free of charge, suitable peanuts (groundnuts). Much of this material is sourced from CGIAR regional centres. For example most sweet potato varieties were from programs in Indonesia and cassava was from Thailand and Indonesia. Potential varieties were also sourced from the University of Philippines breeding group (maize), programs in Australia (mungbeans, wheat and barley) and other parts of the world via local organizations. For example the NGO World Vision provided climbing bean material originally sourced from Rwanda.

Small amounts of seed imported from external institutes undergo observational trials in isolation from other crops. The number of entries are reduced depending on these observations and the successful short listed entries undergo replicated trials at four research station sites. These are generally at Betano, Loes, Aileu and Baucau. Replicated trials possess approximately 20 entries. Rice trials are performed at sites off these stations which possess irrigation. Some other upland crops unsuited to the four stations mentioned above may be evaluated on farmers fields. For example, replicated trials on wheat, barley, climbing beans and potatoes are performed on farmers fields at higher altitudes. Sites for irrigated rice and high altitude research may be identified in Phase 3 of SoL.

Farmers are invited to field days on the research stations to identify entries which possess the characteristics preferred by the community. Often this involves participants weighing the harvest and often tasting the produce both cooked and uncooked. One or two of the best performing varieties are then evaluated on farmers fields under farmers conditions in unreplicated "on-farm demonstration trials" (OFDT). Five hundred and sixty three OFDTs were installed during the 2009 dry season and 2009-2010 wet season, of which 480 had harvestable yields. This allowed a large number of farmers to observe the growth and development of each variety. OFDTs were installed the seven districts of Manufahi, Aileu, Liquiça, Baucau, Viqueque and Ainaro and Bobonaro (Figure 1), allowing researchers to make comparisons of the test varieties over a range of agro-ecosystems and management practices. If any outstanding varieties are identified after this exhaustive process, they are recommended to the Minister of MAF for official release.

Nine varieties evaluated by SoL had been released by MAF at the end of 2010. Two maize varieties (Suwan 5 and Sele) outyield local varieties under farmer conditions, in OFDTs, by approximately 50%; the released peanut variety (Utamua) is higher yielding than locals by 47%; rice (Nakroma) 24% and the three sweet potato varieties (Hohrae 1, Hohrae 2 and Hohrae 3) by more than 66%. The two released cassava varieties (Ai-Luka 2 and Ai-Luka 4) have yet to be harvested from OFDTs.

In addition to evaluation of improved varieties for release, the SoL program continued farming systems research to address other constraints to production in Timor-Leste. Considerable effort was invested in controlling weeds using velvet bean as a smother crop and in weeding, fertilizer and pesticide trials. The social science program examined the constraints under which farmers operate, conducted seed mapping exercises and studied marketing of SoL varieties in the districts. SoL continued an extensive training program.

Seed multiplication expanded during the year with foundation seed being maintained on the research stations and seed bulked up on farmer fields was distributed to farmers both directly and via Non Governmental Organizations (NGOs) and the United Nations (UN) Food and Agriculture Organization (FAO).

The SoL office is located in the MAF compound in Comoro, Dili.

This report is the fifth Annual Research Report prepared during the second phase of SoL. It provides details of the research conducted over the year, summarizes the seed production program plus gives an outline of the training program. The following section provides a summary of program activities for the period from 01 September, 2009 to 31 August, 2010. It constitutes the final report for Phase 2 of SoL. Phase 3 (SOL 3) is planned to commence in February, 2011. The design of this phase was drafted in April, 2010 (finalized in July, 2010) on a concept note recommendation by the Technical Advisory Group (TAG) towards the end of 2009.

1.2 Program summary, 2009-2010

The SoL program was designed with four components with specific objectives. These are a) Seed production, storage and distribution, b) Evaluation of germplasm and associated technologies, c) On-farm demonstrations and trials and 4) Program management and coordination. Capacity building is a priority of the program and is imbedded within the four components. However for reporting purposes, it is presented in a different section below. The activities of each component for the 2009-2010 year are presented below:

Component 1: Seed production, storage and distribution.

Component objective: To enhance the capacity of MAF and other agricultural development agencies/groups to produce, store and distribute quality seed for Timor-Leste's main food crops:

Activities in this component include:

- Rehabilitation of Betano, Loes and Darasula research stations
- Utilization of the Aileu research site
- Seed production and storage at MAF stations and Districts
- Training in seed production and storage
- Testing and formulation of a seed certification, seed import and variety release policy

Towards the end of the final year of implementation, all rehabilitation work on the buildings at Betano Research Station were complete and facilities operating. Five houses and two office buildings were also constructed at Loes Research Station. Suitable farm equipment for both stations was purchased and that for Betano was in operation at the end of August, 2010. At Loes, the MAF funded chainlink fence around the perimeter of the station was complete and a warehouse and front fence were designed for construction.

The research station site at Darasula, Baucau was fenced by MAF, a station manager assigned to oversee its development and an Environmental Site Assessment (ESA) drafted. The site was surveyed by the Department of Forestry and approximately one half of the area approved for clearing. Some of this area will be prepared by MAF for cropping in the 2010-2011 wet season.

Replicated trials were conducted at four research station sites during the year (Aileu, Loes, Betano, Fatumaca). These were well managed throughout the cropping season. Replicated trials on these sites included maize, cassava, sweet potato and peanuts. Replicated trials on rice, wheat, barley, potatoes and beans were also conducted on farmers fields as representative ecosystems for these crops were not available on research stations. Field days were held at Aileu, Betano and Loes during which farmer observations of different varieties were recorded. These were supplemented with small field days held by each RA in his/her sub district.

Training on seed production and storage was provided to by SoL personnel as an on-going basis by the R/EAs and the Seed Production Advisor (SPA). Fourteen courses seed production were held during 2010 totalling 410 person training days.

At the request of the Directorate for Research and Special Services (DRSS), an advisor assisted the MAF develop a draft policy for agricultural research in Timor-Leste. The draft policy acknowledged that a centralized research system by instituted for Timor-Leste, with strong regional linkages through regional stations and the extension network. It was also suggested that research concentrate on adaptive and applied research. This draft policy was with the DRSS at the end of August, 2010.

The Seed Law drafted with the assistance of SoL personnel was with the MAF at the end of August, 2010. The Seed Production Advisor (SPA) will continue to work with the MAF during 2010/2011 to develop regulations to complement the Law. This Law will not be submitted to Parliament for ratification until the MAF has sufficient personnel in place to administer the regulations.

Seven seed production officers operating in six districts worked with an advisor to produce 54.7t Nakroma seed, 38.8t of maize, 100,000 sweet potato cuttings and 22t Utamua during the reporting period. Seed dryers, seed cleaning equipment and storage facilities were installed at two sites and smaller depots were constructed at two other sites.

Component 2 Evaluation of new germplasm and associated technologies

Component objective: to identify improved and acceptable food crop varieties and associated technologies for subsistence farmers, particularly in upland areas.

Activities in component 2 include:

- Introduction, evaluation and maintenance of new varieties
- Development of new technologies
- Development of an inventory of local varieties
- Staff training

The program continued to evaluate new varieties of food crops for cultivation in Timor-Leste during 2009-2010. Included were 20 maize (mainly from CIMMYT), 15 peanut (mainly from ICRISAT), 16 varieties of sweet potato (mainly from CIP), 20 irrigated rice (from IRRI) and 25 cassava clones (mainly from CIAT). In addition, preliminary research was conducted on climbing beans, barley, wheat and potato. Within each trial were at least two local varieties. A collection of local legumes was also planted for evaluation. Introduced germplasm was cultivated during the season at Betano (Manufahi), Quintal Portugal (Aileu), Fatumaca (Baucau) and Loes (Liquica) plus on farmers fields. Forty two varietal evaluation trials were installed and evaluated in 2010.

Agronomic trials to evaluate weeding, spacing, pesticide and tillage systems were also installed. Approximately 10 of these trials were installed by the research section of SoL and a further 10 as part of the seed multiplication program.

Germplasm maintenance during the year included 80 cassava entries, 40 sweet potato varieties and 30 peanut varieties. A collection of native legume species also added to the diversity of material under evaluation for East Timorese farming systems.

SoL delivered a total of two thousand three hundred and six formal training course days, mainly to MAF personnel, during 2010. Of these, 1345 days were in English language training, 749 in agronomy, statistics, research planning, plant protection and research implementation and 410 in seed production training. One person attended a two week on-farm research training course in Perth, Australia. Each subdistrict also held a field day for 10-50 farmers for the major food crops in the area. The formal training courses were presented at a rate of 12 persons trained per working day of the year. In addition, the R/EAs and visiting scientists provided constant on the job training in soils, the use of Excel, GPS, soil pH testing equipment etc. This level of local training will continue into 2011.

Seven East Timorese were taken on a study tour of research facilities at Hermitage Research Centre in Queensland, Australia. Participants were able to observe the precision and methodologies utilized by Australian researchers and discuss methods for improving their own practices.

During the 2009-2010 two SoL/MAF staff members attended MSc training in Bogor, Indonesia, two other students studied English at UWA in preparation for studying MScs (with John Allwright scholarships), one student completed his Masters in GIS in Australia with SoL funding and the ATL co-supervised a PhD student studying at UWA. A further MAF staff member was also identified for MSc training with a John Allwright scholarship.

Component 3. On-farm demonstrations and trials

Component objective: to test and extend new crop varieties to farmers – through extensive on-farm demonstration and trials and development of improved crop production "packages".

Component 3 is comprised of:

- Implementation of OFDTs
- Social science and economics (SOSEK) research
- Research and Demonstration Unit (RDU) training
- Development of improved crop production packages

Five hundred and sixty three (563) maize, peanut, sweet potato and rice on-farm demonstrations and trials (OFDTs) were established in 17 sub districts during the 2009-2010 wet season (Nov-April). Included were 228 maize, 109 sweet potato, 157 peanut and 69 rice trials. A number of these were not harvested for a range of reasons. Some plots suffered from drought or other disaster while others may have been harvested without the researcher's knowledge. At the end of the season, four hundred and eighty (480) had been harvested and were evaluated. Cassava OFDTs were also installed.

The SOSEK team conducted a series of studies on the impact of SoL technologies on farm households, examined the farmer adoption patterns for different crops and continued a consumption study in SoL adopter households. Much of this research is reported in the Annual Research Report for 2009. A series of cropping calendars for each district was also completed and published.

Over the wet season (Nov, 2009 – May, 2010), 75 field days were held fielding more than 1,500 participants. The crops were harvested during the field day, weighed and results discussed with the farmers and other members of the RDU. Feedback on the crops characteristics were then solicited from the visiting farmers.

OFDTs were installed in all major AEZs to evaluate the new varieties under different conditions. The coordinates of all were logged and mapped. The distribution of OFDT sites for maize, sweet potato, rice and peanuts during 2009/2010 is presented in Figure 1.

Apart from varietal development, research was also conducted to improve the "packages of technology" available to farmers which would complement the high yielding varieties. Weed control is a major constraint in the upland areas and experiments on this were installed on maize, peanuts and rice. Included was the use of Velvet bean (*Mucuna pruriens*) to control weeds in maize. Nitrogen application trials were also implemented on farmers rice fields.

Component 4. Program coordination and research institutionalization MAF

Component objective: to effectively manage the program and to institutionalize crop research and extension in MAF

Component 4 includes:

- Office staffing
- Coordination of activities
- Development of a national extension strategy
- Progress reviews and planning
- Reporting
- M&E framework

SoL activities were administered from the office at the MAF compound in Comoro, Dili for the entire year. This office is in the same building as the Directorate of Research and Special Services. SoL personnel, especially the Australian Team Leader interacted regularly with the Director for Research and Director for Agriculture and Horticulture.

Institutionalization of SoL into the MAF continued during the year with MAF directors requesting an increase in the level of funding to be directly managed by the MAF. The managers of research stations at Betano, Darasula and Loes were also more active. District personnel were running the research program in the districts. All SoL correspondence was channelled through MAF.

SoL personnel attend MAF "harmonization" meetings between donors and holds regular meetings with NGOs.

The final TAG visit for SOL 2 was held in August, 2009. This occasion doubled as an opportunity to prepare a Concept Note for a possible third Phase (SOL 3). A TAG report was prepared and SoL personnel acted on the recommendations. Additionally, the Concept Note recommended a third phase of the program and suggested that in the future, emphasis now be placed on seed production and extension of the new material. A SoL Program Steering Committee meeting followed in September, 2009 endorsing the concept note and the desire of all involved parties for a new Phase. AusAID and ACIAR supported the concept note in separate meetings. In November, 2009 a preliminary design for SOL 3 was completed and a design team visited East Timor in April to finalize the design. This design was modified and finalized in September, 2010.

There were a number of personnel changes during the year. Ms Myrtille Lacoste and Mr Martin Browne commenced as Research Extension advisors in September and October, 2009 respectively, Ms Carla Da Silva commenced work as the SoL Office Manager in November, 2009; Mr Luis De Almeida and Mr Marcelino Da Costa departed the program in December, 2009 to pursue MSc training in Australia; Ms Rebecca Andersen and Mr Rowen Clarke departed for Australia in February, 2010; Mr Apolinario Ximenes commenced as a data entry specialist on March, 2010 and Ms Alexandra Araujo as and Administration Officer in April, 2010. Ms Frances Barnes served as the Social Science Researcher between March and July, 2010. The Finance Officer departed the office in July, 2010. These changes are detailed in the Personnel table.

1.3 Rainfall

Introduction

Rainfall data for Timor-Leste has been collected to some degree since as far back as 1914 during the Portuguese colonial era. Though sporadic inter-annually and incomplete intra-annually, this archaic data gives us an idea of the climatic conditions near the beginning of last century. From the mid 1950's until 1974 Portuguese data improved to the extent where comparisons with current data are possible, at least for some of the more established towns and districts throughout the country. Indonesian era data is again harder to come by, with only Dili, Baucau and Occusse having any useful data between 1974 and 1998.

Rainfall data for 2010 has been compiled at the subdistrict level (where subdistricts host OFDTs) by Seeds of Life staff, and in regional important locations by ALGIS using both automated and manual weather stations (Figure 2). Combined, this means that rainfall data is available for a variety of elevations and areas across Timor-Leste, however it is not available for specific OFDT sites and calculations with yield from OFDTs must therefore be assumed based on the sub-district rainfall data.

Historical data can be compared with more recent decadal data and with new annual data to give us an idea of how the climate is changing. Below is a graph of the average monthly rainfall data for the periods from 1914 to 1974 (Portuguese data) and 2006-2009 (Timor-Leste data) and 2010. The data is selected based on OFDT sites and available historic data from the same sub districts. In some cases district level data was used as proxy to represent the locality of the modern locations.

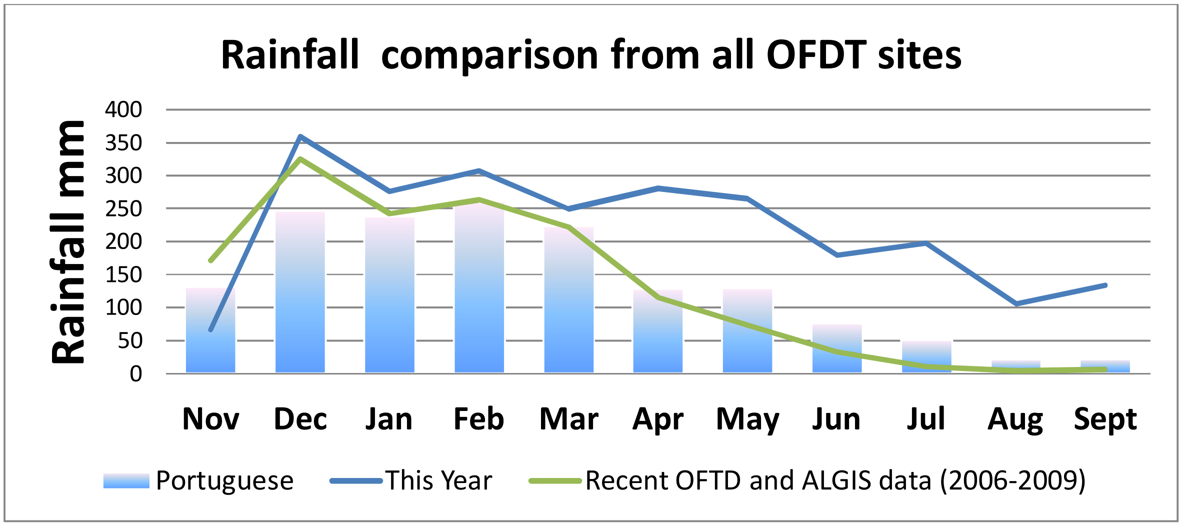


Figure 2. 2009-2010 wet season rainfall compared to the long and short term means.

It can be seen from Figure 2, that the wet season rainfall was similar to normal levels but where rainfall normally drops off in April through to September, the 2010 data actually shows an increase in rainfall during April, July and Sep. This data has been sourced from Portuguese Meteorological records, ALGIS recordings and Seeds of Life OFDT sub-district rain gauges.

The recent average OFDT (green line) and historical average Portuguese data (blue bars) as expected show very similar peaks and troughs in the annual rainfall cycle. This gives us a good base to compare this year's monthly absolute rainfall with. The rainfall data from 2010 shows a very different pattern and volume of rain, particularly during the 'dry' season months from June to September.

The data was collected from many sites and averaged to give a holistic Timor-Leste reading. This average of all sites masks some of the more extreme dry-season rainfall experienced, most noticeably in the southern districts of Manufahi and Viqueque (see Figure 3).

There is data from the Indonesian era, but only available for 3 locations; Oecussi, Baucau and Dili. This data, as well as the Portuguese and modern recordings represent the 3 periods of data collection in Timor. Unfortunately, the data is from such varied locations and consists of such variable quality (missing and highly spurious data) that putting the 3 periods together results in a graph of limited use.

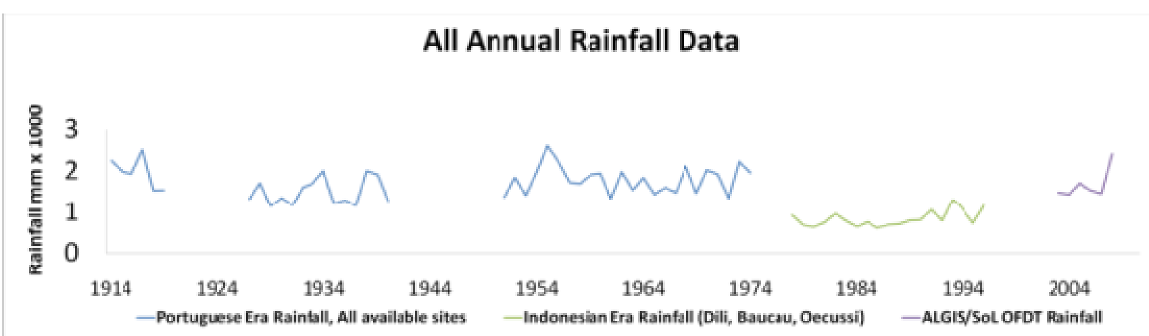


Figure 3. Annual rainfall data from 1914 to 2010.

The spatial variability of rainfall across Timor-Leste means that comparisons can only be drawn between areas that are very close in proximity and of a similar elevation. Comparing averaged rainfall recordings from different sites produces extremely variable results, even within the same AEZ'z and districts. As can be seen in Figure 3, the Indonesian data, while valuable for Baucau, Dili and Oecussi, cannot tell us how rainfall between 1975 and 1999 compare with the overall Timor-Leste averages (averaged from more than 20 locations). Similarly inferring rainfall for OFDT sites that do not have collection facilities from other sites in the same sub district (where collection facilities are present) does not guarantee that calculations based on these proxies will be useful, even where the elevations are similar. These types of issues are characteristic of empirical data limitations in Timor and present severe hindrances for rainfall pattern and climate change analysis.

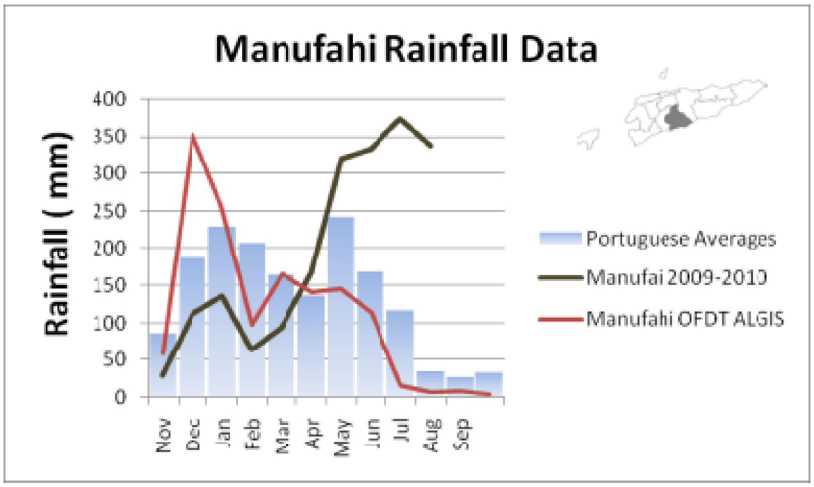


Figure 4. Rainfall data (mm) for Manufahi

Manufahi's 2009 wet-season started far below average, especially compared with recent years, and declined to very low levels in February causing drought and crop losses in Betano. Contrastingly April, May, June, July, August and perhaps through to September were exceptionally wet, with 2010 dry-season rainfall being 3-10 times higher than expected in a normal year. This huge increase from a dry wet-season to a wet dry-season is indicative of an El Niño event running into a La Niña episode.

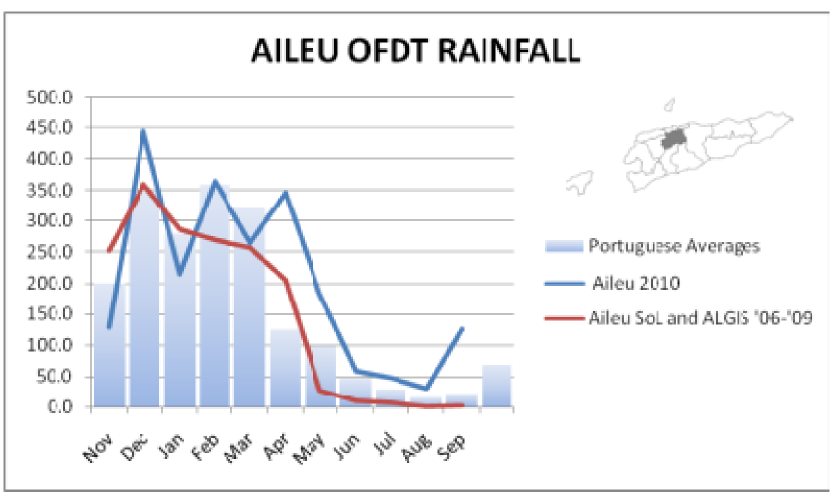


Figure 5. Rainfall data (mm) for Aileu

This blue line on this chart (Figure 5) representing 2010 rainfall in Aileu shows us that the inter-monthly fluctuations follow the pattern of the Portuguese average rainfall quite closely until March- April, where historical averages show a steep decline. Contrary to the average trend, 2010 shows an increase in rainfall into what would usually be the beginning-of-the-end of the wet season. This marked increase rather than decrease is however short lived and the May 2010 reading, while still elevated far above average levels for May, shows the trend has reverted back to a similar pattern as the average values. The quantity of rain throughout the dry season remains elevated above Portuguese averages, and far above recent averages (red line).

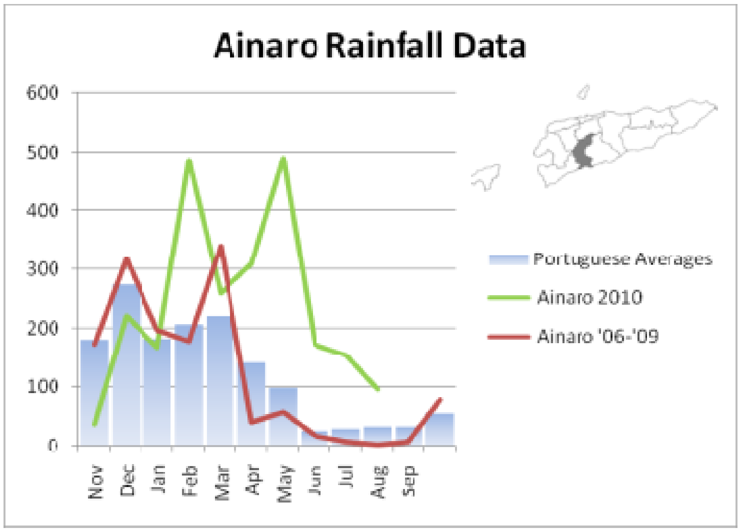


Figure 6. Rainfall data (mm) for Ainaro

Ainaro (central highlands and south coast) (Figure 6) experienced two large peaks of rainfall, one in February and one in May. The trough this year was during March, which is usually the month which experiences the second peak in rainfall giving the district a strong bi-modal wet season rainfall pattern. From the graph we can also see that this year's wet season rainfall pattern follows a similar pattern to a normal year, but 2 months later and much wetter, i.e. normal year = 2 peaks, December and March. This year = 2 peaks February an May and over 50% more rain. The dry season also stayed consistently much wetter than normal years.

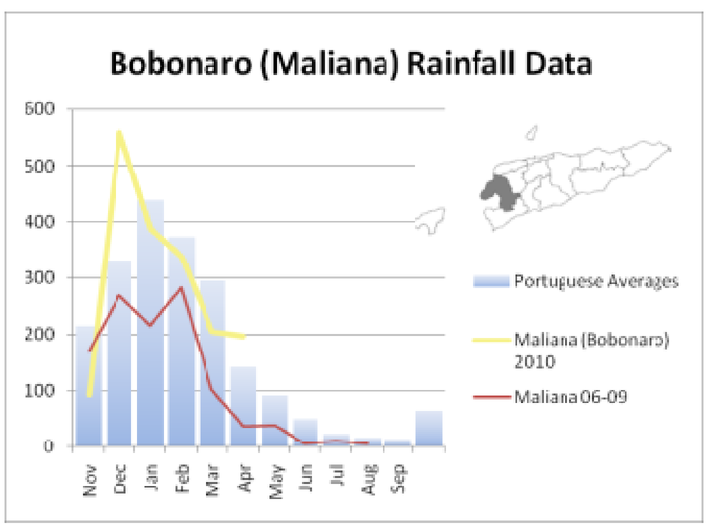


Figure 7. Rainfall data (mm) for Bobonaro

Bobonaro (Maliana data) (west coast, central) shows extremely high rainfall in December and relatively normal quantities for the rest of the wet season. Dry season data is incomplete.

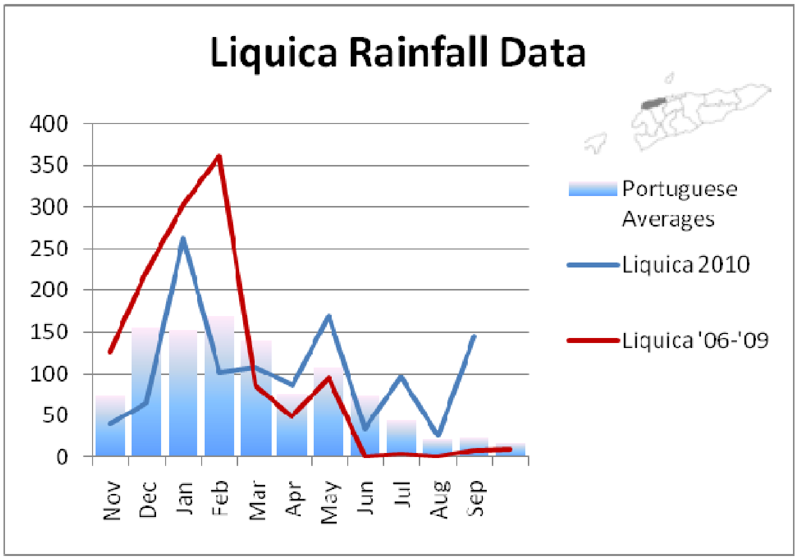


Figure 8. Rainfall data (mm) for Liquica

Liquica's rainfall data for the 2009-2010 (Figure 8) wet-season shows mixed results. Some months are drier, some are wetter and variability between months is high. This trend extends into the dry season. The extremely wet season experienced in other parts of the country appears to have been less acute in Liquica district.

The high values for Dec, Jan and Feb for the recent average data ('06-'09, red line) is likely due to a lack of data from most sites for most years, coupled with some very high recordings from Maubara in the early wet-season of '07-'08. Portuguese averages however are useful for comparison. The monthly totals from the commencement of the wet season to August show that this year has been approximately 10% wetter than normal in Liquica district.

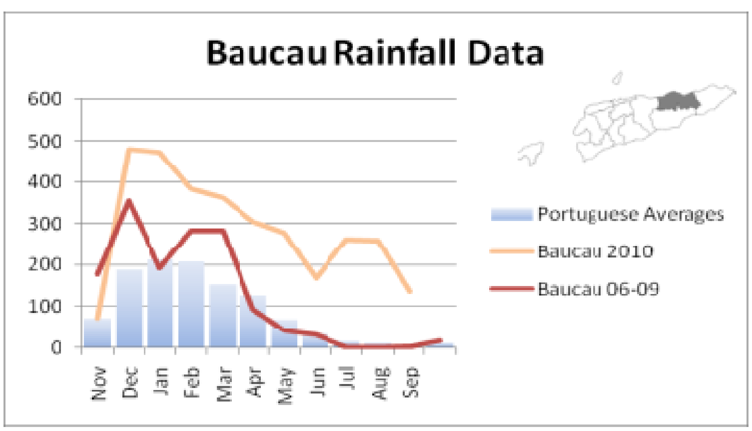


Figure 9. Rainfall data (mm) for Baucau

An extremely wet December and the continuation of high rainfall through to September characterizes Baucau's 2009-2010 wet-season. While the total monthly rainfall did drop after the peak recordings in December, it remained twice as large as Portuguese values, and far above the averages from recent years, especially during the dry-season (which saw monthly rainfall values comparable with those of the wet-season months December-March of normal years).

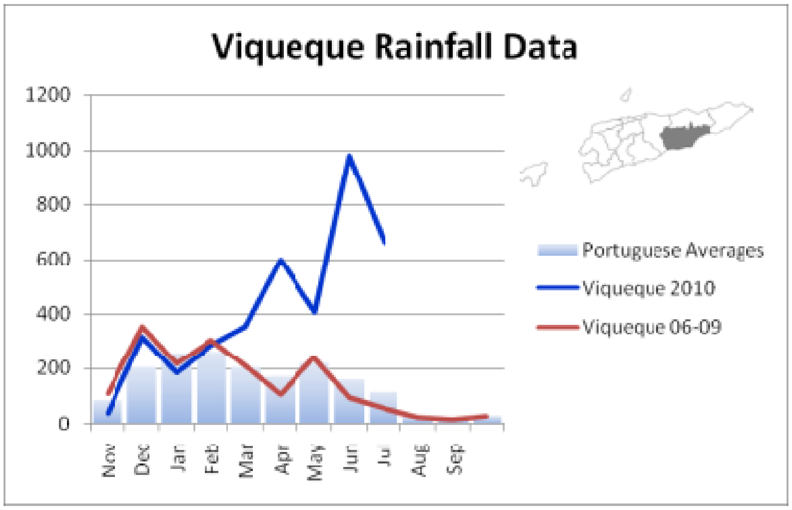


Figure 10. Rainfall data (mm) for Viqueque

The low November values and above normal December values for Viqueque (Figure 10) matched recent ('06-'09) averages, and the normal January and February values matched both recent and Portuguese averages. This very usual start to the wet-season ended with a wet March followed by extremely high recordings in April and June. May and July were also far higher than normal. The graph shows us again that the 'dry-season' this year has been comparable to and sometimes much wetter than usual wet-seasons. These Viqueque conditions are very similar to the conditions in Manufahi.

Trends:

Country-wide low rainfall in November (perhaps due to the outgoing El Niño suppressing rainfall at the beginning of the wet-season).

Ainaro, Manufahi, Viqueque districts (all central /south coast) – Wet-season -slightly lower than average rainfall until at least February. Some very dry conditions. The end of the wet-season showed a huge increase in rainfall with extremely wet conditions throughout the dry-season. This was perhaps due to the south coast being exposed to the prevailing oceanic meteorological processes (south easterly trade winds) and therefore being more susceptible to the outgoing El Niño influences early in the year and La Niña influences later during the dry season.

Aileu, Liquica, Baucau (north coast) characterized by a dry November followed by erratic variability in month to month rainfall. Generally the overall patterns of rainfall on the northcoast were similar to previous years, but with higher overall volumes of rain in the dry-season, often doubling average values.

Maliana in the west was very dry in November, very wet in December but normal through to April when the data stops.

<u>Climate change, cyclic rainfall or just a very wet year?</u>

Looking into records for Timor-Leste for the past 60 years shows us that there have been 4 occasions where rainfall has been similar to the 2009-2010 wet/dry-season. The two most similar year's annual rainfall patterns are shown below.

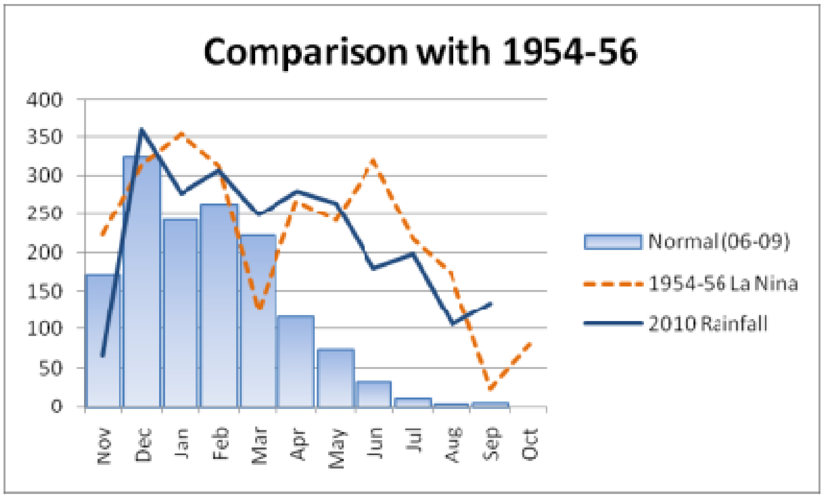


Figure 11. 2010 comparison with the wettest years on record, 1945-1956 (averaged).

This graph shows the comparison of the 1954-56 La Niña episode (averages) with recent averages and 2009-2010 averages from all sites. We can see that the 1954-56 La Niña produced similar high rainfall conditions particularly noticeable during the dry-season.

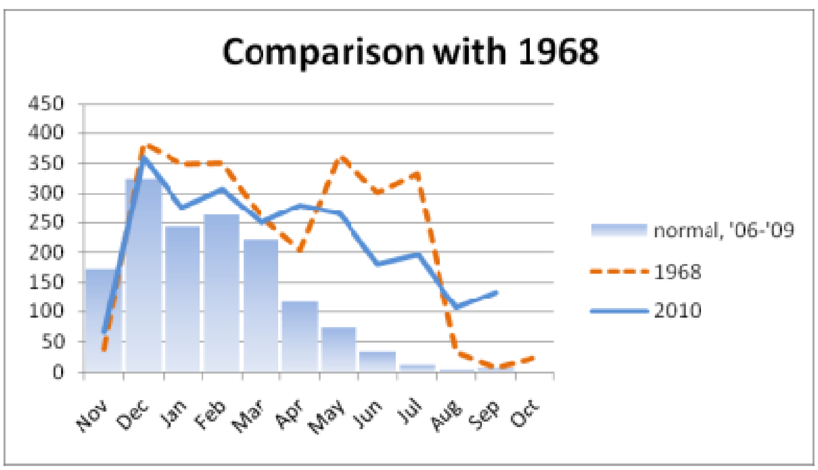


Figure 12. Rainfall comparison with 1968, another high rainfall year

1968 conditions were again similar to 2010's, with a low November rainfall, high December and consistently very high dry season rainfall (higher even than wet season averages). 1968 actually had more rain from May to July than 2010, though 2010 has a higher August and September (1968 conditions reverted to normal towards the mid-end of the dry season). There is no real consensus on whether 1968 was a La Niña episode, though there were significantly negative sea surface temperature anomalies indicating that La Niña conditions were in place during the beginning of the year, while the middle and end of the year were dominated by incoming El Niño conditions.

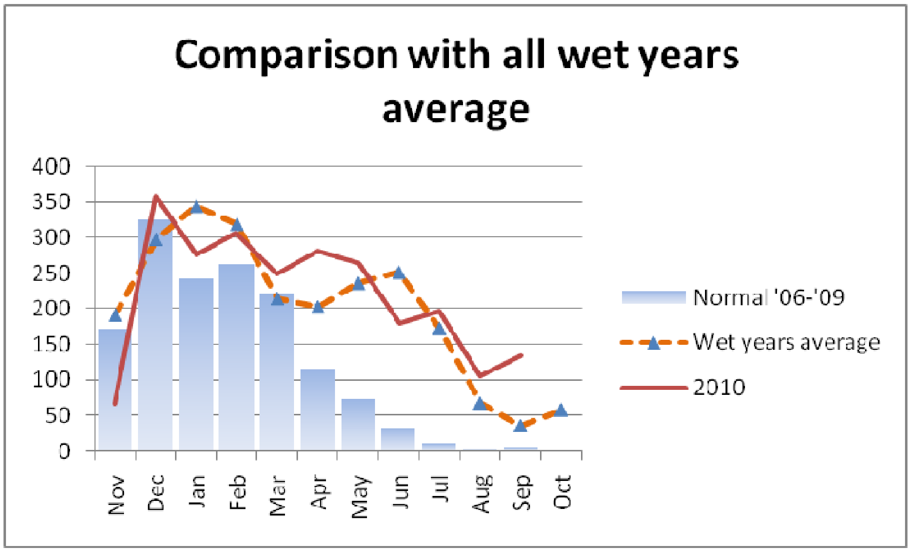


Figure 13. Comparison of 2010 rainfall and average of La Nina 'wet' years.

Combining the data from all the unusually wet years over the past 60 years (3 La Niña's and one probable La Niña) we get an average that is similar to 2010. The only major difference is that the rainfall in August and September 2010 was remarkable due to it remaining many times higher than normal conditions, and twice or three times higher than other wet years.

Previous wet years have however had higher rainfall in January, February and June. This information shows us that 2010 was an unusual year for rainfall particularly the dry season, but that it is not unprecedented.

La Niña

La Niña conditions are the opposite of the well known El Niño conditions. Both events are caused by sea surface temperature differences between the west and east Pacific Ocean's water masses. La Niña events are preceded and caused by a build up of cold water on the eastern side of the Pacific. These conditions affect the balance of sea surface temperature and atmospheric pressure across the Pacific. Trade winds increase in strength going from the cold areas of high pressure to the warm, low pressure areas. This results in pushing more and more warm conditions over to the west of the Pacific and pulling more deep cold water up along the eastern side. The warm moist air being held on the western side strongly affects weather conditions, commonly increasing precipitation in SE Asia, Australasia and South and Central America. As well as affecting the immediate Pacific area, El Niño and La Niña conditions can generate a global phenomenon with influences being felt in Europe, North America and Africa.

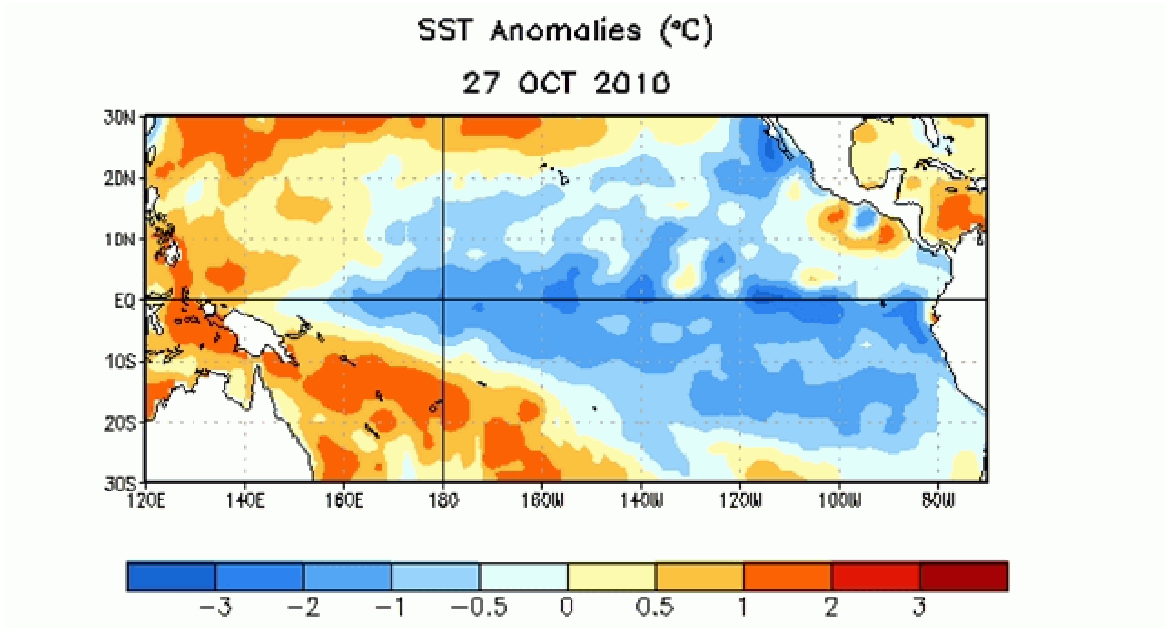


Figure 14. Average sea surface temperature anomalies (°C)*.

* for the week centered on 27 Oct 2010. Anomalies are computed with respect to the 1971-2000 base period weekly means (Xue et al. 2003). Picture from NOAA.

Figure 14 shows us difference in sea surface temperatures compared with the normal average temperatures across the Pacific Ocean. The presence of warmer than average seas in the west of the Pacific and colder than average seas in the east are characteristic of a La Niña event. The warmer seas generate more cloud and rising air in the west which promotes precipitation throughout SE Asia and Northern Australia. The trade winds that blow from east to west are unusually strong and prolonged during La Niña years due to the enhanced pressure gradient created by the differences in temperature of the seas surfaces and atmosphere (high pressure cold to low pressure warm).

"The Australian rainfall outlook for the December quarter (October to December) favours wetter than average conditions over large parts of the continent, with strongest odds across northern Australia.

The October to December outlook is the result of warm conditions in the Indian Ocean and cool conditions in the equatorial Pacific Ocean, both of which are associated with the current La Niña event."

– Australian Government Bureau of Meteorology. 2010

We can see that rather than climate change being the probable affect on the rainfall for 2010, it is most likely that the strongest driver for the increase in precipitation and extension of the wet season throughout the entire dry season has been the presence of La Niña conditions. This conclusion is drawn from observed data from Timor as well as regional evidence whose data points towards a La Niña event with associated high rainfall in the western Pacific.

2. Evaluation of new germplasm

2.1 Maize

2.1.1 Replicated maize trials, 2009-2010

Maize (*Zea mays* L.) varieties sourced from international institutions have been evaluated in replicated trials since 2001 (SoL, 2006). In more recent years, select test entries entered on-farm trials located in different agro-ecological zones across Timor-Leste. Two yellow maize varieties were identified through this process and released in 2007 as Sele and Suwan 5 (SoL, 2007).

During the wet season of 2009-2010, four replicated trials were installed on MAF research stations to evaluate nine open pollinated downy mildew resistant white maize varieties. These were compared with the two released varieties and a popular yellow Indonesian variety, Arjuna. Three local white and mixed varieties were also included in the trials as local controls. Characteristics of the varieties used in the trials are as presented in Table 1.

Table 1. Population details of maize trials, wet season 2009/10

Code	*Name*	*Source*	*Colour*
Har 05	DMRSSyn024/DMRSSyn021	Zimbabwe CIMMYT	White
Har 12	V036=PopDMRSRE(MOZ)F2	Zimbabwe CIMMYT	White
M 02	Suwan 5	Thailand	Yellow
M 03	Sele (LYDMR)	India	Yellow
M 24	Arjuna	Indonesia	Yellow
M 45	Local Fatulurik	TL - Manatutu	Mixed
M 47	Local Kakatua	TL - Covalima (Suai)	White
M 49	Local Viqueque	TL - Viqueque	Mixed
M 50	AMCAP	Phillipines	White
P 01	IPB Var 4	Philippines	White
P 03	USM Var 10	Philippines	White
P 07	CMU Var 12	Philippines	White
P 08	IES 8906	Philippines	White
P 09	Tupi white	Philippines	White
P 11	CMU Var10	Philippines	White

Methods and materials

The trials were conducted at Betano, Aileu, Loes and Fatumaka research stations. Each consisted of a completely randomized block with three replicates, the plots being 5 x 5 m in size. Seven rows were planted per plot with 75cm row spacing and 25 cm between hills. Two seeds were planted per hill which were later thinned to one plant per hill. Gaps were reseeded to achieve maximum plant stands (i.e. 5.3 plants/m²). The trials were neither fertilized nor irrigated except in Aileu (15 kg/ha of N and P) where the lack of station area does not allow for fallow. Trials were planted in early December 2009 and harvested in April-May 2010 (Table 2).

Table 2. Planting and harvest details of maize varietal trials, wet season 2009/10

Location	*Season*	*Number of entries*	*Number of replicates*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)**	*Mean yield (t/ha)*
Aileu (K.Portu.)	Wet	15	3	02 Dec. 2009	20 May 2010	152	1430	1.3
Betano (Same)	Wet	15	3	17 Dec. 2009	13 Apr. 2010	117	340	0.5
Loes (Maubara)	Wet	15	3	01 Dec. 2009	08 Apr. 2010	128	430	2.3
Baucau (Fatumaka)	Wet	15	3	07 Dec. 2009	07 Apr. 2010	121	2065	1.5

* Total rainfall from planting to harvest dates for each research station.

Yield components

A number of parameters were recorded during plant growth, starting with emergence rates at 2-3 weeks. In Loes, the number of plants showing downy mildew symptoms was counted at 3 months. The height of five plants which had been randomly marked earlier in the season was measured just before harvest (at 3 months for Betano). The number of lodged plants in each plot was also counted. At harvest, the cobs of the two outside rows were dried separately and put aside for taste and weevil tolerance testing. Yield and yield components were evaluated from the five central rows. The numbers of plants and cobs were counted and the fresh weight of the latter measured. After drying, cobs were weighted again with and without sheathes. Total grain weights (after threshing) were recorded to calculate final yields and the weight of a random sample of 100 seeds recorded for seed weights.

The data of each trial was analysed separately using GenStat Discovery 3 or 2 in order to determine varietal effects. Depending on planting designs (regular or irregular grid) and on the presence of row and/or column effect in the yields, different tests were performed.

Table 3. Statistical tests used in the analysis of the 2009/10 maize varietal trials

Station	*Row/Col effects*	*Grid*	*Test*	*Type*
Aileu	No	Regular	ANOVA	One-way in Randomized blocks
Betano	No	Regular	ANOVA	One-way in Randomized blocks
Loes	Yes, Row	Regular	REML	AR2 Linear on Row
Baucau	Yes, both	Regular	REML	AR1 on Row & Col and Linear on Row

Yield advantages were calculated from the resulting predicted means over the average of the locals.

The existence and degree of correlation between the predicted means of the yields and of the other parameters were then identified using Simple Linear Regressions. A first regression with 'Trials' as Groups (with 'separate lines' as the final model) was initially run over all the data in order to determine whether the regression slopes were significantly different from zero within each trial dataset (t tests on the parameters estimates). If it appeared to be so, individual regressions were then run on the corresponding trial data in order to determine whether the actual correlation was significant. The percentage of variability accounted for is then equivalent to an adjusted R^2.

Farmers' preferences

Farmers' field days were conducted at Betano and Loes at harvest time in order to assess the farmer's preferences of maize varieties and to determine the traits that farmers use to value the varieties. The numbers of participants and tested varieties are detailed in Table 4.

Table 4. Maize taste tests during farmers' field days, 2010

Station	*No. of varieties tested**	*No. of participants*	*Proportion of women*
Betano	8	39 pers.	36 %
Loes	9	10 pers.	70 %

* Best yielding varieties and 2 or 3 local checks

As part of the field day, farmers inspected the freshly harvested cobs of all varieties. All the unopened cobs of one replicate were displayed to allow the farmers to judge the yield as well as cob and grain characteristics of each variety. Afterwards, farmers were presented with boiled samples and asked to evaluate taste characteristics (particularly sweetness, a highly regarded criterion to define the eating quality of maize). In Loes, farmers were asked to give their opinion on sheath length, as being able to tie the cobs together is considered to provide a physical barrier essential for weevil tolerance and hence grain conservation. Pounding qualities were also recorded, as farmers favour grain which breaks into small pieces without making too much flour (pieces are used for human consumption whilst the residual powder is given to pigs and poultry). Finally, the participants were asked if they liked the variety and if they were willing to plant it.

To analyse farmers' preferences, General ANOVAs were run with Variety*Gender as the treatment factors and with the participants as the blocking one. Correlations with Simple Linear Regressions were then calculated over the varieties predicted means.

Results

Yields and yield advantages

Table 5 presents the seed yields at each site for all tested varieties, as well as the overall yield advantages over the local checks.

Table 5. Maize yields and yield advantages, 2009/10

Variety	*Yields (t/ha)*				*Averages*			*Yield advantages (%) within site*			
	Aileu	*Betano*	*Loes*	*Baucau*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*Aileu*	*Betano*	*Loes*	*Baucau*
P 07	2.2	0.53	3.9	1.6	1.4	2.1	79	85	127	98	33
Suwan 5	2.0	0.39	4.2	1.0	1.7	1.9	65	72	64	114	-19
P 03	1.4	0.34	3.7	1.7	1.4	1.8	54	16	45	88	40
P 11	1.6	0.56	3.1	1.7	1.0	1.8	52	39	138	58	40
Sele	2.1	0.46	2.2	1.9	0.8	1.7	45	77	96	14	55
Arjuna	1.3	0.41	2.8	1.2	1.0	1.4	23	7	74	42	-1
Har 12	1.6	-	1.9	1.6	0.2	1.4[a]	21	35	-	0	31
Tupi White	0.5	0.47	2.1	2.1	0.9	1.3	12	-57	101	8	70
Loc. Fatulurik	*1.2*	*0.29*	*1.6*	*1.5*	*0.6*	*1.2*	*1*	*5*	*25*	*-17*	*22*
Loc. Kakatua	*1.1*	*0.23*	*1.7*	*1.5*	*0.7*	*1.2*	*0*	*-4*	*-4*	*-13*	*27*
Loc. Viqueque	*1.2*	*0.19*	*2.5*	*0.6*	*1.0*	*1.1*	*-2*	*-1*	*-21*	*30*	*-50*
Har 05	0.9	0.34	2.0	1.1	0.7	1.1	-5	-25	44	3	-9
P 01	1.3	0.38	1.1	1.5	0.5	1.1	-6	10	61	-43	27
P 08	0.6	0.53	1.6	1.4	0.5	1.0	-12	-53	126	-19	12
AMCAP	0.7	0.42	0.6	1.6	0.5	0.9	-26	-39	80	-69	35
F prob	*0.011*	*n.s.*	*<0.001*	*n.s..*							
l.s.d.	*0.9*	*-*	*1.4*	*-*							
*%CV / Walf/df**	*41.2*	*87.4*	*6.8**	*1.2**							
Mean site	1.3	0.41	2.3	1.5	0.8	1.4					
Mean locals	*1.2*	*0.23*	*2.0*	*1.2*	*0.7*	*1.1*					

[a] Missing value replaced by site mean

The season mean yield across all sites was 1.4 t/ha which was similar to the mean site yields of Aileu and Baucau. Average performances were much higher in Loes (2.3 t/ha) and much lower in Betano (0.4 t/ha, against 2.7 t/ha last year) where rains were late and resulting germination rates were low. Both germination rates and later establishment were variable across stations with plant density ranging from 1.6 to 4.3 plants/m² at harvest time.

The statistical tests revealed that the varieties yielded significantly differently within Aileu and Loes trials. Har 12 data are not available for Betano where it was accidentally watered from a nearby irrigated plot. The year's top yielding varieties were the Philippine variety P 07 and the released Suwan 5 with +80% and + 65% yield advantages respectively (corresponding to yields of about 2 t/ha). P 11, P 03 and Sele also performed well with +55-+45% overall yield advantage (about 1.8 t/ha). Suwan 5 yielded particularly well in Loes where it reached 4.2 t/ha, by far the highest yield for 2010 replicated trials. Sele had the most consistent result among the top yielding varieties.

Shelling percentages averaged 80% (Aileu and Loes data).

Yield components and other parameters

The predicted means for the yield components and other parameters associated with the yields are detailed in Table 6 and Table 7.

Table 6. Maize yields and yield components, replicated trials 2009/10

Trial	*Variety*	*Yield (t/ha)*	*Plants /m^2 at harvest*	*Cobs /plant*	*Seeds /cob*	*Seeds weight (g/100)*	*Cob weight, seeds only (g)*	*Trial*	*Yield (t/ha)*	*Plants /m^2 at harvest*	*Cobs /plant*	*Seeds /cob*	*Seeds weight (g/100)*	*Cob weight, seeds only (g)*
AILEU	P 07	2.2	2.3	1.1	543	34.3	89	**BETANO**	0.53	3.1	0.5	112	26.7	29
	P 11	1.6	1.5	1.4	387	30.2	83		0.56	2.9	0.6	150	28.3	41
	Sele (M03)	2.1	2.2	1.2	426	35.2	82		0.46	3.8	0.5	87	28.7	24
	Suwan 5 (M02)	2.0	1.8	1.3	382	34.6	93		0.39	3.0	0.4	73	27.0	19
	P 03	1.4	1.4	1.1	356	37.7	88		0.34	3.5	0.5	81	23.7	20
	Arjuna (M24)	1.3	1.5	1.5	435	37.4	67		0.41	2.6	0.7	87	26.7	23
	Tupi White (P 09)	0.5	0.6	1.0	273	23.8	42		0.47	2.7	0.6	104	25.0	25
	Har 12	1.6	2.1	1.4	426	24.7	63							
	P 08	0.6	1.2	1.0	190	37.3	40		0.53	3.2	0.5	102	24.0	25
	P 01	1.3	1.5	1.1	409	28.7	79		0.38	3.5	0.5	81	25.7	21
	Loc. Fatulurik (M45)	*1.2*	*1.9*	*1.3*	*267*	*35.8*	*46*		*0.29*	*3.8*	*0.6*	*49*	*23.7*	*12*
	Har 05	0.9	1.4	1.4	351	23.1	49		0.34	2.7	0.6	89	25.7	21
	AMCAP (M 50)	0.7	1.4	0.7	397	32.5	57		0.42	3.3	0.6	100	25.0	23
	Loc. Kakatu (M47)	*1.1*	*1.8*	*1.7*	*225*	*35.3*	*46*		*0.23*	*2.9*	*0.4*	*73*	*25.3*	*19*
	Loc. Viqueque (M49)	*1.2*	*1.4*	*1.6*	*357*	*29.1*	*47*		*0.19*	*2.3*	*0.5*	*65*	*25.7*	*17*
	MEAN	1.3	1.6	1.3	362	32.0	65		0.39	3.1	0.5	90	25.8	23
	F prob	*0.011*	*ns*	*ns*	*<0.001*	*ns*	*<0.001*		*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
	lsd	*0.9*	-	-	*134*	-	*26*		-	-	-	-	-	-
	%CV	*41.2*	*38.6*	*29.8*	*22.0*	*21.4*	*24.6*		*87.4*	*22.3*	*33.7*	*55.5*	*21.3*	*52.5*
LOES	P 07	3.9	2.8	1.2	384	29.1	111	**BAUCAU**	1.2	4.7	0.8	197	22.3	42
	P 11	3.1	3.6	0.8	323	28.6	93		1.1	4.7	0.9	101	21.1	26
	Sele (M03)	2.2	2.4	1.3	271	29.1	77		1.6	4.8	1.0	151	24.7	36
	Suwan 5 (M02)	4.2	2.6	1.6	304	31.0	95		1.5	4.2	0.8	155	26.9	40
	P 03	3.7	2.8	1.2	372	28.1	105		1.5	3.7	1.2	122	30.5	38
	Arjuna (M24)	2.8	2.4	1.3	261	31.5	83		0.6	3.6	0.5	119	25.3	30
	Tupi White (P 09)	2.1	2.4	1.2	292	26.3	75		1.5	4.1	0.8	148	28.3	46
	Har 12	1.9	2.2	1.2	288	23.8	70		1.6	4.3	0.8	171	30.6	54
	P 08	1.6	1.6	1.1	272	26.8	74		1.7	4.3	1.1	171	23.2	39
	P 01	1.1	1.4	1.1	298	27.8	83		1.6	4.3	0.9	129	28.5	39
	Loc. Fatulurik (M45)	*1.6*	*2.8*	*1.6*	*141*	*24.5*	*34*		*1.4*	*4.5*	*0.8*	*162*	*26.3*	*40*
	Har 05	2.0	2.7	1.1	286	23.0	68		1.7	4.6	0.9	188	24.1	47
	AMCAP (M 50)	0.6	0.3	2.0	214	29.7	65		1.9	4.1	1.1	188	21.7	43
	Loc. Kakatu (M47)	*1.7*	*2.6*	*1.2*	*150*	*29.5*	*45*		*1.0*	*4.2*	*0.6*	*180*	*22.4*	*35*
	Loc. Viqueque (M49)	*2.5*	*3.5*	*1.3*	*222*	*28.4*	*61*		*2.1*	*4.9*	*1.0*	*181*	*24.6*	*48*
	MEAN	2.3	2.4	1.3	272	27.8	76		1.5	4.3	0.9	157	25.4	40
	χ^2 prob	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*		*ns*	*ns*	*<0.001*	*ns*	*<0.001*	*0.014*
	lsd	*1.4*	*1.1*	*0.3*	*68*	*2.7*	*20*		-	-	*0.4*	-	*4.1*	*14*
	Walf/df	*6.8*	*5.5*	*6.3*	*8.4*	*6.8*	*8.8*		*1.2*	*1.4*	*2.7*	*1.6*	*5.4*	*2.0*

Table 7. Maize yields and other parameters, replicated trials 2009/10

Trial	*Variety*	*Yield (t/ha)*	*Emergeance rate at 2-3 weeks (%)*	*Plant height at harvest (cm)*	*Downy mildew (% plants)*	*Lodging (% plants)*	*Trial*	*Yield (t/ha)*	*Emergeance rate at 2-3 weeks*	*Plant height at harvest (cm)*	*Lodging (% plants)*
AILEU	P 07	2.2	93	215			**BETANO**	0.53	32	116	
	P 11	1.6	87	169				0.56	28	138	
	Sele (M03)	2.1	86	199				0.46	29	129	
	Suwan 5 (M02)	2.0	88	196				0.39	28	110	
	P 03	1.4	51	205				0.34	30	142	
	Arjuna (M24)	1.3	79	211				0.41	15	155	
	Tupi White (P 09)	0.5	49	163				0.47	28	135	
	Har 12	1.6	97	171							
	P 08	0.6	82	194				0.53	25	129	
	P 01	1.3	60	188				0.38	0	132	
	Loc. Fatulurik (M45)	*1.2*	*98*	*249*				*0.29*	*40*	*134*	
	Har 05	0.9	94	156				0.34	27	110	
	AMCAP (M 50)	0.7	72	162				0.42	24	129	
	Loc. Kakatu (M47)	*1.1*	*97*	*227*				*0.23*	*20*	*131*	
	Loc. Viqueque (M49)	*1.2*	*96*	*199*				*0.19*	*21*	*123*	
	MEAN	1.3	82	194				0.39	25	130	
	F prob	*0.011*	*<0.001*	*0.001*				*ns*	*ns*	*ns*	
	lsd	*0.9*	*18*	*40*				-	-	-	
	%CV	*41.2*	*12.9*	*12.3*				*87.4*	*44.2*	*13.9*	
LOES	P 07	3.9	62	192	2.3	1.9	**BAUCAU**	1.2		157	14
	P 11	3.1	71	202	5.5	0.9		1.1		160	9
	Sele (M03)	2.2	48	185	0.0	1.0		1.6		179	7
	Suwan 5 (M02)	4.2	58	254	1.9	0.9		1.5		207	7
	P 03	3.7	65	227	0.3	0.9		1.5		221	12
	Arjuna (M24)	2.8	52	177	2.1	0.2		0.6		215	9
	Tupi White (P 09)	2.1	51	176	3.4	0.0		1.5		169	13
	Har 12	1.9	43	192	0.8	0.4		1.6		177	13
	P 08	1.6	36	168	1.3	0.5		1.7		176	11
	P 01	1.1	38	101	3.1	0.9		1.6		171	6
	Loc. Fatulurik (M45)	*1.6*	*65*	*275*	*5.2*	*1.1*		*1.4*		*178*	*12*
	Har 05	2.0	58	150	0.6	0.2		1.7		181	9
	AMCAP (M 50)	0.6	11	200	0.5	0.3		1.9		180	12
	Loc. Kakatu (M47)	*1.7*	*46*	*249*	*2.9*	*1.6*		*1.0*		*179*	*13*
	Loc. Viqueque (M49)	*2.5*	*64*	*284*	*0.5*	*1.1*		*2.1*		*180*	*7*
	MEAN	2.3	51	202	2.0	0.8		1.5		182	10
	χ^2 *prob*	*<0.001*	*<0.001*	*<0.001*	*ns*	*ns*		*ns*		*<0.001*	*ns*
	lsd	*1.4*	*17*	*63*	-	-		-		*20*	-
	Walf/df	*6.8*	*7.0*	*5.6*	*1.2*	*1.3*		*1.2*		*7.7*	*0.8*

Correlations were found in Loes and Aileu (Figure 15). In contrast, few relationships could be identified at Betano and Baucau. In Loes, yields were strongly correlated to the emergence rates and the plant density at harvest (R^2 above 0.40). Aileu yields were correlated to the number of seeds per cob. The average cob weight (seeds only) was investigated as farmers often specify that "big cobs" are important for good results. This parameter proved indeed to be highly correlated for the results of three stations out of four, with adjusted R^2 ranging from 0.41 to 0.64 and associated F probabilities below 0.010 or 0.001.

Downy mildew damage was recorded in Loes. No significant varietal differences were detected, probably because its impact was very moderate (2% of plants on average). Lodging was also low in this station, but damaged 10% of the plants in Baucau.

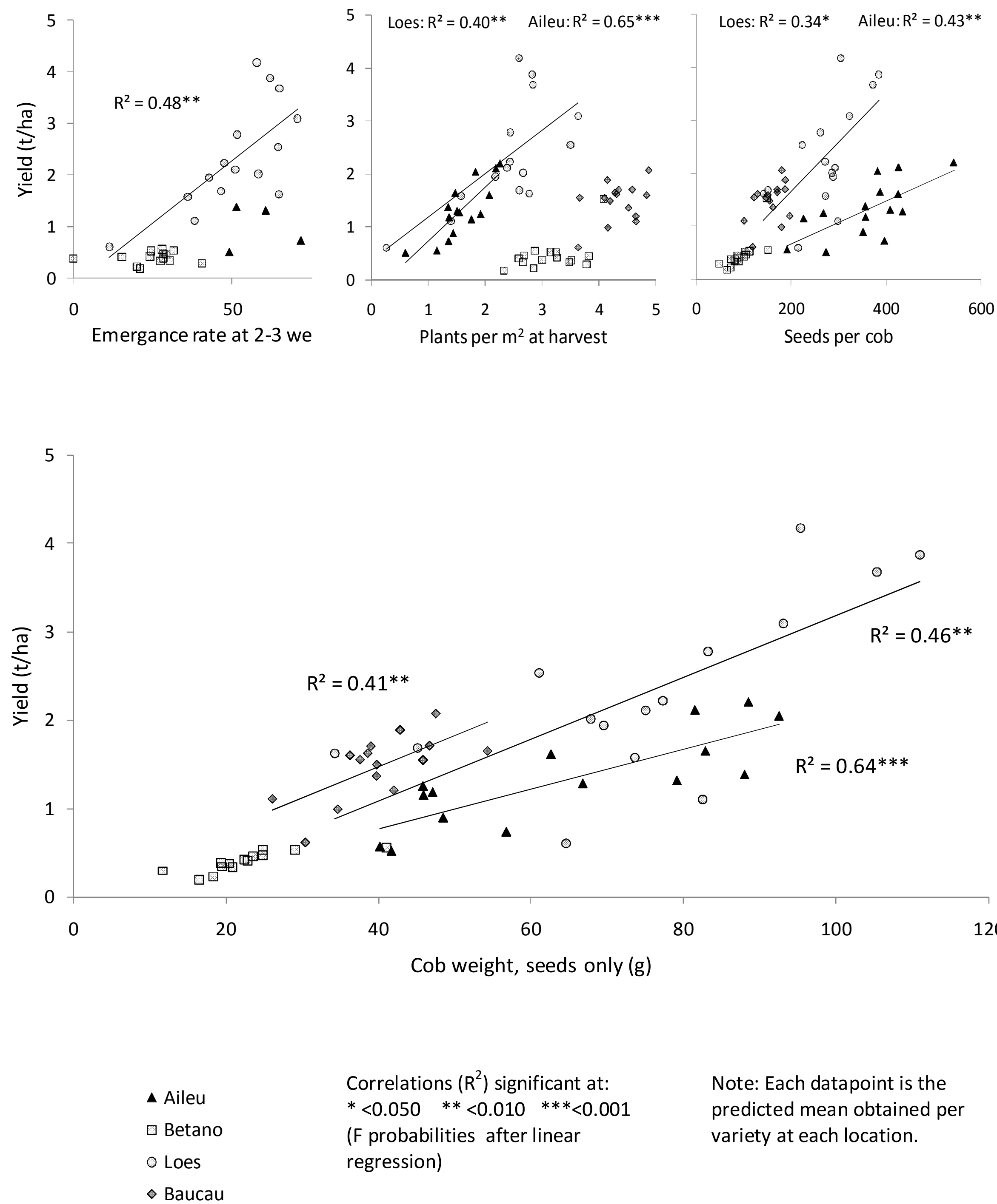


Figure 15. Correlations between yields and yield components, maize 2009/10

Farmers' preferences

Table 8 summarizes the results of both farmer field days about the willingness of farmers to plant the tested varieties in their field. Most introduced varieties were chosen by a majority of farmers, with the exception of P 11, Arjuna, P03 and AMCAP. No significant difference could be found between gender preferences, although women seemed to give their approval more often (about 70% of the participants on average for the five preferred varieties, against an average of 55% for the men).

Table 8. Farmers' preferences, maize, Betano & Loes stations, 2010

Variety	*"Like and wish to plant" (%)* *Both stations (49 pers.)*	*Betano only (39 pers.)*	*Loes only (10 pers.)*	*Males*	*Females*
P 07	63			54	76
Sele		62		60	64
P 08		62		56	71
Suwan 5	61			54	71
Har 12		59		48	79
Loc. Fatulurik	51			57	43
P 11		39		32	48
Loc. Kakatu	35			39	29
Arjuna			20	33	14
P 03			20	0	29
Loc. Viqueque			10	33	0
AMCAP			0	0	0

Note: Male/Female participants: Betano: 25/14; Loes: 3/7

Details of the results of each station are presented in Table 9 and Table 10. Significant varietal differences were found between overall preferences ("Like and wish to plant") for both farmers field day. Significant differences were also identified for the "Soft grain" and "Flavourless" criteria in Betano and for the "Long sheaths" and "Easy to thresh" characteristics in Loes.

In Betano, P07 was the preferred variety (72% of the participants liked it) followed by Sele and P 08 (62%). The latter had the best results for sweetness. Even though the "Fragrant" criteria did not prove to be significant in terms of varietal differences, a strong relationship was found with the overall appreciation of a variety (R^2=0.47, Figure 16), confirming the importance of this taste characteristic.

In Loes, P 07 ranked only third whilst the released variety Suwan 5 was by far the favourite variety. This occurred even though it was said to be tasty by only half the respondents and the least easy variety to thresh. Its exceptional performance (4.2 t/ha) drew the participants choice, as the strong correlation between yield and "Like" (R^2=0.57, Figure 16) indicates. Pounding recovery, i.e. the ability of the grain to break down in medium size bits, was also very important to the respondents. Women in particular emphasised their preference for this characteristic.

Table 9. Farmers' preferences, maize FFD, Betano 2010

Variety / *(%)*	*"Like & wish to plant"*	*"Soft grain"*	*"Sweet taste"*	*"Flavour-less"*	*"Fragrant"*	*Yield (t/ha)*
P 07	72	72	54	26	56	0.53
P 11	38	38	38	54	36	0.56
Sele	62	36	44	59	38	0.46
Suwan 5	56	64	44	41	56	0.39
Har 12	59	77	51	41	54	-
P 08	62	74	59	23	54	0.53
Loc. Fatulurik	*64*	*56*	*44*	*38*	*51*	*0.29*
Loc. Kakatua	*44*	*56*	*41*	*49*	*36*	*0.23*
F prob	*0.012*	*<0.001*	*ns*	*0.011*	*ns*	
l.s.d.	*19*	*20*	*-*	*21*	*-*	
%CV	*74*	*77*	*105*	*117*	*100*	

Table 10. Farmers' preferences, maize FFD, Loes 2010

Variety (*%*)	*"Like & wish to plant"*	*"Very flavoursom"*	*"Long sheaths"*	*"Easy to thresh"*	*"Easy to pound"*	*"Good pounding recovery"*	*Yields (t/ha)*
P 07	30	60	100	90	70	80	3.9
P 11	40	50	70	90	70	70	3.1
Suwan 5	80	50	90	30	60	80	4.2
P 03	20	70	40	60	90	60	3.7
Arjuna	20	10	40	100	50	60	2.8
Loc. Fatulurik	*0*	*30*	*100*	*80*	*30*	*60*	*1.6*
AMCAP	0	40	90	100	50	50	0.6
Loc. Kakatua	*0*	*50*	*70*	*90*	*50*	*70*	*1.7*
Loc. Viqueque	*10*	*40*	*90*	*60*	*30*	*60*	*2.5*
F prob	*<0.001*	*ns*	*0.001*	*<0.001*	*ns*	*ns*	
l.s.d.	*34*	*-*	*35*	*33*	*-*	*-*	
%CV	*169*	*102*	*51*	*48*	*85*	*74*	

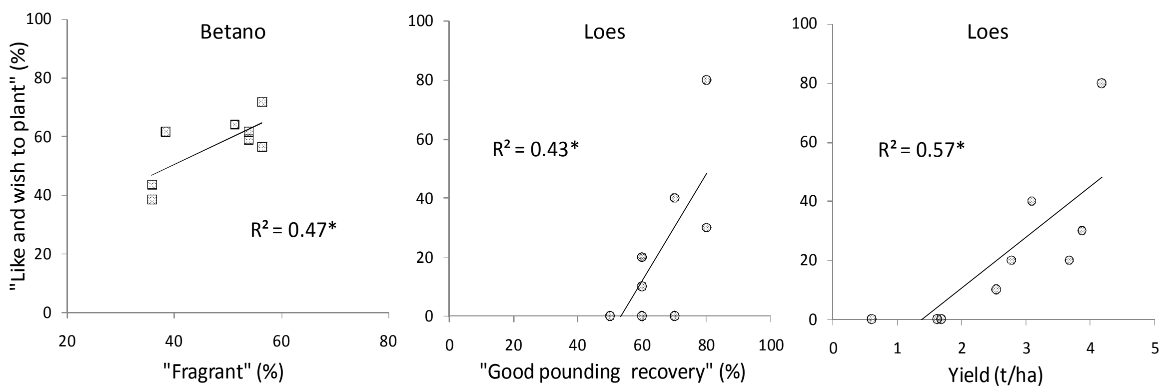


Figure 16. Correlations between farmers' preferences for maize* (2010)

* data from FFD and replicated trials 2010

Conclusions

The best yielding varieties in 2010 were P 07 and Suwan 5 followed by P 11, P03 and Sele. Those varieties performed with overall yields of 2.1-1.7 t/ha which corresponded to +80%-+45% yield advantages above the local checks. Suwan 5 performed particularly well in the excellent growing condictions at Loes while Sele was the most consistent top yielding variety.

These trials confirmed that the driving factor behind the yield was the weight of cobs, i.e. the ability of varieties to do well in the two corresponding yield components (number of seeds per cob and seed weight) rather than either one or the other.

As for farmers' preferences, the white variety P 07 was a favourite in Betano whilst the 4.2 t/ha of yellow Suwan 5 led the participants' choice in Loes. In this station where most participants were female, the importance of pounding qualities was also emphasized. White varieties are generally preferred in the west of the country while there tends to be no colour preference in the East.

2.1.2 Maize replicated trials, multi-year and multi-location analysis

Materials and methods

24 successful maize variety trials (including 3 dry seasons) were implemented by SoL over the period from 2005 to 2010 (5 years) at 6 different sites (Aileu, Betano, Baucau, Maliana, Loes and once in Ladiki), testing the performances of 41 varieties (including 6 local varieties as controls). Some varieties were not included in all trials and some trials were not conducted at every site every year.

The entire dataset, presented in Table 11, comprises 464 data points, i.e. variety per environment combinations. An environment (here synonymous of trial) is defined by the site, year and season (for instance Betano dry season 2009, Loes wet season 2010, etc). All data points are ANOVA or REML predicted means from 3 replicates, 2 in some cases.

Cross-site analyses were conducted using biplots (GGE BiPlot program) in order to evaluate the performances and consistency of the tested varieties across years and locations (genotype / environment). A limitation of the procedure is that only datasets with less than 5% missing data points could be analysed. In addition, datasets resulting in higher percentages of variance explained by the biplot principal components analysis were preferred. Following those principles, two datasets were chosen. Set 1 maximises the number of environments and set 2 the number of genotypes.

Data set 1 investigated the performances of Sele, Suwan 5, Har12, Har 05 and Local Fatulurik in all 24 available environments. This selection included 120 data points with about 3% missing data.

Data set 2, the selection which included the highest number of varieties, covers 14 of them in 14 environments, corresponding to 206 data points (2% missing values).

The effects of environments groups were studied using Linear Mixed Models (REML) in GenStat Discovery 3.

Table 11. All SoL maize replicated variety trials over 2005-2010 (464 data points)

Yield (t/ha) /trial Variety	W06 AIL	W06 BET	W06 BAU	W06 MAL	D06 BET	D06 LDK	W07 AIL	W07 BET	W07 BAU	W07 MAL	W08 AIL	W08 BET	W08 BAU	W08 MAL	W09 AIL	W09 LOE	W09 MAL	W09 BET	W09 BAU	D09 BET	W10 AIL	W10 BET	W10 LOE	W10 BAU	No. Trials	St. dev.	Average yield (t/ha)	Yield adv. (%)
AMCAP (M 50)											1.9	0.7	1.7	1.2	1.2	0.9	1.4	3.6	1.2	1.0	0.7	0.4	0.6	1.6	14	0.8	1.3	10
Arjuna (M24)	2.8	0.9	0.5	2.0	3.0	2.1	1.4	2.1	1.9	1.4	1.2	1.0	0.3		0.9	0.8	0.7	3.1	1.2	1.0	1.3	0.4	2.8	1.2	23	0.8	1.5	26
Har 01	1.6	1.1	0.3	1.2	1.1	1.0																			6	0.4	1.0	-12
Har 02	1.6	1.5	0.5	1.5						0.8															5	0.5	1.2	0
Har 04	1.8	1.0	1.1	1.7	1.9	1.8	3.4	1.5	3.1	0.4															10	0.9	1.8	50
Har 05	2.0	1.7	0.6	2.0	1.6	1.7	3.4	1.5	3.3	0.6	1.6	1.2	0.6	1.4	0.5	1.5	1.4	2.8	1.4	0.8	0.9	0.3	2.0	1.1	24	0.8	1.5	27
Har 05-A (cross)							3.1	2.4	2.2	1.2															4	0.8	2.2	89
Har 05-K (cross)							3.5	1.7	1.6	1.2															4	1.0	2.0	70
Har 06	1.4	1.5	0.8	1.7	3.2	2.0	4.2	2.4	2.2	1.0	1.4	1.6	1.4	1.5						1.1					15	0.9	1.8	55
Har 07	1.9	1.8	0.8	1.6			4.2	2.4	1.8	0.7															8	1.1	1.9	61
Har 12	3.2	2.2	0.7	1.7	3.4		3.5	2.7	3.8	0.3	1.8	0.6	1.6	1.2	0.8	0.9	1.4	3.6	1.4	1.3	1.6		1.9	1.6	22	1.1	1.9	59
Har 13					2.1	1.8			4.2																3	1.3	2.7	129
Kalinga (M39)	2.3	0.9	0.9	1.5			4.9	1.9	2.7	0.6				0.5											9	1.4	1.8	53
M 04	2.9	1.0	0.4	1.8																					4	1.1	1.5	29
M 07	3.1	1.4	0.3	1.7																					4	1.2	1.6	38
M 12	2.8	1.6	0.5	1.2					2.5																5	0.9	1.7	46
M 13	1.8	1.1	0.2	1.1	1.9	2.1		2.5	1.9																8	0.7	1.6	33
M 25		1.5	0.2																						2	1.0	0.8	-30
M 46	0.3	1.1	0.4	1.0																					4	0.4	0.7	-41
Nai (M 51)											1.5	1.5	1.1	1.6	1.2	0.5	1.0	2.5	0.9	1.3					10	0.5	1.3	10
P 01					3.7	1.5	3.9	3.5	3.0	0.8	1.7	0.8	1.6	0.3	1.6	0.5	0.9	2.7	1.4	0.0	1.3	0.4	1.1	1.5	20	1.2	1.6	37
P 02					2.3	1.2	4.4	2.3	3.0	0.9					0.6	1.8	1.1	3.0	1.0	0.7					12	1.2	1.9	58
P 03					3.5	1.5	3.7	2.6	2.9	0.6	1.8	1.4	1.7	0.9	0.7	0.6	1.5	2.9	1.2	0.7	1.4	0.3	3.7	1.7	20	1.1	1.8	49
P 04					2.4	2.3	3.0	2.2	1.7	0.5															6	0.9	2.0	71
P 05					2.0	1.6	3.8	1.9	2.5	0.6										1.0					7	1.0	1.9	62
P 06					2.6	1.7	3.7	2.3	3.4	0.6					0.9	0.9	1.4	1.7	1.3	0.8					12	1.0	1.8	50
P 07					3.1	2.3	4.6	2.6	1.5	1.0	1.6	1.2	1.4	0.8	0.3	1.5		0.5	1.8	1.0	2.2	0.5	3.9	1.6	19	1.1	1.8	49
P 08					3.1	1.7	4.6	2.4	2.8	0.7	1.3	0.9	1.1	0.9	0.7	0.7	1.2	2.3	1.0	0.9	0.6	0.5	1.6	1.4	20	1.0	1.5	29
P 11											1.2	1.3	1.4	1.2	1.7	0.9	1.7	2.5	1.8	0.6	1.6	0.6	3.1	1.7	14	0.7	1.5	29
P 13															0.8	0.9	1.1	2.6	0.5	0.6					6	0.8	1.1	-8
Sele (M03)	1.8	2.0	0.3	2.0		2.3	4.2	1.7	2.5	2.4	1.8	0.7	2.0	1.5	1.4	1.0	1.3	3.8	1.9	1.1	2.1	0.5	2.2	1.9	23	0.9	1.8	57
Suwan 5 (M02)	2.3	2.0	0.4	2.0	1.9	1.6	3.7	1.9	1.8	0.5	1.5	1.6	1.2	1.6	0.8	1.5	1.4	3.5	2.2	1.5	2.0	0.4	4.2	1.0	24	1.0	1.8	50
Syn White (P 10)											1.7	0.8	1.7	0.9					1.8						5	0.5	1.4	17
Takro (P 12)											1.1	0.2	0.9	0.7					1.1						5	0.4	0.8	-33
Tupi White (P 09)											1.5	1.0	1.8	1.1	1.1	0.1	0.7	3.8	1.8	0.6	0.5	0.5	2.1	2.1	14	0.9	1.3	14
L. Daisua (M52)																				*1.0*					*1*	*-*	*1.0*	*-12*
L. Fatulurik (M45)	*1.5*	*1.4*	*0.2*	*0.7*	*2.0*	*1.5*	*3.0*	*2.2*	*1.8*	*0.3*	*1.9*	*1.3*	*1.7*	*0.8*	*0.6*	*0.6*	*0.7*	*1.3*		*0.7*	*1.2*	*0.3*	*1.6*	*1.5*	*23*	*0.7*	*1.3*	*6*
L. Fatumaka (M48)					*1.9*		*0.9*	*0.5*			*1.2*		*1.1*	*0.5*											*6*	*0.5*	*1.0*	*-14*
L. Kakatua (M47)	*0.5*	*2.0*	*0.1*	*0.8*			*3.5*	*1.6*	*2.2*	*0.5*	*0.7*	*0.6*	*1.2*	*1.4*	*1.0*	*0.8*	*0.9*	*2.3*	*1.1*	*0.9*	*1.1*	*0.2*	*1.7*	*1.5*	*22*	*0.8*	*1.2*	*3*
L. Maubara (M44)	*1.6*	*1.5*	*0.5*	*0.8*			*1.8*	*0.4*	*2.3*	*1.1*	*1.2*	*0.4*	*1.7*	*0.4*											*12*	*0.6*	*1.1*	*-3*
L. Viqueque (M49)															*0.7*	*0.2*	*1.0*	*2.0*	*1.0*		*1.2*	*0.2*	*2.5*	*0.6*	*9*	*0.8*	*1.0*	*-12*
l.s.d.	*n.a.* *n.a.*	*n.s.*	*n.a.* *n.a.*	*n.a.* *n.a.*	*1.1* **	*1.3* **	*1.3* **	*1.1* **	*0.6* **	*0.5* **	*0.7* *	*0.8* **	*0.8* ***	*0.5* ***	*0.7* **	*0.8* ***	*0.7* ***	*1.1* ***	*1.0* ***	*0.6* **	*0.9* *	*n.s.*	*1.4* ***	*n.s.*	*Total no. of data points: 464*			
Mean locals	*1.2*	*1.6*	*0.3*	*0.8*	*2.0*	*1.5*	*2.3*	*1.2*	*2.1*	*0.6*	*1.3*	*0.8*	*1.4*	*0.8*	*0.8*	*0.5*	*0.9*	*1.9*	*1.1*	*0.9*	*1.2*	*0.2*	*2.0*	*1.2*	*24*	*0.6*	*1.2*	*0*
Mean site	2.0	1.5	0.5	1.5	2.5	1.8	3.5	2.1	2.5	0.8	1.5	1.0	1.4	1.0	0.9	0.9	1.2	2.7	1.4	0.9	1.3	0.4	2.3	1.5	24	0.8	1.5	30

Notes: AIL = Aileu, BET = Betano, BAU = Baucau, MAL = Maliana, LOE = Loes, LDK = Ladiki.
W06 = wet season 2005-2006, D06 = dry season 2006. ANOVA/REML p-values: * <0.050, ** <0.010, ***<0.001

Results

The average yield of the entire dataset (24 environments, 464 data points) was 1.5 t/ha (st.dev = 0.8) against 1.2 t/ha for the local checks alone (24 environments, 73 data points, i.e. 16% of the entire dataset). Yield averages from trial to trial varied from 0.4 t/ha to a maximum of 3.5 t/ha (wet seasons of Betano 2010 and Aileu 2007 respectively), with about half the sites performing within 1.0-2.0 t/ha. Across 5 years, all sites recorded low and high yields.

Among the 41 varieties, 20 were tested 10 times or more. Assuming that those trials represent random samples of environments, a comparison of the overall results can be made, as presented in Table 12:

Table 12. Maize mean yields and yield advantages over 2005-2010 (5 cropping years)

Variety	*No. of trials*	*Mean St. dev.*	*Mean yield (t/ha)*	*Yield advantages (%)**	*2010 status*
Har 12	22	1.1	1.9	59	Tested twice on OFDTs. Not as good as Sele. To be discarded
P 02	12	1.2	1.9	58	Continue testing. Seeds to be re-imported.
Sele	23	0.9	1.8	57	Release in 2007. Standard for OFDT testing.
Har 06	15	0.9	1.8	55	Continue testing. Seeds to be re-imported.
P 06	12	1.0	1.8	50	Continue testing. Seeds to be re-imported.
Suwan 5	24	1.0	1.8	50	Release in 2007.
Har 04	10	0.9	1.8	50	Continue testing. Seeds to be re-imported.
P 03	20	1.1	1.8	49	Continue testing.
P 07	19	1.1	1.8	49	Currently being tested on OFDTs.
P 01	20	1.2	1.6	37	Continue testing.
P 11	14	0.7	1.5	29	Continue testing.
P 08	20	1.0	1.5	29	Continue testing.
Har 05	24	0.8	1.5	27	Tested twice on OFDTs. Not as good as Sele. To be discarded
Arjuna	23	0.8	1.5	26	To be discarded (poor weevil tolerance).
Tupi White	14	0.9	1.3	14	To be discarded.
Nai	10	0.5	1.3	10	To be discarded.
AMCAP	14	0.8	1.3	10	To be discarded.
Loc. Fatulurik	*23*	*0.7*	*1.3*	*6*	*Control*
Loc. Kakatua	*22*	*0.8*	*1.2*	*3*	*Control*
Loc. Maubara	*12*	*0.6*	*1.1*	*-3*	*Control*

* Calculated over the local varieties overall average = 1.17 t/ha, st.dev. = 0.57 (6 varieties representing 73 datapoints over 24 environments)

Nine varieties performed with about 1.8 t/ha overall, which corresponded to +60%-+50% yield advantages over the locals. Among those varieties are the released varieties Suwan 5 and Sele, the latter being one of the most consistent top yielding varieties. The other best yielding varieties are the white grain Har 12, 06 and 04 from Zimbabwe and P 02, 06, 03 and 07 from the Philippines.

The biplot from data set 1, which investigates the performances of Sele, Suwan 5, Har12, Har 05 and Local Fatulurik in all 24 available environments, is plotted in Figure 17 along with the 'which wins where' analysis.

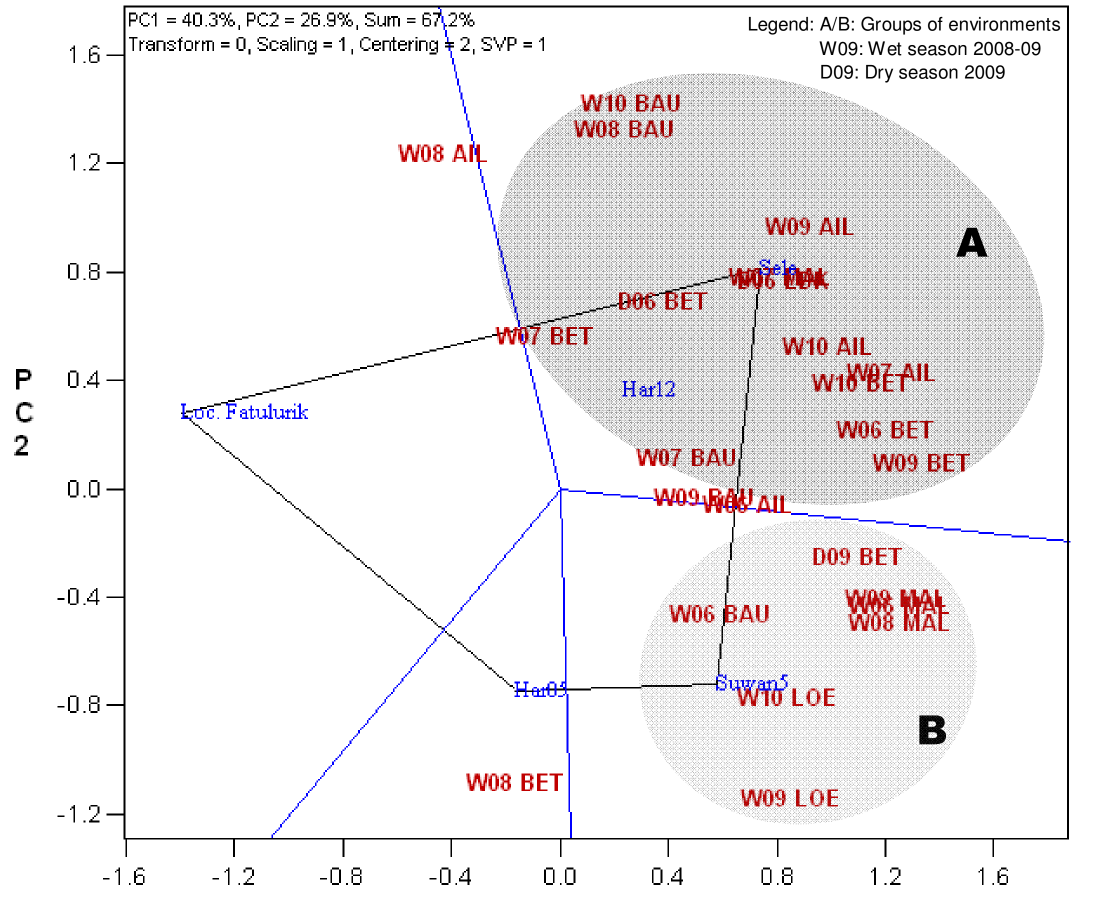


Figure 17. **BiPlot analysis of 5 maize varieties in 24 environments (set 1), 2005-2010**

Table 13. **Genotype and environment groups interaction, 2005-2010**

Fixed term (REML)	*Wald statistic*	*d.f.*	*Wald/d.f.*	*Chi-sq prob*
Genotype	28.2	4	7.06	<0.001
Group	1.9	2	0.97	n.s.
Geno.Group	20.7	8	2.59	0.008

Genotype \ *Environment groups*	*Group A (13 envir.)*	*Group B (7 envir.)*	*Others (4 envir.)*	*All (24 envir.)*
Suwan5	1.7	1.8	1.9	1.8
Sele	2.3	1.3	1.6	1.7
Har12	2.2	1.3	1.8	1.7
Har 05	1.5	1.4	1.6	1.5
Local Fatulurik	*1.4*	*0.8*	*1.6*	*1.3*

Genotype.Group LSD = 0.85

The biplot, which represent about 70% of the data variance, shows a division of the environments, showing which varieties are performing best where. For instance, Suwan 5 performed exceptionally well during 2010 at Loes which is represented by the proximity of 'Suwan 5' and W10 LOE in the Biplot, while Sele was average. In contrast, the situation was reversed for W07 Maliana and D06 Ladiki.

The analysis confirmed that the local variety and Har 05 performed poorly in all environments. The Biplots divisions also showed that Sele and Har 12 performed well in a majority of environments and somehow similarly and Suwan 5 performed well too, however differently. Two groups of environments (A and B) could therefore be discriminated where varieties, and particularly Sele/Har12 versus Suwan 5, ranked differently. This was confirmed by running a REML analysis, as shown in Table 13. Environment groups were not significantly different but the interaction Genotype.Group was.

One particular pattern could be found in the environments groups. Group A was mostly made up of Aileu, Betano and Baucau sites (12 environments out of 13) while Maliana and Loes sites constituted most of Group B (5 out of 7). An hypothesis would therefore be that Sele is to be particularly recommended in the first set of locations while Suwan 5 should be in the others. However, this should be further investigated with OFDT data and any recommendation mitigated with farmers' local preferences and weevil tolerance.

The biplot corresponding to data set 2, the selection which included the highest number of varieties, is plotted in Figure 18.

The analysis represented less than 50% of the variability observed. Nevertheless, some valuable observation could be made. First, Sele and Suwan 5 kept their predominant positions, both performing best in all environments divided in two groups as identified from set 1 in Figure 17. Then, P 11 could be observed following a similar pattern to Sele's while P 07 was closer to Suwan 5. Otherwise, none of the other varieties performed as well, being comparatively plotted far from all environments.

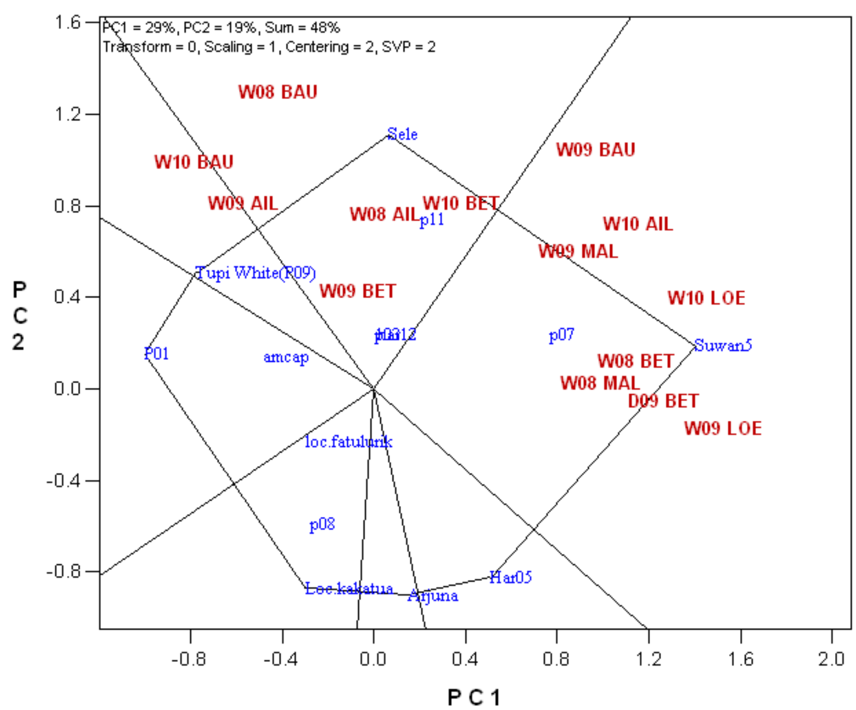


Figure 18. BiPlot analysis of 14 maize varieties in 14 environments (set 2), 2005-2010

Conclusions

Over 5 years, SoL conducted 24 successful varietal maize trials on 41 varieties, representing a total of 464 individual data points (variety per environement combinations). Results varied significantly both by genotype (varieties) and environment (locations, years, seasons).

The collected data allowed selecting, releasing and confirming the Sele and Suwan 5 varieties as suitable according to production (measured over five years as +60% and +50% respectively over locals), taste and suitability (OFDTs). Sele in particular, in addition of yielding the highest, also showed good consistency and good weevil tolerance.

Several white varieties from Zimbabwe and the Philippines also performed well overall, particularly Har 12, P 02, Har 06, P 06, Har 04, P03 and P07. These were followed by P 01, P 11, P 08, Har 05 and Arjuna. However, after two years of OFDT evaluation, Har 12 and Har 05 did not prove to yield as well as Sele on farmers fields and will therefore be discarded from further evaluation. Arjuna was also discarded because of its low weevil tolerance. The suitability and consistency of P 07 is currently being investigated, as well as a cross between P 07 and H 12. As for P 11, it will be further observed on research stations.

2.1.3 Maize On-Farm Demonstration Trials 2009-2010

On Farm Demonstration Trials (OFDTs) were established in 17 Sub-Districts of Timor-Leste to test whether open pollinated downy mildew resistant varieties selected on research stations perform better than the local varieties that farmers plant when tested in farmers fields, using local agronomy.

Varieties tested in the 2009-2010 wet season included Sele (M03), the yellow maize variety originally from India and released by the MAF. White maize varieties, Har12, which is from CIMMYT, Zimbabwe, and P07 from Central Mindanao University in the Philippines, were also tested. The new maize varieties tested produced yields above local maize populations during testing on research stations at four locations in Timor-Leste.

The OFDTs were used to test the hypothesis that these varieties can produce yields above local maize populations on farmers' fields with no extra inputs, or changes to agronomy. Accordingly a plot of the same area of a local maize variety was established next to the test varieties for comparison.

Materials and methods

228 OFDTs were established in all the Agro ecological zones in Timor-Leste, incorporating 17 Sub-Districts in the Districts of Aileu, Ainaro, Baucau, Bobonaro, Liquica, Manufahi and Viqueque. One or two researchers worked in each Sub-District and their target was to establish 15 maize OFDTs each.

Each researcher used their own contacts to identify participating farmers. This was often through consultations with the Chefe de Suco, with MAF extension and other staff, or farmers that were already known to the staff.

MAF staff explained to farmers that the SoL program would not be giving away extra seed or fertilizer, but aimed only to trial the new varieties. The researchers were careful to explain that the evaluations were one of the stages of research and they were not sure how the varieties would perform. Hence limited amounts of seed were given to farmers.

The researchers gave 200g seed packets of the test maize varieties to the farmers. Local varieties used at each site were chosen by collaborating farmers, and were generally the normal full season maize variety grown on that farm. Local variety seed was supplied by the collaborating farming family, and therefore was unique to each test location.

Each OFDT site was marked out by string or bamboo by the researchers so that each variety was planted in a 5m x 5m plot. These plots were arranged side by side along contour lines. The order in which they were planted at each site was allocated randomly and there was no replication.

Generally, the researchers were present with farmers during planting. This was a goal but was not always possible to achieve due to the number of sites for which each researcher was responsible, but for the majority of sites it was realized.

Researchers visited the site an average of 6.5 times from planting to harvest. At each visit they recorded different information about the OFDT. These data collection protocols monitored progress of the trial/demonstration. In-season measurements included plant height, identification of pests and diseases in each plot, wilting and other plant symptoms.

At harvest, staff recorded the fresh weight of cobs from the whole plot ($25m^2$). A sub-sample of 5 cobs was taken from the fresh cobs at harvest time, and only grain from these cobs were threshed and dried. The ratio of dried grain to the cob fresh weight was used to convert the total fresh weight of cobs to amount of grain weight per plot, and then converted to tons per hectare.

Site characterization

All sites were located (latitude, longitude and elevation) with a Garmin ETrex. The ETrex is a 12 channel GPS receiver, which allows accuracy of measurement of plus or minus 6m. In addition, the slope of the land was defined at each site as was the aspect of the test location. Based on elevation and location, each site was allocated to a particular Agro-Ecological Zone (AEZ) (ARPAPET 1996). AEZs are numbered from 1 to 6, starting with 1 in the lowlands of the north coast to 6 in for the lowlands of the south coast (Table 14).

Table 14. Definition of the 6 agro-ecological zones in Timor-Leste (ARPAPET, 1996).

AEZ	*Location*	*Elevation*
1	Northern coast	0-100m
2	Northern slopes	100-500
3	Northern uplands	>500m
4	Southern upland	>500m
5	Southern slopes	100-500
6	Southern coast	<100m

All sites for OFDTs in the 2009/10 cropping season were tested for soil pH using Manutec test kits. The test kits are designed for in-field use. Composite samples of soil were collected from each plot and sieved through a 2 mm sieve. Sieving removes rocks, large clods etc. A small amount of soil was placed on a white slide and indicator fluid added. After thorough mixing, a white powder was added to the surface of the soil/indicator mixture. The white powder assumed the color of the indicator, and pH value identified by comparing that color with a standard color sheet.

Soil texture (Table 15) was estimated using a field based ribbon test method. Prior to testing, a handful of surface soil was sieved and water added to make a malleable bolus. This wet soil was formed into a round ball, and then attempts made to form a ribbon with the wet soil. The length of the ribbon (in cm) was measured and compared to a reference table which staff carried with them in the field, and the ability to form a U shape and a donut shape with the ribbon was used as a further indicator to describe soil texture.

Table 15. Determining soil texture characteristics.

Texture	*Description*	*Length of soil ribbon*
Sandy	The soil stays loose and separated, and can only be accumulated in the form of a pyramid.	Nil
Sandy Loam	The soil contains enough silt and clay to become sticky, and can be made into the shape of a fragile ball.	15-25 mm
Silty Loam	Similar to the sandy loam, but the soil can be shaped by rolling it into a small, short cylinder. Soil has a 'silky' feel.	25 mm
Loam	Contains almost the same amount of sand, silt and clay. Can be rolled into a 15 cm long (approximately) cylinder that breaks when bent.	25 mm
Clay Loam	Similar to loam, although the cylinder can be bent into a U shape (without forcing it) and does not break.	40-50 mm
Fine Clay	The soil cylinder can be made into the shape of a circle, but shows some cracks.	50-75 mm
Heavy Clay	The soil cylinder can be shaped into a circle, without showing any cracks.	>75 mm

From Agricultural Compendium for Rural Development in the Tropics and Subtropics' (1989) and B McDonald et al. (1990).

Analysis

Data from the protocols was first entered into an MS Excel spreadsheet database before being transferred for further analysis to GenStat Discovery Edition 3. Yield data was analyzed by ANOVA (Unbalanced Model) in a range of methods. The model of the analysis always included variety and AEZ as factors in the model once the other location factors of District and Sub-District had been tested. As elevation was shown to have an impact on crop yield between sites, elevation was included as a co-variate in testing across factors in the analyses.

The influence of a wide range of factors on maize yield was tested. In turn, each factor was added to the model, one at a time. If they were significant, the factor was kept in the model, and if they were non-significant the factor was discarded. Once a significant factor was identified, the interaction of that factor and variety was also tested for significance at the $P = 0.05$ level.

Results

Testing environments

Maize OFDTs were conducted on a wide range of soil textures, pH, slope and elevation. Elevation of OFDT sites ranged from almost sea level to over 1,835m in Maubisse. The distribution of sites at the various elevation ranges for trial sites is similar to the previous year. (Table 16). Nineteen percent of trials were conducted at elevations over 1000m.

Table 16. Distribution of maize OFDT sites by elevation, 2008/09 and 2009/10.

Elevation (masl)	*Locations 2008/09 (%)*	*Locations 2009/10 (%)*
0-150	27	28
150-350	15	14
350-550	12	10
550-750	12	11
750-950	12	15
950-1150	10	11
1150-1350	7	4
1350-1550	3	5
>1550	2	2

Soil pH, elevation and texture

The average soil pH across the OFDT test sites was 6.7, ranging from 5 to 9. A low percentage of sites had soil pH levels at the extremes compared with previous years. Approximately 8% of sites can be described as having acid soils (pH 5.5 or less) and approximately 9% of the sites described as having alkaline soils (pH 8.0 or above). The remainder of the sites (83%) had soil pH values between 6.0 to 7.5 inclusive (Table 17).

Table 17. Distribution of soil pH across maize OFDT sites 2008/09 and 2009/10

Soil pH	*Locations 2008/09 (%)*	*Locations 2009/10 (%)*
4.5	1	0
5	2	2
5.5	12	6
6	18	18
6.5	18	30
7	14	19
7.5	14	16
8	16	7
8.5	9	1
9	2	0

Soil pH and elevation differed statistically (F Pr. <0.001) between Sub-District (Table 18).

Table 18. Soil pH and elevation of maize OFDT locations, 2008/09 and 2009/10

District	*Sub-District*	*Elevation 2008-09*	*Soil pH 2008-09*	*Elevation 2009-10*	*Soil pH 2009-10*
Aileu	Aileu	1030	6.1	943	6.3
Aileu	Laulara	na	na	1219	6.1
Aileu	Liquidoe	1195	5.6	1268	6.5
Aileu	Remexio	962	5.7	988	5.9
Ainaro	Hatudo	218	7.4	254	7.4
Ainaro	Maubisse	1550	7.2	1508	6.8
Baucau	Baucau	499	4.0	529	6.9
Baucau	Laga	311	8.3	na	na
Baucau	Vemasse	454	6.6	497	6.6
Baucau	Venilale	799	7.8	830	7.5
Bobonaro	Balibo	na	na	150	7.1
Bobonaro	Maliana	268	7.5	199	7.0
Bobonaro	Cailaco	113	7.0	n/a	n/a
Liquica	Liquica	352	6.3	291	6.7
Liquica	Maubara	277	6.8	181	6.9
Manufahi	Alas	48	7.5	79	7.0
Manufahi	Same	314	6.4	274	7.4
Manufahi	Turiscai	1197	6.2	n/a	n/a
Viqueque	Ossu	610	6.1	830	6.2
Viqueque	Viqueque	na	na	44	6.3
LSD ($p<0.05$)		81	0.29		

na Not available

There was a general trend of the higher altitude Sub-Districts having lower soil pH values though not as strong as in other years. The regression (Figure 19) suggests that the higher the elevation, the lower the pH. A rate of the decline in pH of approximately $^1/_2$ unit of pH per 1000m of elevation compares with 1 unit of pH over the same elevation range in previous years. Like last year, Maubisse and Venilale Sub-Districts were the most distant from the regression line. Maubisse has the highest elevation of any Sub-District, but possesses neutral soil pH (pH 7.2). The more neutral pH in Maubisse and Venilale was probably due to the large number of limestone outcrops in those areas, reducing the acidifying effect of high rainfall. Omission of Maubisse and Venilale from the regression results in mean elevation of each Sub-District raises to 44% the percentage of variation in soil pH across Sub-Districts explained by elevation.

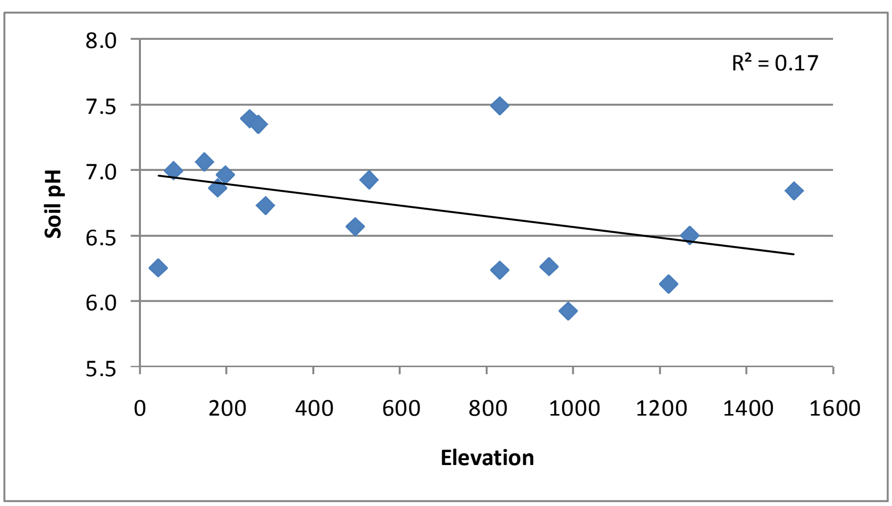


Figure 19. Effect of elevation on soil pH for maize OFDT sites, 2009/10.

There was a good spread of soils across the texture gradient with sandy loam, clay loam and fine clay being the most frequent soil types recorded. No extremely sandy soils were found (Table 19).

Table 19. Distribution of soil texture of maize OFDT, 2008/09 and 2009/10

Soil texture	*Location 2008/09 (%)*	*Locations 2009/10 (%)*
Sandy	2	
Sandy Loam	10	20
Silty Loam		11
Loam	19	14
Clay Loam	30	23
Fine Clay	27	23
Heavy Clay	12	8

Trial losses

OFDT trial result losses of 18% (40 from 228 trials established) in 2009/10 were higher than the previous 3 years of testing cropping seasons (17% in both 2008/09 and 2007/08, 18% in 2006/07), though lower than in 2005/06 (25%). Of the reasons reported, as in other years, animal predation on crops was the reason for most crop losses. Other factors reported were that farmers did not follow planting directions and that the plots were harvested in the absence of the OFDT staff.

Variety

Like the previous year, grain yields of Sele, and P07 were significantly higher than local maize populations averaged over all Districts (Table 20). However the yield of Har12 just failed to reach significance for yield advantage over the local varieties on this occasion. Such increases were obtained without the addition of fertilizer, pesticides etc to the farmers agronomic practices.

Table 20. Yield components for OFDT maize varieties over all OFDTs, 2009/10

Variety	*Yield (t/ha)*	*Density (plants/m^2)*	*Cobs/plant*	*Seeds/cob*	*Cob weight (g)*	*Seed weight (g/100)*
Local	1.8	4.7	0.92	226	48	24
Har12	2.1 (17 %)	4.8	0.93	229	54	25
P07	2.5 (40%)	4.7	0.94	235	64	27
Sele	2.7 (51%)	4.8	0.94	240	66	28
LSD ($P \leq 0.05$)	*0.3*	*ns*	*ns*	*ns*	*7*	*1.8*

* Figures in brackets indicate yield advantage over Local

As in all previous testing years, Sele produced significantly more yield than the local populations, through having larger cob weights.

Har12, as in 2007/08 just failed to reach significance for yield advantage over local. However on this occasion differences in plant density were not a determining factor. This is in contrast to 2008/09 where Har12 did reach significance on yield over the local populations.

The performance of P07 was more impressive in 2009/10 with a yield of 2.5 t/ha compared to 1.7 t/ha in 2008/09. It had similar seed and cob weights to Sele. A slightly higher plant density for Sele appears to be the main determinant in it outperforming P07 on yield in the 2009/10 years OFDTs.

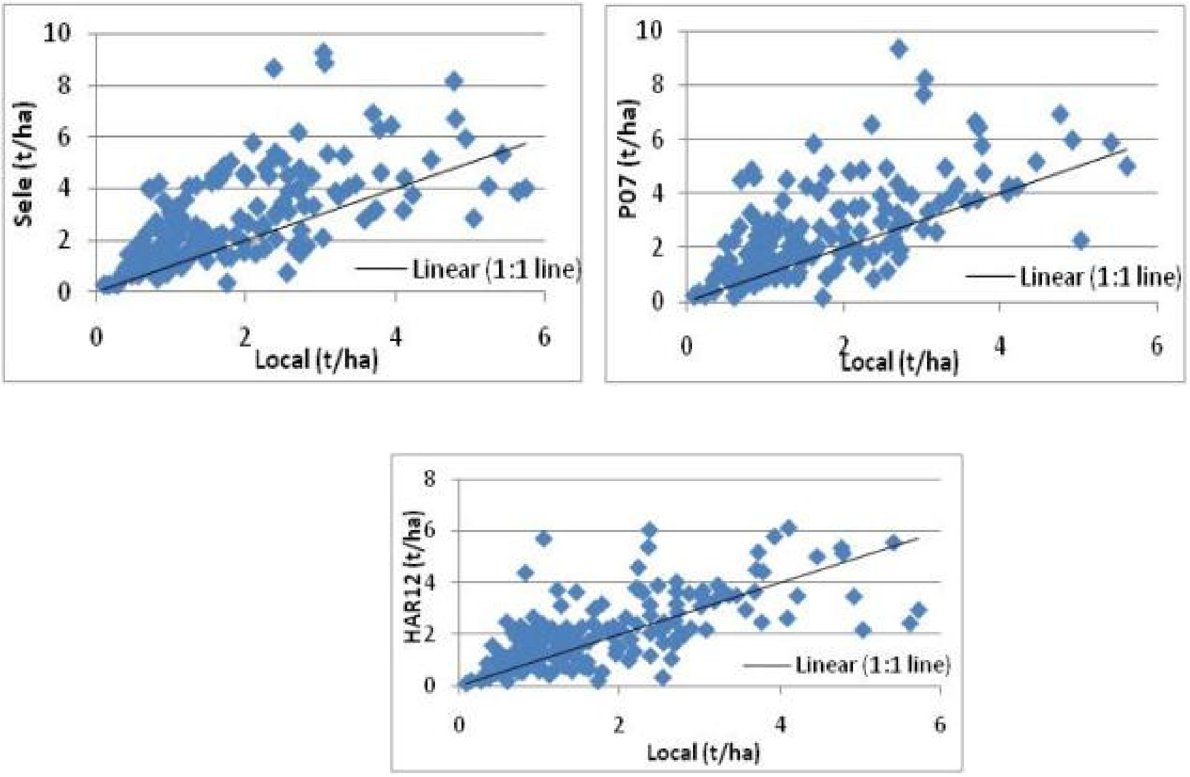


Figure 20. Yield of 3 test populations versus the local population at all sites in 2009/10

Figure 20 demonstrates graphically the yield relationship between the local and new varieties at each site. It can be seen from the graphs that with Sele and P07 most of the data points lie above the 1:1 line that is plotted through the aggregate of local yield data. However with Har12 there are many more points lying below this line, a fact borne out in the ANOVA analysis where Har12 fails to reach significance in yield difference over local varieties.

Maize yield increased for all varieties as plant density increased to 5 plants/m^2, and tended to plateau thereafter. (Table 21 and Figure 21). There was no statistically significant interaction between plant density and variety for grain yield, with Sele tending to outperform the other varieties at most plant density ranges. There is no reason therefore to recommend different planting densities for these tested varieties but the lack of data for density greater than 7 plants/m^2 would make such a recommendation difficult to justify in any case.

Table 21. Effect of crop density on yield for OFDT maize varieties, 2009/10

Plant density (plants/m^2)	*Local Yield (t/ha)*		*Har12 Yield (t/ha)*		*P07 Yield (t/ha)*		*Sele Yield (t/ha)*	
< 1	0.1	(1)	0.1	(1)	0.2	(1)	0.3	(1)
1 – 2	0.9	(2)	1.1	(7)	0.5	(5)	1.0	(2)
2 – 3	1.1	(27)	1.8	(21)	1.7	(25)	1.8	(24)
3 – 4	1.7	(30)	1.9	(28)	2.3	(25)	2.8	(29)
4 – 5	1.8	(49)	2.3	(54)	3.1	(51)	3.0	(47)
5 – 6	2.1	(38)	2.2	(26)	2.6	(29)	2.5	(41)
6 – 7	2.0	(25)	2.1	(26)	2.3	(19)	3.2	(26)
7 – 8	2.3	(9)	2.7	(13)	3.0	(11)	3.3	(12)
> 8	2.3	(5)	2.3	(8)	3.7	(5)	2.7	(5)

* Figures in brackets indicate the number of observations.

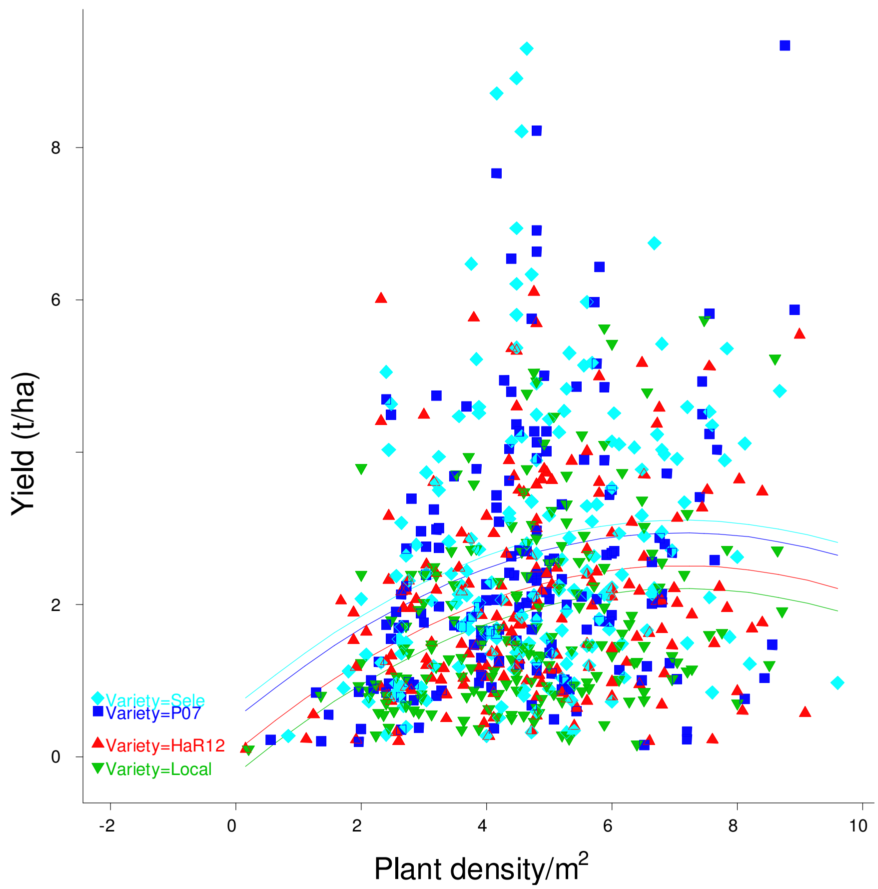


Figure 21. Regression graph comparing plant density and yield

Districts

Yields of Sele and P07 were highest in Baucau Sub-District (Table 22). The neighboring Sub-Districts of Same and Hatudo yielded highest for Har12 and Local respectively. Lowest yields for Sele, Har12 and Local were in Maubisse Sub-District. Maliana was the lowest yielding Sub-district for P07.

Baucau was the highest yielding Sub-District in 2007/08 suggesting that its below par performance for 2008/09 on maize OFDT yield was somewhat of an anomaly. The soils of much of the Sub-District are red and deep in many instances. These red soils have been observed to be some of the most fertile in the country during Seeds of Life work over the years. Hatudo and Same both inhabit moderate elevations towards the south of the country which typically have more rainfall than the north.

In contrast, Maubisse with the lowest maize yields is the highest Sub-District with the average trial site elevation here being over 1500m. It is one of the main sites for Seeds of Life work on temperate crops and is also a hub of the horticulture industry. Maize, wheat, barley and rice can be seen growing side by side here but elevation limits maize production. Maliana is best known for its rice production. However maize yields were above average in OFDTs for 2008/09 in contrast to 2009/10.

There was no significant interaction between variety and Sub-District. This suggests that the higher yield of Sele is consistent across Sub-Districts and there is no reason to recommend different varieties for different Sub-Districts.

Table 22. Maize OFDT grain yield (t/ha) and yield advantage by Sub-District 2009/10

District	*Sub-District*	*Local*	*Har12*	*P07*	*Sele*	*Yield advantage P07 over local*	*Yield advantage Sele over local*
Aileu	Aileu	1.1	1.5	2.3	2.0	113%	87%
Aileu	Laulara	1.2	1.2	*	3.4	*	186%
Aileu	Liquidoe	1.5	1.1	*	1.7	*	17%
Aileu	Remexio	2.2	2.8	*	3.0	*	36%
Ainaro	Hatudo	3.5	2.5	2.5	3.5	13%	1%
Ainaro	Maubisse	1.0	1.1	1.6	1.3	54%	32%
Baucau	Baucau	2.3	2.6	3.9	4.5	72%	101%
Baucau	Vemasse	1.5	1.5	2.1	2.4	40%	61%
Baucau	Venilale	1.3	1.6	1.6	2.2	29%	71%
Bobonaro	Balibo	3.0	3.0	3.4	3.5	11%	49%
Bobonaro	Maliana	1.5	1.4	1.1	1.3	-12%	-5%
Liquica	Liquica	1.5	2.5	2.7	2.2	76%	44%
Liquica	Maubara	2.5	2.7	3.1	3.2	26%	28%
Manufahi	Alas	2.0	2.2	2.6	2.7	28%	33%
Manufahi	Same	2.3	3.1	3.8	3.2	63%	40%
Viqueque	Ossu	1.5	1.2	1.3	1.4	-9%	-2%
Viqueque	Viqueque	1.2	2.0	2.0	2.3	72%	101%
Average		1.8	2.0	2.4	2.6	*41%*	*52%*

* P07 not planted in these Sub-Districts

Sele and P07 showed yield increases above local maize populations in all Sub-Districts tested excluding Maliana and Ossu, where they yielded marginally less than local varieties (Table 22). The yield advantage of Sele at 52% above local populations was similar to the equivalent value from the previous year. The value for P07 was double the value recorded in 2008/09 but was more than 10% lower than Sele.

Har12 yielded lower than the local maize populations in five Sub-Districts. The margin was very close in a few of these Sub-Districts but there were also some other Sub-Districts marginal in the other direction. This helps to demonstrate why, overall, Har12 did not reach significance for yield advantage over the local populations in the years' trials.

Agro Ecological Zones (AEZ) and yield

Yield results for each variety in each AEZ are presented in Table 23. There was no statistically significant interaction between variety and AEZ for yield. Yields for all varieties were lowest at AEZ 4. This AEZ contained two of the highest Sub-Districts, Ossu and Maubisse. There was far less difference between the AEZs with higher yields. All varieties yielded best or equal highest in AEZ 5. The yield of Sele was similar to AEZ 5 at the higher elevation found at AEZ 3. For the other varieties, the next highest yielding after AEZ 5 was AEZ 1 followed by AEZ 2.

For all varieties, the average yield of the Northern AEZs performed better than the Southern average. There were large differences in yield between AEZ 3 and AEZ 4 even though they are in the same elevation range. The yield of Sele in AEZ 3 was more than double that of AEZ 4. There were however many more trials conducted in AEZ 3 compared to AEZ 4 and in the Northern AEZs compared to the Southern ones

Table 23. Maize OFDT mean yield by AEZ, 2009/10

AEZ Class (See *Table 14*)	Local (t/ha)		Har12 (t/ha)		P07 (t/ha)		Sele (t/ha)		Yield advantage P07 over local (%)	Yield advantage Sele over local (%)
1 Northern coast	2.2	(30)	2.4	(30)	2.7	(27)	2.8	(30)	24	27
2 Northern slopes	1.9	(25)	2.2	(26)	2.7	(26)	2.6	(26)	56	44
3 Northern uplands	1.7	(76)	2.1	(76)	2.7	(65)	3.0	(77)	61	81
4 Southern upland	1.2	(24)	1.1	(21)	1.4	(23)	1.4	(24)	16	13
5 Southern slopes	2.3	(20)	2.5	(19)	2.9	(18)	3.0	(20)	41	27
6 Southern coast	1.4	(11)	2.0	(11)	2.0	(11)	2.3	(11)	43	66

*Figures in brackets denote the number of trials harvested

New varieties had a consistent yield advantage above the local across all AEZs. AEZ 3 had the highest yield advantage for both Sele and P07 with AEZ 4 having the lowest.

Agronomic factors affecting yield

Although the overarching purpose of the OFDT system is to test possible candidates for variety release for use on farmers' fields, the process of measuring and comparing yields also provides an opportunity to collect data on agronomic factors and analyze the effect of these factors on yield. This analysis is described in the Materials and methods section above.

The influence of a wide range of characters was tested for affecting the yield of maize in the complete data set. Most were found to have an influence on grain yield, and these include Variety, AEZ, Sub District, soil color, soil texture, seeds planted per hole and the style of planting (lines or random). Of the factors investigated only planting distance, the gender of the head of the household and the tools used for land preparation had no effect on grain yield (Table 24).

Table 24. Various factors affecting maize OFDT yields, 2007-2010

Factor	*F pr. 2009-2010*	*Significant 2009-2010*	*Significant 2008-2009*	*Significant 2007-2008*
Variety	<0.001	✓	✓	✓
AEZ	<0.001	✓	✓	✓
Sub-District	<0.001	✓	✓	✓
Number of seeds per hill	<0.001	✓	✓	×
Planting distance	-	×	×	✓
Soil pH	<0.001	✓	✓	✓
Soil color	<0.001	✓	✓	✓
Soil texture	<0.001	✓	✓	×
Number of staff visits	<0.001	✓	×	✓
Random or line planting	<0.001	✓	✓	×
Slope class	<0.001	✓	×	×
Number of weeding events	<0.001	✓	×	×
Mixed planting of monoculture	0.015	✓	×	×
Gender of the head of household	-	×	×	×
Tools used for land preparation	-	×		

Seeds per hill

The average yield of all varieties was significantly affected by the number of seeds planted per hill. Only one seed per hill was planted on a negligible number of occasions. Seed number per hill was 2-3 on most occasions (Table 25). However there was not a clear trend between seeds per hill and yield with yield reducing when the number was increased from 2 to 3 but at its highest at 4 seeds per hill. The number of observations for 4 seeds per hill was far less than for either 2 or 3 seeds per hill. There is therefore not a sufficient basis for altering recommendations from previous years that suggest the optimum seeding rate of 2 to 3 seeds per hill.

Table 25. Influence of seeds per hill on OFDT maize yields, 2009/10.

Seeds per hill at planting	*Number of OFDTs*	*Average yield of four tested varieties (t/ha)*
2	57	2.4
3	107	2.1
4	18	2.7
LSD (P<0.05)		*0.3*

In another related measure the categorization for distance between rows planted did not prove significant.

Soil pH

Soil pH significantly impacted maize yield in 2009/2010 (Table 26). However it was only those sites at pH 8, in which only 8% of trials harvested occurred that differed significantly from sites at other pH levels. These years' trials did not have the same extremes in pH compared to previous years. Greatest yield occurred between pH 6 and pH 7.5.

Table 26. OFDT yield by soil pH for all maize varieties, 2009/10

Soil pH	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
% of OFDTs harvested	2	5	17	31	21	17	8	1
Mean yield (t/ha)	1.7	1.9	2.0	2.4	2.4	2.5	1.3	1.7
LSD (P<0.05)					0.8			

Soil colour

Soil colour had a significant effect on maize yield across the test sites (Table 27). Yellow soil with the highest yield recorded but contributed only 1% of the trials harvested. Similarly white soil contributed just 2%. Ignoring the 1% of trials with yellow soils, a trend for higher yields with blacker soils was evident confirming Timorese farmer's experience.

Table 27. Effect of soil colour of maize yield 2009/10

Soil color	*Yield (t/ha)*	*Percent of crops harvested*
White	2.2	2
Red	2.1	26
Black	2.9	24
Yellow	3.4	1
Dark brown	2.5	21
Light Brown	1.7	25
LSD (P<0.05)	*0.7*	

Soil texture

All soil textures were well represented within the trials. Silty loams had by far the greatest yields (Table 28). Sandy loam, loam, clay loam and heavy clay were not significantly different from each other. Fine clay yielded lower than heavy clay.

Table 28. Impact of soil texture on maize yield 2009/10

Soil texture	*Yield (t/ha)*	*Percent of crops harvested*
Sandy Loam	2.2	19
Silty Loam	3.8	10
Loam	2.2	14
Clay Loam	2.4	24
Fine Clay	1.9	24
Heavy Clay	2.3	9
LSD (P<0.05)	*0.4*	

Staff visits to OFDT

Visit sheets were not consistently completed by staff on all visits to OFDT sites and the protocol has been amended for the next season. Of the visits recorded to harvested OFDT sites, the number of visits to each OFDT ranged from 3 to 10, averaging 6.5 visits (Table 29). There was again a correlation between the number of visits and maize yield in this year after an absence for the first time the previous year. The reason for the correlation between visits and yield has not been identified but hopefully more data will help in the confidence given to any future parallel in this area.

Table 29. Effect of number of staff visits on farm maize yield 2009/10

Number of visits	*Average yield (t/ha)*	*Percent of observations*
3	1.9	1
4	1.8	8
5	2.4	15
6	3.3	10
7	3.2	21
8	2.2	16
9	2.2	27
10	2.2	2
LSD (P<0.05)	*1.0*	

Planting method, lines or random

In this data set, planting in lines produced a significantly higher yield than planting in a random design (2.5 t/ha compared to 2.1 t/ha). Generally, crops planted in rows are easier to weed. The previous year was the first occasion in which significance for this factor was found.

Use of fertilizer

No farmers included in the maize OFDTs in 2009/10 reported the use of fertilizer, either organic or non-organic.

Weeds

Weeding was found to have a significant effect on yield. There was a linear relationship between the number of weedings and yield. The vast majority of farmers involved in the maize OFDTs weeded their fields once during the growing season. Researchers recorded 65 different weed names across all OFDTs.

Slope of land

In contrast to the previous two years, slope class was found to significantly affect yield. The vast majority of trial sites were in just one class (0-2%) however and there was not a linear relationship between slope and yield. Slope classes used in Timor-Leste range from 0 - >30%.

Farmer's preference for maize populations

Field days were held at OFDT sites in each Sub-District during the harvest period and farmers were interviewed regarding the maize varieties under evaluation. They were asked to provide information on what characteristics were found in the local and test varieties that would encourage them to re-plant. Farmers preferred to grow each of the test varieties for different reasons (Table 30). Overall, farmers tended to choose Sele followed by P07 to replant. Of 342 choices at field days, 190 were for Sele and 121 for P07 (over 250 farmers attended but many chose more than one variety).

Table 30. Reasons farmers (%)* would replant maize varieties, 2009/10.

Characteristic	*Local*	*Har12*	*P07*	*Sele*
Overall choice	*4*	*8*	*48*	*75*
High yield	27	66	85	83
Color	60	84	85	90
Taste	70	83	67	75
Large cobs	25	84	84	91
Tight sheaths	51	86	85	89
Weevil tolerance	36	38	64	38
Full cobs	34	80	83	86
Wind tolerant	38	82	73	82
Big seeds	32	83	72	87
Total respondents		*254*		

*Many farmers made more than one choice from each criterion

From all the OFDTs, farmers gave reasons why they would chose to re-plant each variety another year. Those who wanted to replant Sele favored it most due to its large cobs, color and tight sheaths. P07 was preferred due to its high yield, colour and tight sheaths. Given the stark difference in color between Sele, and P07 it is interesting that color was ranked highly in both. Har12 was on a par or below the other new varieties for the various traits except for taste where it performed better.

One figure that stands apart in farmer field day observations is the high rating given to P07 for weevil tolerance. If this can be substantiated by weevil damage measurements it would mean a major criteria towards widespread adoption of the variety in East Timor would have been met.

As well as farmer field day data, comments from most farmers hosting OFDTs were also solicited. Like the FFDs, most comments were positive about the new varieties. Main reasons to replant for Sele were big cobs, fleshy seeds, sweet taste and color.

P07 was praised for similar reasons to Sele. A large number of farmers commented positively on the color of P07.

Although still relatively few, there were a greater number of negative comments about Har12 compared to the other new varieties from farmers that grew them. Most tended to relate to small seeds although there were a greater number of opinions to the contrary. Color and eating quality were commented upon as benefits of Har12. Wind resistance rated well for all new varieties.

While many farmers recognized the lower production with local varieties, many wanted to continue planting some as they had always planted it and saw it as adapted to, or of their land.

Conclusions

A further year of testing continued to show the high level of adaptation of the released maize variety Sele in all parts of Timor over many years. The yield advantage of Sele has consistently been 40-50% across all agro-ecological zones of Timor-Leste and across different seasons. Sele is a high yielding maize variety that is valued by farmers not just for its consistent high yield but also its good taste, large seeds and wind resistance.

Results of testing on P07 demonstrated good progress this year. Its' yield components were similar to Sele and overall yield just below that of Sele. The yield advantage of P07 over local varieties at 41% was double that of last year. Taste and color of this variety has been well received by farmers as has its weevil tolerance although the latter will need more investigation. With similar production to the recommended variety of Sele as well as the added bonus that P07 seeds are a white color that many Timorese prefer this variety can make a very strong case to be put forward to MAF for their consideration for general release.

2.2 Sweet potato

2.2.1 Sweet potato replicated trials, 2009-2010

All sweet potato (*Ipomoea batatas* (L.) Lam.) clones tested by SoL were introduced from CIP in Indonesia as part of SOL1. Sweet potato variety trials have been conducted on a set of 12 clones (including 2 local checks) for a number of years, allowing the selection of three varieties for release in 2007 (CIP 01, 06 and 07 under the names of Hohrae 1, 2, 3 respectively).

Since the 2008-2009 wet season, additional sweet potato clones are being investigated in replicated trials and compared with local checks and with the Hohrae released varieties. Clones which performed well in previous observational trials are also being included, depending on the quantity of available planting material.

Methods and materials

The trials were conducted at Betano, Aileu, Loes and Fatumaka research stations. Each consisted of a completely randomized block design with two or three replicates, the plots being 5 x 5 m in size. Stems for planting were all sourced from Loes. One cutting per hill was planted with a 100 x 50 cm spacing (i.e. 2 plants/m²). The trials were neither fertilized nor irrigated except in Aileu (15 kg/ha of N and P) where the lack of station area does not allow for fallow. Trials were planted in early January 2010 and harvested between May and July 2010 (Table 31). In Aileu and Betano, the introduced sweet potato clones produced a harvestable yield much quicker than local sweet potato ones, which led to adjusted harvest dates.

Table 31. Planting and harvest details of sweet potato varietal trials, wet season 2009/10

Location	*Season*	*No. of entries*	*Number of replicates*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)**	*Mean yield (t/ha)*
Aileu (K.Portu.)	Wet	15	2	18 Jan. 2010	12 July 2010	175[a]	1075[a]	12.4
Betano (Same)	Wet	16	3	19 Jan. 2010	02 Jun. 2010	134[b]	820[b]	2.3
Loes (Maubara)	Wet	15	3	06 Jan. 2010	11 May 2010	125	430	6.3
Baucau (Fatumaka)	Wet	15	3	27 Jan. 2010	10 Jun. 2010	134	1475	2.6

* Total rainfall from planting to harvest dates for each research station.
[a] The variety 'Local mean' was harvested 21 days later and received an additional 20 mm rainfall.
[b] The two local varieties were harvested 35 days later and received an additional 310 mm rainfall.

Yields, yield components and yield advantages

At harvest, the number of plants, the number of tubers and the total production were recorded for each plot. Additional parameters were measured in some stations as ground cover and disease impact, number of tubers and related weight, marketable and non marketable tubers (too small or damaged), average weight of big and small tubers, production from the main root or from secondary roots.

In order to determine varietal effects, the data of each trial was analysed separately using spatial analysis modules under GenStat Discovery 3. Those modules, developed by the Computer and Biometric Services Unit of ICARDA (Syria), allow capturing spatial patterns and automatically choose the most relevant REML model for each variate. All planting designs being regular, the SPCB module ("SPatial analysis of replicated trials in Complete Block designs") was used to analyse all four data sets.

Yield advantages were calculated from the resulting adjusted predicted means (BLUPs) over the locals averages. The existence and degree of correlation between the predicted means of the yields and of the other parameters were then identified using Simple Linear Regressions. As yields ranges differed greatly from a trial to another, individual regressions were run (as opposed as running regression over all data sets) in order to determine whether correlations were significant. The percentage of variability accounted for is then equivalent to an adjusted R^2.

Farmers' preferences

Farmers' field days were conducted in all four stations at harvest time in order to assess the farmer's preferences of sweet potato varieties and to determine the traits that farmers value. The numbers of tested varieties and participants are detailed in Table 32.

Table 32. Sweet potato taste tests during farmers' field days, 2010

Station	*No. of varieties tested*	*No. of participants*	*Proportion of women*
Aileu	15	13	46 %
Betano	8	27	26 %
Loes	8	21	57 %
Baucau	11	17	41 %
Total	16	78	41 %

As part of the field day, farmers inspected the freshly harvested tubers of all varieties. All the tubers of one replicate were displayed to allow the farmers to judge the yields as well as other characteristics for each variety. Afterwards, farmers were presented with boiled samples and asked to evaluate taste characteristics. Farmers were asked whether they generally liked the varieties and how sweet they were, this criterion being highly regarded to define the eating quality of sweet potato. Finally, all the participants were asked whether they were willing to plant the varieties.

To analyse farmers' preferences, Unbalanced ANOVAs were run with Station+Variety x Gender as the treatment factors and with the participants as the blocking one. Correlations with Simple Linear Regressions were then calculated over the varieties predicted means.

Results

Yields and yield advantages

Table 33 presents the yields achieved at each site for all tested varieties as well as the corresponding yield advantages over the local checks.

Table 33. Sweet potato yields and yield advantages, 2009/10

Variety	*Yield (t/ha)*				*Average*			*Yield advantage (%) within site*			
	Aileu	*Betano*	*Loes*	*Baucau*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*Aileu*	*Betano*	*Loes*	*Baucau*
Hohrae 3	20.5	1.0	12.1	4.3	8.7	9.5	61	14	-54	306	885
CIP 83	16.9	2.6	10.6	4.4	6.5	8.6	46	-6	23	255	922
Loc. mean	*28.2*	*2.1*	*2.4*	*0.4*	*13.3*	*8.3*	*41*	*57*	*-1*	*-21*	*2*
CIP 72	3.7	11.4	12.8	2.9	5.1	7.7	30	-79	429	329	558
Hohrae 2	11.4	1.1	7.6	6.3	4.3	6.6	12	-37	-50	154	1358
CIP 17	11.4	1.1	10.5	2.9	5.2	6.5	10	-37	-50	253	576
CIP 73	12.8	1.2	8.7	2.6	5.4	6.3	7	-29	-45	193	493
Loc. Atabae	*15.4*	*1.4*	*6.5*	*0.8*	*6.8*	*6.0*	*2*	*-14*	*-36*	*119*	*87*
CIP 8	5.8	3.6	7.3	6.8	1.6	5.9	0	-68	67	145	1476
Hohrae 1	17.2	0.6	1.3	1.1	8.1	5.0	-15	-5	-72	-56	149
CIP 66	4.9				-	4.9	-17	-73			
CIP 4	12.7	2.8	1.4	2.5	5.3	4.8	-18	-30	29	-54	465
CIP 70	9.9	1.1	4.0	2.2	3.9	4.3	-27	-45	-50	36	405
CIP 64		0.6	2.5	0.8	5.6	4.1[a]	-31		-72	-15	80
CIP 76	4.5	1.3	7.2	1.5	2.8	3.7	-38	-75	-38	143	251
Loc. mutin	*10.4*	*2.9*	*0.1*	*0.1*	*4.9*	*3.4*	*-43*	*-42*	*37*	*-98*	*-88*
CIP 71		1.7			-	1.7	-72		-22		
l.s.d. (p≤0.001)	*6.9*	*3.1*	*4.0*	*1.6*							
%CV	*40*	*137*	*50*	*45*							
Mean site	12.4	2.3	6.3	2.6	4.7	5.9					
Mean locals	*18.0*	*2.15*	*3.0*	*0.4*	*8.1*	*5.9*					

[a] Missing value replaced by site mean

Variation among sites was noticeable with Aileu yielding much higher than the other stations (over 12 t/ha against 3 t/ha on average). Aileu has been the only station always performing with at least 10 t/ha since 2006. In 2010, the site high average yield was probably due to the small quantities of fertilizer applied as well as the exceptional performance of the local mean variety, which had never performed so well in earlier trials (28 t/ha, even higher than the top yielding Hohrae 3). Local means benefited from 20 extra days to mature. This practice followed the farmers' usual pattern of harvesting progressively the small tubers of this local variety (about 18 tubers of 0.1 kg per plant against an average of 4 tubers of 0.2 kg per plant in this station, Table 34). Local varieties allow progressive harvests, an important feature for subsistence farmers. However they produce few marketable tubers in comparison with the introduced varieties which have less numerous but much bigger tubers-much appreciated by consumers.

In 2010, the best yielding variety remained being the released Hohrae 3 with 9.5 t/ha, representing an overall yield advantage of +60% over the local varieties. Next came the newly tested CIP 83 and CIP 72 with about 8 t/ha. CIP 72 was the best yielding variety in Betano and Loes. Hohrae 2 and CIP 17 performed with +10% yield advantage over locals, while CIP 8, Hohrae 1 and CIP 4 performed very averagely. The other introduced varieties performed less well than the local checks.

Yield components and other parameters

The predicted means for the yield components and other parameters associated with the yields are detailed in Table 34.

Table 34. Sweet potato yields and yield components, replicated trials 2009/10

Trial	Variety	Yield (t/ha)	Marketable yield (t/ha)	Plants /m² at harvest	Tubers /plant	Weight of 10 tubers (kg)	No. of small tubers /plant	No. of tubers from second. roots /plant	Ground cover (%)	Disease impact at harvest (max-min: 0-5)	Trial	Yield (t/ha)	Marketable yield (t/ha)	Plants /m² at harvest	Tubers /plant	Weight of 10 tubers (kg)	No. of small tubers /plant
BETANO	Hohrae 3	1.0	0.7	0.6	8.1	1.0	1.0	6.1	44	2.0	AILEU	20.5		2.1	3.3	2.9	
	CIP 83	2.6	1.8	0.5	10.0	0.8	6.7	9.8	44	1.1		16.9		1.9	3.6	2.4	
	Loc. mean	2.1	1.2	0.5	12.7	0.3	16.9	18.5	73	0.1		28.2		2.1	18.1	1.1	
	CIP 72	11.4	7.0	0.9	11.5	0.7	12.7	14.6	66	0.2		3.7		1.8	1.8	1.0	
	Hohrae 2	1.1	0.8	0.7	5.1	1.3	1.4	4.0	63	1.3		11.4		1.8	2.3	2.4	
	CIP 17	2.8	2.3	0.5	9.6	1.5	4.3	6.8	38	0.8		11.4		1.8	2.8	2.2	
	CIP 73	1.2	0.9	0.6	3.1	1.1	1.8	0.0	57	0.8		12.8		2.0	3.1	2.0	
	Loc. Atabae	1.4	0.8	0.5	10.8	0.4	8.7	11.7	57	0.5		15.4		1.9	9.7	1.3	
	CIP 8	3.6	2.6	1.1	7.7	1.1	2.6	3.4	64	0.9		5.8		1.8	2.3	1.3	
	Hohrae 1	0.6	0.5	0.8	6.3	0.9	7.5	8.7	63	3.0		17.2		1.7	2.9	3.1	
	CIP 66											4.9		1.8	4.3	2.0	
	CIP 4	1.1	0.9	0.4	3.7	1.7	1.7	3.3	53	2.1		12.7		1.6	2.8	2.8	
	CIP 70	*1.1*	*0.7*	*0.7*	*2.4*	*0.7*	*2.6*	*1.4*	*51*	*1.9*		*9.9*		*1.9*	*2.5*	*1.8*	
	CIP 64	0.6	0.5	0.5	2.6	0.9	7.5	8.7	30	2.3							
	CIP 76	1.3	0.8	0.4	10.5	0.5	14.6	9.9	45	1.0		4.5		1.8	1.2	1.4	
	Loc. mutin	*2.9*	*1.9*	*0.4*	*9.0*	*0.6*	*10.2*	*10.7*	*57*	*0*		*10.4*		*2.2*	*3.4*	*1.7*	
	CIP 71	*1.7*	*1.2*	*0.4*	*12.2*	*1.2*	*20.4*	*22.2*	*41*	*2.2*							
	MEAN	2.3	1.5	0.6	7.8	0.9	7.5	8.7	53	1.3		12.4		1.9	4.3	2.0	
	l.s.d. (p ≤0.05)	*3.1*	*2.1*	*0.3*	*7.0*	*0.5*	*8.1*	*9.5*	*19*	*0.6*		*6.9*		*0.2*	*2.0*	*0.9*	
	%CV	*137*	*140*	*44*	*114*	*42*	*80*	*90*	*26*	*60*		*40*		*12*	*28*	*35*	
LOES	Hohrae 3	12.1	8.3	1.87	2.3	3.4	0.7		86	1.6	BAUCAU	4.3	2.4	1.84	1.7	1.3	0.8
	CIP 83	10.6	8.0	1.91	2.4	2.3	0.7		85	1.9		4.4	2.6	1.84	1.6	1.3	1.0
	Loc. mean	2.4	2.2	1.85	3.4	0.5	1.4		87	1.5		0.4	0.7	1.82	0.6	0.4	0.4
	CIP 72	12.8	7.9	1.92	7.6	0.8	2.7		85	1.7		2.9	2.3	1.84	1.8	0.9	1.2
	Hohrae 2	7.6	5.4	1.90	2.6	1.6	0.7		94	2.0		6.3	3.3	1.84	2.0	1.5	0.9
	CIP 17	1.4	0.9	1.90	1.3	1.0	0.7		82	1.5		2.5	1.2	1.84	1.7	0.7	1.0
	CIP 73	8.7	7.8	1.93	2.7	2.1	1.0		88	1.8		2.6	1.7	1.83	2.2	0.6	1.5
	Loc. Atabae	6.5	4.1	1.89	5.1	0.7	1.9		94	1.9		0.8	0.9	1.84	0.8	0.5	0.6
	CIP 8	7.3	5.1	1.93	3.3	1.0	1.5		87	1.8		6.8	3.1	1.83	3.5	0.9	1.7
	Hohrae 1	1.3	1.2	1.91	1.0	2.0	0.5		85	1.3		1.1	1.0	1.79	1.2	0.9	0.5
	CIP 66																
	CIP 4	10.5	7.2	1.89	3.3	1.6	1.0		73	1.1		2.9	1.7	1.83	1.5	1.0	0.9
	CIP 70	*4.0*	*2.5*	*1.93*	*3.2*	*0.7*	*0.9*		*92*	*2.0*		*2.2*	*1.6*	*1.87*	*1.3*	*0.8*	*0.8*
	CIP 64	2.5	0.9	1.88	2.2	1.1	0.8		74	1.2		0.8	1.0	1.81	1.1	0.6	0.8
	CIP 76	7.2	4.4	1.91	3.9	0.9	1.2		87	1.4		1.5	1.3	1.83	2.3	0.4	1.6
	Loc. mutin	*0.1*	*0.5*	*1.91*	*0.9*	*1.1*	*0.5*		*85*	*1.7*		*0.1*	*0.5*	*1.80*	*0.6*	*0.3*	*0.4*
	CIP 71																
	MEAN	6.3	4.4	1.90	3.0	1.4	1.1		86	1.6		2.6	1.7	1.83	1.6	0.8	0.9
	l.s.d. (p ≤0.05)	*4.0*	*3.3*	*0.07*	*2.0*	*0.6*	*1.3*		*9.5*	*n.s.*		*1.6*	*1.3*	*n.s.*	*0.9*	*0.4*	*0.6*
	%CV	*50*	*60*	*4*	*63*	*34*	*117*		*12*	*84*		*45*	*67*	*7*	*45*	*46*	*54*

In Betano, Loes and Baucau the distinction between total yield and marketable yield was made. For those three stations, the marketable yields were found to represent 65-70% of the total yield, with correlations between the total/marketable yields reaching at least R^2=0.94 with $p<0.001$. Those were similar to the results of 2008/2009 and show that total production was a good approximation of the marketable tubers.

A strong and significant correlation was found between the yield and the tuber weight in only one station out of four (Betano: R^2=0.60, $p<0.001$) against three out of four for the yield with the number of tubers per plant (Figure 22). Strong correlation were also found between the total number of tubers per plant and the number of small tubers per plant for the three stations for which data was available. The total number of tubers per plant and the number of tubers produced by secondary roots per plant were also strongly correlated in Betano, showing the importance of the clones ability to produce additional stems and roots for high yields. As a summary, it seems that varieties able to produce more secondary roots produce more tubers, even though small, and higher yields. The Hohrae varieties hence prove to be quiet exceptional as they produce, large, marketable tubers.

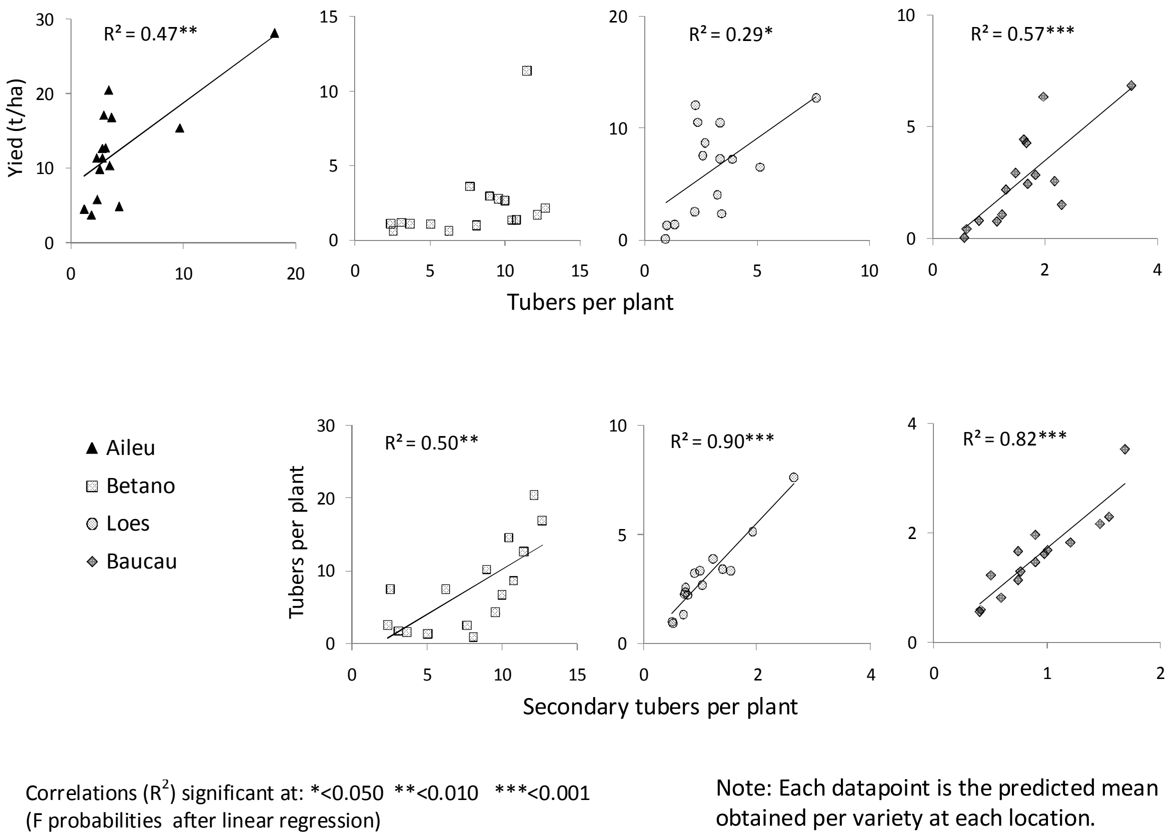


Figure 22. Correlations between yields and yield components, sweet potato 2009/10

Ground cover and disease impact were recorded close to harvest time in two locations. No significant correlation with the yields was detected except in Betano where diseases (mainly viruses) impacted negatively the yields (Figure 23)

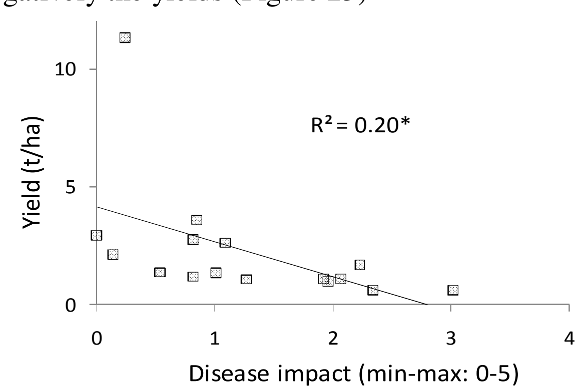


Figure 23. Correlations between sweet potato yield and disease impact, Betano 2009/10

Farmers preferences

No effect of the station, the gender or the gender per variety interaction was identified. Conversely, there was a strong varietal impact for all tested farmers preferences (p=0.002 for

“Sweet” and p<0.001 for all the other criteria) . Table 35 presents the overall results for the four farmers’ field days held in Aileu, Betano, Baucau and Fatumaka stations, while Figure 24 displays the correlations between various criteria.

Table 35. Farmers’ preferences, sweet potato FFD results, 1-4 stations, 2010

Variety	*No. of tests (stations)*	*No. of respondents*	*"Wish to plant"(%)*	*“Like” (%)*	*"Very sweet" (%)*	*"Sweet" (%)*	*Average yield (t/ha)*
Hohrae 3	3	51	34	34	10	34	9.5
CIP 83	4	78	33	48	32	50	8.6
L. Mean	*2*	*34*	*26*	*48*	*16*	*33*	*8.3*
CIP 72	4	78	27	37	19	44	7.7
Hohrae 2	3	51	15	48	32	26	6.6
CIP 17	3	57	27	54	41	42	6.5
CIP 73	4	78	18	41	30	44	6.3
L. Atabae	*2*	*34*	*29*	*60*	*45*	*24*	*6.0*
CIP 08	3	57	25	51	34	42	5.9
Hohrae 1	2	30	35	50	42	40	5.0
CIP 66	1	13	7	0	0	6	4.9
CIP 04	4	78	12	30	11	30	4.8
CIP 70	2	30	9	56	16	60	4.3
CIP 76	3	57	18	37	43	33	3.7
L. Mutin	*1*	*13*	*7*	*37*	*30*	*22*	*3.4*
CIP 71	1	27	58	67	13	37	1.7
l.s.d. (p≤0.002)			*20*	*20*	*20*	*21*	
%CV			*178*	*95*	*158*	*116*	

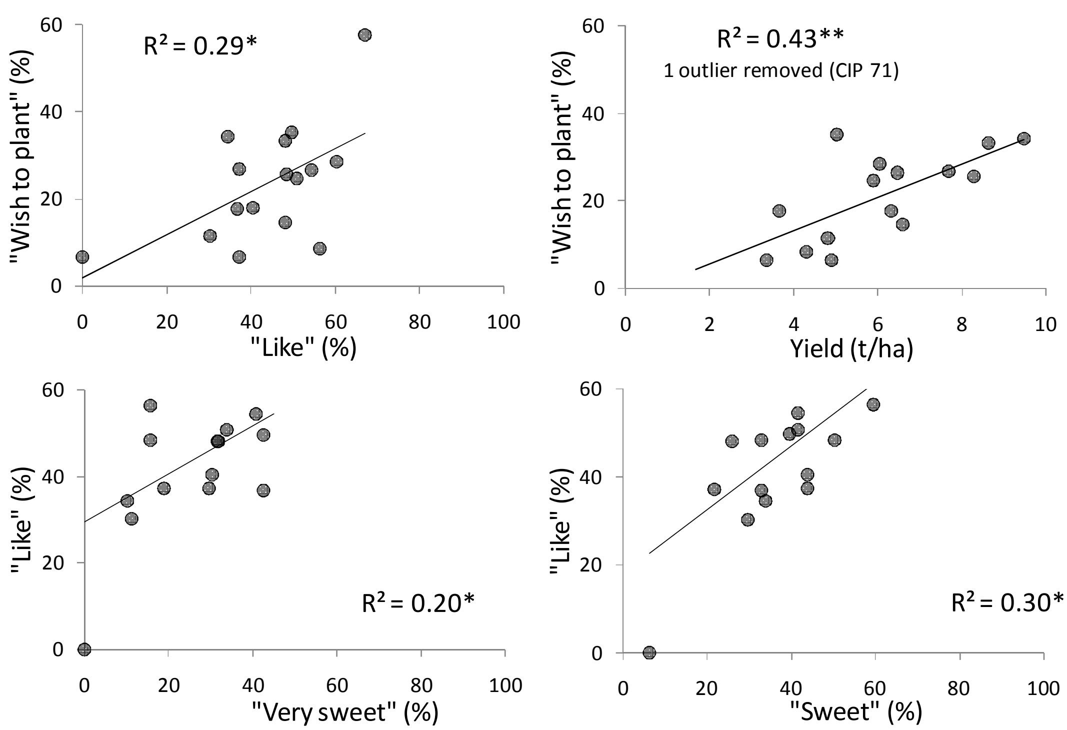


Figure 24. Correlations between farmers’ preferences and varieties sweet potato, 2010

In 2010, respondents gave particular attention both to yield performances and taste, as shown in Figure 24. For those reasons, in 2010 preferred varieties were the released varieties Hohrae 1 and 3 as well as CIP 83. In terms of taste only, the local Atabae ranked very well as well as CIP 71 but presented poor yields. The latter was however tested in only one station. So was CIP 66, which on the other hand was the least preferred variety.

Conclusions

The varieties which both performed the best with about 9 t/ha and were most appreciated by farmers were the released variety Hohrae 3 and the newly introduced CIP 83, with +60% and +45% yield advantages over the local checks respectively. The suitability of CIP 83, found to be one of the best tasting varieties tested during the year, is currently being tested on-farm (OFDTs) and compared to Hohrae 3 and CIP 72 (+30% yield advantage this year). The later ranked third this year replicated trials among the introduced varieties and received similar reviews from farmers' preferences as Hohrae 3.

The local variety 'mean' did particularly well in Aileu where it was harvested twice, following farmers' usual practices. The variety's performances with regard to progressive harvests will be further investigated in 2011.

2.2.2 Sweet potato multi-year and multi-location trial analysis

Materials and methods

19 successful sweet potato variety trials were implemented by SoL over the period from 2005 to 2010 (5 years) at 5 different sites (Aileu, Betano, Baucau, Maliana and Loes), testing the performances of 21 varieties (including 3 local varieties as controls). Some varieties were not included in all trials and some trials were not conducted at every site every year.

The entire dataset, presented in Table 36, comprises 193 data points, i.e. variety per environment combinations. An environment (here synonymous of trial) is defined by the site, year and season (for instance Betano wet season 2009, Loes wet season 2010, etc). All data points are ANOVA or REML predicted means from 3 replicates, 2 in some cases.

Cross-site analyses were conducted using biplots (GGE BiPlot program) in order to evaluate the performances and consistency of the tested varieties across years and locations (genotype / environment). A limitation of the procedure is that only datasets with about 5% missing data points could be analysed. In addition, datasets resulting in higher percentages of variance explained by the biplot principal components analysis were preferred. Following those principles, two datasets were chosen. Set 1 maximises the number of environments and set 2 the number of genotypes.

Data set 1 investigated the performances of 6 varieties in 17 environments. This selection included 102 data points with less than 6% missing data.

Data set 2, the selection which included the highest number of varieties, covers 15 of them in the four 2010 environments, corresponding to 60 data points (less than 2% missing values).

Table 36. All SoL sweet potato replicated variety trials over 2005-2010 (193 data points)

Group	Yield (t/ha) /trial Variety	W06 AIL	W06 BAU	W06 MAL	W07 AIL	W07 BET	W07 MAL	W08 AIL	W08 BET	W08 BAU	W08 MAL	W09 AIL	W09 LOE	W09 MAL	W09 BET	W09 BAU	W10 AIL	W10 BET	W10 LOE	W10 BAU	No. Trials	St. dev.	Ave. yield (t/ha)	Yield adv. (%)
2006	CIP 02	2.0	0.0	1.4	13.5	0.6	2.6	6.2	9.5												8	4.8	4.5	-37
2006	CIP 03	2.7	2.2	2.8	14.2	0.3	0.8	9.7	2.6	3.5	9.9										10	4.7	4.9	-31
2006	CIP 05	2.8			10.6	0.1	0.4	15.6	0.2		0.8										7	6.2	4.4	-39
2006	CIP 15	10.2		1.7	18.5	0.6	2.3	28.5	11.0			2.7			10.3	3.1					10	8.9	8.9	25
2006	CIP 04			2.0	34.9		0.3	28.4	11.4	6.9	10.4	10.2	30.0	4.4	18.1	9.7	12.7	2.8	1.4	2.5	16	10.9	11.6	64
2006	CIP 08	23.5	2.2		16.7	0.0	1.3	26.0	17.0			10.5			11.6	3.6	5.8	3.6	7.3	6.8	14	8.3	9.7	37
2006	CIP 17	11.1		0.1	42.4	0.7	0.3	17.9	0.5	2.9		11.1	9.7	1.6	4.4	3.9	11.4	1.1	10.5	2.9	17	10.4	7.8	10
2006	Hohrae 3	4.8	1.3	3.6	26.5	5.2	1.9	20.5	23.3	6.8	12.8	20.4	35.9	4.8	30.2	6.6	20.5	1.0	12.1	4.3	19	10.9	12.8	80
2006	Hohrae 2	24.1	4.8	5.6	23.9	1.7	2.7	23.7	8.1	5.7	9.8	18.7	24.3	5.6	15.6	4.8	11.4	1.1	7.6	6.3	19	8.2	10.8	52
2006	Hohrae 1	16.8	2.8	0.3	29.6	2.8	0.1	30.1	14.2	5.8	8.3	18.1	7.3	5.3	12.5	2.8	17.2	0.6	1.3	1.1	19	9.5	9.3	31
2006	*Loc. Mean*		*0.7*		*9.8*			*16.1*	*1.7*				*3.5*	*0.6*	*5.2*	*0.5*	*28.2*	*2.1*	*2.4*	*0.4*	*12*	*8.4*	*5.9*	*-16*
2006	*Loc. Mutin*		*0.6*	*2.4*	*8.7*			*25.3*	*1.9*			*26.7*	*0.9*		*32.9*	*0.7*	*10.4*	*2.9*	*0.1*	*0.1*	*13*	*11.7*	*8.7*	*23*
2010	*Loc. Atabae*																*15.4*	*1.4*	*6.5*	*0.8*	*4*	*6.8*	*6.0*	*-15*
2010	CIP 70																9.9	1.1	4.0	2.2	4	3.9	4.3	-39
2010	CIP 72																3.7	11.4	12.8	2.9	4	5.1	7.7	8
2010	CIP 73																12.8	1.2	8.7	2.6	4	5.4	6.3	-11
2010	CIP 76																4.5	1.3	7.2	1.5	4	2.8	3.7	-49
2010	CIP 83																16.9	2.6	10.6	4.4	4	6.5	8.6	21
2010	CIP 64																	0.6	2.5	0.8	3	1.1	1.3	-82
2010	CIP 66																4.9				1	-	4.9	-31
2010	CIP 71																	1.7			1	-	1.7	-76
	l.s.d.	*6.8* *	*1.7* *	*1.3* *	*n.a.* *n.a.*	*n.a.* *n.a.*	*n.a.* *n.a.*	*10* *	*n.s.*	*n.s.*	*1.8* *	*11* **	*6.9* ***	*3.3* *	*11* ***	*2.0* ***	*6.9* ***	*3.1* ***	*4.0* ***	*1.6* ***	*Total no. of data points: 193 (incl. 15% locals)*			
	Mean locals	*10.9*	*0.7*	*2.4*	*9.3*	*1.3*	*1.3*	*20.7*	*1.8*	*5.3*	*8.7*	*26.7*	*2.2*	*0.6*	*19.0*	*0.6*	*18.0*	*2.1*	*3.0*	*0.4*	*19*	*8.2*	*7.1*	*0*
	Mean site	10.9	1.8	2.2	20.8	1.3	1.3	20.7	8.5	5.3	8.7	14.8	15.9	3.7	15.6	4.0	12.4	2.3	6.3	2.6	19	6.6	8.4	18

Notes: AIL = Aileu, BET = Betano, BAU = Baucau, MAL = Maliana, LOE = Loes.
W06 = wet season 2005-2006. ANOVA/REML p-values: * <0.050, ** <0.010, ***<0.001

Results

The average yield of the entire dataset (19 environments, 193 data points) was 8.4 t/ha (st.dev = 6.6) against 7.1 t/ha for the local checks alone (19 environments, 29 data points, i.e. 15% of the entire dataset). Yield averages from trial to trial varied from 1.3 t/ha to a maximum of 20.3 t/ha (wet seasons 2007 of Aileu and Maliana respectively), with about half the sites performing within 2.5-12.5 t/ha. Across 5 years, the Aileu site always performed over 10 t/ha while, with two exceptions in 2007, the other sites recorded lower average yields.

Among the 21 varieties, 10 were tested 10 times or more and 18 were tested at least 4 times. Some varieties require further testing, but assuming that most varieties trials represent random samples of environments, the comparison of the varieties overall results can be made, as presented in Table 37.

Seven introduced varieties yielded above 8.5 t/ha overall (+20% yield advantage over the locals). Among those varieties the released Hohrae 3, 2 and 1 were extensively trialled and reached yield advantages of +80%, +50% and +30% respectively over the local checks (about 9 to 13t/ha on average). The other best yielding varieties were CIP 04, 08 and 15 which also presented good eating varieties. However, those varieties performed less well than the Hohraes on OFDTs and will therefore be discarded. Among the new varieties first tested in 2010, the best performances came from CIP 83 and CIP 72 which also proved to have high eating qualities. Further testing will be necessary.

The biplot from data set 1, which investigates the performances of 6 varieties in all 24 available environments, is plotted in Figure 25 along with the 'which wins where' analysis. The results, which represent 60% of the observed variation, clearly show that Hohrae 3 is by far the variety which did the best in most environments, a result soundly confirmed by four years of on-farm trials.

Table 37. Sweet potato mean yields and yield advantages over 2005-2010 (5 years)

Variety	*No. of trials*	*Mean St. dev.*	*Mean yield (t/ha)*	*Yield advantage (%)**	*2010 status*
Hohrae 3	19	10.9	12.8	80	Released in 2007. Standard for OFDT testing.
CIP 04	16	10.9	11.6	64	Tested twice in OFDTs. Not as good as Hohrae 3. To be discarded.
Hohrae 2	19	8.2	10.8	52	Release in 2007.
CIP 08	14	8.3	9.7	37	Tested twice in OFDTs. Not as good as Hohrae 3. To be discarded.
Hohrae 1	19	9.5	9.3	31	Release in 2007.
CIP 15	10	8.9	8.9	25	Discarded.
Loc. Mutin	*13*	*11.7*	*8.7*	*23*	*Control.*
CIP 83	4	6.5	8.6	21	Continue testing. Starts OFDTs.
CIP 17	17	10.4	7.8	10	Tested twice on OFDTs. Not as good as Hohrae 3. To be discarded.
CIP 72	4	5.1	7.7	8	Continue testing. Starts OFDTs.
CIP 73	4	5.4	6.3	-11	Continue testing.
Loc. Atabae	*4*	*6.8*	*6.0*	*-15*	*Control.*
Loc. Mean	*12*	*8.4*	*5.9*	*-16*	*Control.*
CIP 03	10	4.7	4.9	-31	Discarded.
CIP 02	8	4.8	4.5	-37	Discarded.
CIP 05	7	6.2	4.4	-39	Discarded.
CIP 70	4	3.9	4.3	-39	Continue testing.
CIP 76	4	2.8	3.7	-49	Continue testing.

* Calculated over the local varieties overall average = 7.1 t/ha, st.dev. = 8.2
(3 varieties representing 29 datapoints over 19 environments)

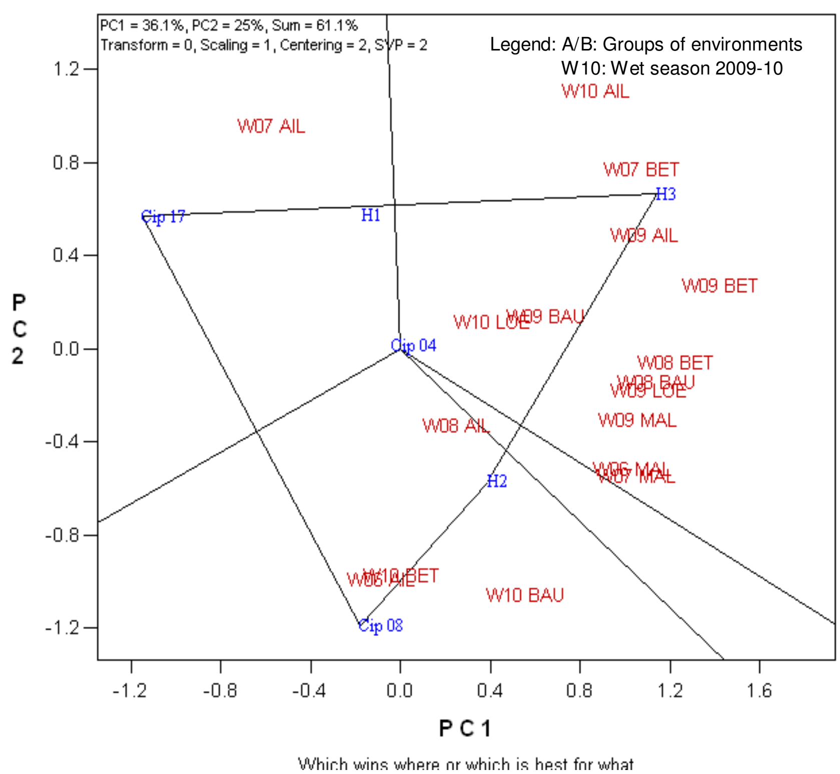


Figure 25. Biplot analysis (6 sp varieties in 17 environments (set 1), 2005-2010

The biplot corresponding to data set 2, the selection which include the four trials in 2010 and the highest number of varieties, is plotted in Figure 26. The analysis captured over 75% of the variability observed, a good percentage. CIP 8, Hohrae 2 and 3, and the recently trialled CIP 72 and CIP 17 made up the lead in addition of having the best eating qualities, hence justifying their release for the firsts and their trials on-farm for the seconds. CIP 8 had already been trialled on OFDTs along with CIP 4 and CIP 17 but the three were discarded as not as suitable as Hohrae 3. The biplot otherwise shows that those leading varieties were fairly consistent among sites with the exception of CIP 72 which performed particularly well in Loes and Betano but poorly in Aileu.

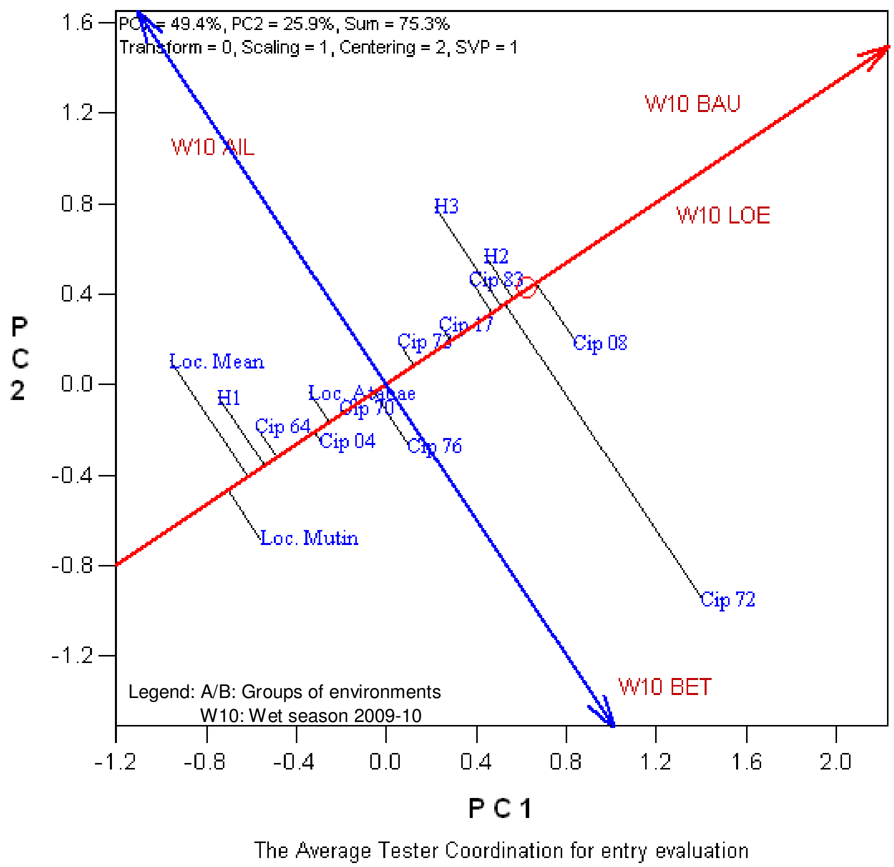


Figure 26. Biplot analysis of sweet potato variety by environment (set 2), 2005-2010

Conclusions

Over 5 years, SoL conducted 19 successful varietal maize trials on 21 varieties, representing a total of 193 individual data points (variety per environment combinations). Results varied significantly both by genotype (varieties) and environment (locations, years, season).

A first phase of the clones evaluation led to the release of three varieties. Among them, Hohrae 3 confirms its position as the new standard. This year marks the beginning of a new phase with new varieties being trialled and already two promising varieties both in term of yield performances and taste, CIP 72 and CIP 83. Additionally, the latter presenting a particularly orange flesh and hence potential higher nutritious value (vitamin A).

The on-farm suitability and consistency of those two potential candiadates will be investigated in the 2010/11 OFDT programme.

2.2.3 Sweet potato observational trials

Materials and methods

Sweet potato observational trials were implented during 2010 with the objective of both conserving the existing germplasm and identifing promising varieties for evaluation in replicated trials during 2010-2011. Depending on the available planting material, two observation trials were implemented, the details of which are presented in Table 38. In Aileu, the big tubers were harvested earlier, allowing smaller ones to mature in an additional 54 days.

Table 38. Planting and harvest details of sweet potato observation trials, 2009/10

Site	*No. of entries*	*Plot size (m) (1 replicate)*	*Planting distances (cm)*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)*[a]	*Mean yield (t/ha)*
Loes	11	5 × 5	100×50	13 Jan 2010	18 May 2010	125	365	7.1
Aileu	11	5 × 5	100×50	01 Feb 2010	02 Aug 2010	182	1030	9.4
					25 Sept 2010	236	1100	

[a] Total rainfall from planting to harvest dates

Yield advantages were calculated over the sites averages. The results at Aileu were analysed in GenStat discovery 3 with an ANOVA on the yields of the two harvests. The existence and degree of correlation between the yields and of the other parameters were identified using a Simple Linear Regression in GenStat Discovery 3. The percentage of variability accounted for is equivalent to an adjusted R^2.

Results

Overall

Tuber yields were higher in Aileu which received much more rainfall than Loes (Table 39). A comparison was also made between yields achieved in the previous year.

Table 39. Yields and yield advantages, sweet potato observation, 2008/09 and 2009/10

Variety	*Yields (t/ha)*						*Averages***		
	2009-2010		*2008-2009**						
	Loes	*Aileu*	*Betano*	*Loes*	*Maliana*	*Aileu*	*St.dev.*	*Yield (t/ha)*	*Yield adv. (%)*
CIP 77	9.5		11.5*	24.0	11.3	17.2	6.6	14.3	32.0
CIP 71	20.6	7.2		17.4	10.4	14.7	5.3	14.2	31.5
CIP 68	10.3			12.7	8.7		2.0	11.6	6.6
CIP 67	9.1	16.3		16.7	3.3	6.0	6.0	11.1	2.3
CIP 79	6.0	7.8		10	4.8	20.4	6.3	10.7	-1.0
CIP 82	14.4	10.8		6.2	2.8	7.5	4.4	9.5	-12.7
CIP 65	0.0	19.3		1.6	6.4	13.5	8.2	9.3	-13.9
Jered M21	3.5	8.6	3.2*	12.9		15.5	5.3	9.3	-14.2
CIP 66	0.0	12.9		0.0	1.1	22.9	10.2	8.7	-20.0
CIP 69	2.4	5.3		11.5	4.1		4.0	8.6	-21.0
CIP 81		5.2		3.6	2.9	5.0	1.1	6.5	-40.2
CIP 74	2.0	0.8	14.3*	8.2	2.1	11.3	4.6	4.9	-55.1
Mean site	7.1	9.4	15.1	14.3	6.1	13.0	3.9	10.8	

* For the complete dataset, see ARR 2009. **Missing values were replaced by site averages.

Sequential harvest

The results of the sequential harvests in Aileu are presented in Table 40.

Table 40. Yields from sequential harvest, sweet potato observation, Aileu 2009/10

Variety	Yield (t/ha) First harvest	Yield (t/ha) Second harvest (54 days later)	Yield (t/ha) Total	Proportion of the 1st harvest (%) in the total yield
CIP 65	9.6	9.7	19.3	50
CIP 67	3.4	12.9	16.3	21
CIP 66	0.3	12.6	12.9	2
CIP 82	6.0	4.8	10.8	55
Jered M2	4.8	3.8	8.6	56
CIP 79	6.0	1.8	7.8	77
CIP 71	5.5	1.7	7.2	76
CIP 69	0.5	4.8	5.3	9
CIP 81	0.7	4.5	5.2	14
CIP 74	0.0	0.8	0.8	0
Averages	3.7	5.7	9.4	39

No significant effect harvest time was detected on the yields.

The second harvest contributed more to the total yield than to the first (correlation R^2=62% with p=0.002 against R^2=29% with p=0.054), while no correlation was detected between the yields of the first and second harvests, as shown in Figure 27.

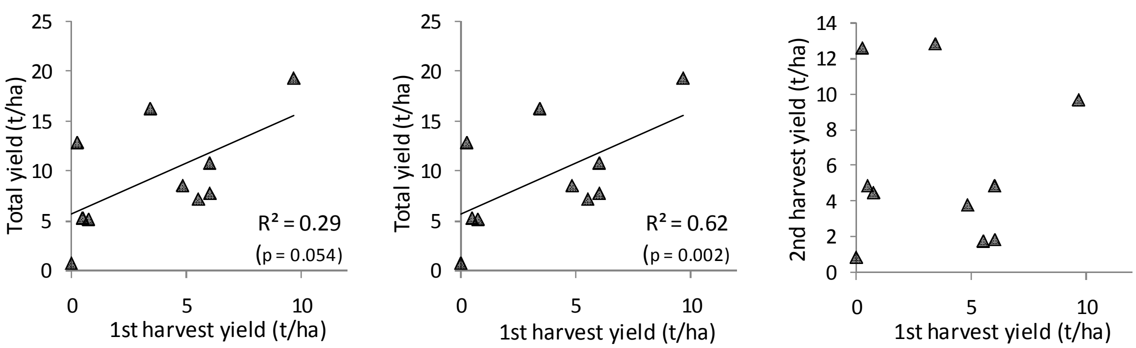


Figure 27. Correlations between sequential harvests yields, sweet potato, Betano 2010

Conclusions

The results of these observation trials do not replace those from the replicated trials. Nevertheless, the trial data does assist select promising varieties among the new clones. Future replicated trials will integrate CIP 77, 71, 68 while the other varieties will be kept for further observation or for the germplasm collection.

A first sequential harvest yielded interesting results and will be investigated further in replicated trials.

2.2.4 Sweet potato OFDTs 2009-2010

A selection of 4 promising sweet potato varieties was evaluated on-farm in 15 Sub-Districts of Timor-Leste in the 2009/10 wet season. The objective of the research was to determine if the promising sweet potato varieties identified on the research stations are suitable for farmers needs in terms of yield and overall acceptability.

The promising sweet potato varieties were tested alongside a local variety provided by each farmer. As such, the local check at each site could be a different variety. All the tested varieties (Hohrae 3 , CIP 4, CIP 8 and CIP 17) were tested in OFDT's in the previous wet season.

Materials and methods

The method of conducting the sweet potato OFDT's was similar to that for the sweet potato trials in previous years. Sweet potato OFDTs were conducted in the seven districts of Aileu, Ainaro, Baucau, Bobonaro, Liquiça, Manufahi and Viqueque. This sampled the range of agro-ecological zones (AEZ) found in East Timor from sea level to 1300 m altitude.

Each plot for each variety was planted as a 5m by 5m square and planted with 25 to 50 stems in that area. Plots were monitored regularly from planting to harvest for any sign of disease, poor growth, etc.

As for cassava, a sample of 5 plants was dug by the researchers with the farmers to obtain harvest data. The remaining area was harvested as the farmer determined. In previous years, it was found the farmers would harvest the trial plots throughout the season, not allowing a harvest estimate. By identifying 5 plants that the researcher and farmer would harvest together, on the one day, an estimate of the yield was made. For each plant, the researcher recorded the number of tubers per plant, the weight of tubers from the 5 plants and perceptions of the farmers regarding each test entry. In each subdistrict there was a farmers field day held at one of the OFDT sites. A number of local farmers were present at each field day and gave comments on the new varieties.

Site characterization

Each site was characterised by soil pH, colour and texture, latitude, longitude and elevation. Soil pH was tested on site using a mobile indicator method. Soil texture was estimated based on the ribbon test, and soil was described as one of 7 pre-determined colours.

Analysis

Similar to maize OFDT data, raw data was entered into an Excel spread sheet, then summarised and analysed using Genstat Discovery 3. Yield data were analysed by ANOVA (Unbalanced Model) in a range of methods. First, main effects and the interactions between variety and District, Sub-District, AEZ were tested.

Further to this main analysis, the influence of a wide range of factors on sweet potato yield was tested. The model of the analysis always included variety and AEZ as factors in the model. As elevation was shown to have an impact on crop yield between sites, elevation was included as a co-variate in all the analyses. In turn, a range of factors were added to the model, one at a time. If they were significant, the factor was kept in the model, and if they were non-significant the factor was discarded. Once a significant factor was identified, the interaction of that factor and variety was also tested for significance at the $P = 0.05$ level.

Results

One hundred and nine trials were established across a wide range of environments. Seventy eight of these sites were harvested and results recorded.

Testing environments

Sweet potato OFDTs were conducted on a wide range of soil textures, pH, slopes and elevations. Elevation of OFDT sites ranged from almost sea level to over 1,300 masl (Table 41).

Table 41. Distribution of sweet potato OFDT sites by elevation, 2009/10.

Elevation (masl)	Locations 2008/09 (%)
0-100	16
100-200	10
200-300	10
300-400	8
400-500	5
500-600	12
600-700	5
700-800	6
800-900	10
900-1000	9
1000-1100	4
1100-1200	3
1200-1300	3
1300-1400	1

Soil pH, elevation and texture

The average soil pH across the OFDT test sites was 6.7, ranging from 4.0 to 9.0. The average Sub-District soil pH ranged from 5.2 in Lequidoe to 7.6 in Venilale. As well as having the lowest pH for a sub-district, Lequidoe also had OFDT's at the highest elevation of all Sub-Districts. In general, there is a negative correlation between soil pH and elevation, so that as elevation decreases, the soil become less acid. This trend is similar to that found in OFDTs for other crops (see maize OFDT report in SoL, 2008).

Table 42. Mean soil pH and elevation, sweet potato OFDTs by subdistrict, 2009/10

Sub_District	Soil pH	Elevation
Aileu Villa	6.2	936
Balibo	7.2	365
Baucau Vila	6.7	563
Hatudo	7.2	191
Laulara	7.3	1175
Lequidoe	5.2	1293
Liquica	7.1	152
Maliana	7.0	217
Maubara	7.3	47
Ossu	6.3	919
Remexio	6.8	964
Same Villa	7.3	233
Vemasse	6.0	785
Venilale	7.6	818
Viqueque Villa	6.8	22
LSD (p<0.05)	0.4	

Trial losses

It is very difficult to determine the yield of all root crops including sweet potato and cassava on farmer's fields in Timor-Leste. In this set of OFDTs, of the 109 trials established, yields were only recorded at 78 locations. Trial losses were due mainly to animal predation, especially cows, buffalos as well as wild and domestic pigs. Predation by people was also a possibility, particularly in the least food-secured areas.

Variety

Similar to last year, all introduced sweet potatoes produced a higher yield than the local check varieties (Table 43). Hohrae 3 (the released variety) produced the highest yield of all tested varieties, however not significantly higher than CIP 8.

Table 43. Yield components for OFDT sweet potato varieties, 2009/10

Variety	*Yield (t/ha)*	*Tubers per plant*	*Weight per tuber (g)*
Hohrae 3	15.8	2.9	289
CIP 4	11.5	2.8	229
CIP 8	14.0	2.6	254
CIP 17	11.0	2.8	211
Local	*6.5*	*2.9*	*109*
LSD (p<0.05)	*3.2*	*0.6*	*67*

The higher yield of Hohrae 3 and the other introduced varieties were due to a larger tuber size, not to more tubers per plant. The average tuber of Hohrae 3 was approximately 3 times the weight of the local sweet potatoes.

Districts

The highest yielding sub-districts were in Manufahi and Viqueque districts (Alas, Same Villa and Ossu, see Table 44). However, there was not a significant interaction between variety and sub-district for sweet potato yield. The lack of interaction was due to the consistent high yield of Hohrae 3 in almost all subdistricts and the relatively low yield performance of local sweet potatoes.

Table 44. Sweet potato OFDT tuber yield (t/ha) by sub-district 2009/10

District	Sub-District	Hohrae 3	CIP17	CIP4	CIP8	Local
Aileu	Aileu Villa	9.6	8.9	8.9	7.1	2.9
Aileu	Laulara	8.9	5.1		6.8	2.7
Aileu	Lequidoe	5.6	3.2		3.6	1.2
Aileu	Remexio	5.4	4.0		5.6	1.3
Ainaro	Hatudo	12.2	12.1	6.9	15.8	
Baucau	Baucau Vila	19.9	11.9	11.4		0.7
Baucau	Vemasse	12.6	12.7		11.8	3.8
Baucau	Venilale	35.5	22.8		34.9	19.2
Bobonaro	Balibo	20.0	13.1	11.3		9.2
Bobonaro	Maliana	9.5	4.8	13.0		8.4
Liquica	Liquica	3.0	2.9	2.6		2.3
Liquica	Maubara	15.7	8.7	9.3		2.7
Same	Same Vila	20.6	16.4	5.3	14.8	6.4
Viqueque	Ossu	16.2	15.3	17.3		13.3
Viqueque	Viqueque Vila	20.8	9.3			6.7

Interaction Yield. Sub-District: non-significant at p<0.05

The released variety Hohrae 3, was the highest yielding variety in all but 2 of the 15 subdistricts. In those 2 Sub-Districts (Maliana and Ossu), Hohrae 3 yielded well above the local check varieties.

Agro ecological zones (AEZ) and yield

Yield results for each variety in each AEZ are shown in Table 45. Yields for all varieties were greatest in the highlands and on the south coast, at all latitudes. There was no interaction between variety and AEZ. This suggests there is no need to recommend different varieties for different locations and AEZs.

Table 45. Sweet potato OFDT mean yield by AEZ, 2008/09

AEZ	*Local (t/ha)*	*Hohrae 3 (t/ha)*	*CIP 4 (t/ha)*	*CIP 8 (t/ha)*	*CIP 17 (t/ha)*
1 Northern coast (0-100m altitude)	2.2	11.3	10.1		7.1
2 Northern slopes (100-500m altitude)	3.5	11.5	7.7	11.8	9.7
3 Northern uplands (>500m altitude)	6.7	18.3	14.3	14.8	12..0
4 Southern Uplands (>500m)	13.3	16.2	17.3		15.3
5 Southern slopes 100-500m)	6.2	16.4	6.4	15.2	16.4
6 Southern coast (<100m altitude)	7.7	23.3	10.2		23.3
Total					
LSD (P<0.05)	*Interaction: ns*				

Hohrae 3 again was the top yielding variety in almost all agro-ecological zones. Only in zone 4 (southern uplands) did CIP 4 have a higher yield than Hohare3, but not significantly higher.

Agronomic factors affecting yield

Although the overarching purpose of the OFDT system is to test possible candidates for variety release for use on farmers' fields, the process of measuring and comparing yields also provides an opportunity to collect data on agronomic factors and analyse the effect of these factors on yield. This analysis is described in the materials and methods section above.

The influence of a wide range of characters was tested for affecting the yield of sweet potato in the complete data set. A large number of characters were found to have an influence on root yield. These included Variety, AEZ, Sub-District, soil colour, soil texture, slope, soil pH and terracing. The gender of the head of the household and whether the crop was mono cropped or not and planting in lines or not had no effect on sweet potato yield (Table 46). Correlations were similar to those found in 2008/2009 excepting for soil colour which did not significantly affect root yields.

Table 46. Significance of management factors affecting sweet potato yield

Factor	*Significance P<0.05*	
	2009/10	*2008/2009*
Variety	✓	✓
Sub-District	✓	✓
AEZ	✓	✓
Soil pH	✓	✓
Soil colour	✓	ns
Elevation	ns	ns
Soil texture	✓	✓
Slope of land	✓	✓
Plant in lines or not	ns	ns
Mixed planting or monoculture	ns	ns

Soil pH

Soil pH had a much larger effect on sweet potato yields than observed in the previous year. Crops planted in soil with a pH below 6 appeared to have a lower yield, and high pH soil above 8 drastically reduced yields. (Table 47).

Table 47. OFDT yield by soil pH for all sweet potato varieties, 2009/10

Soil pH	5.0	5.5	6.0	6.5	7.0	7.5	8.0	8.5
Mean yield (t/ha)	6.7	7.1	9.2	9.9	14.4	12.6	19.4	4.0
LSD (p<0.05)	*5.4*							

There was no interaction between soil pH and variety for yield. This suggests that the impact of low pH on sweet potato yields is similar for local and introduced varieties.

Soil texture

In general, sweet potato yield increased with heavier soil texture (Table 48). Crops grown on sandy loam and silty loam soils had significantly lower yields than crops grown on soils with heavier texture (i.e. loams and clays). The exception was heavy clay soil, that resulted in a low yield.

Table 48. Impact of soil texture on sweet potato yield, 2009/10

Soil texture	*Yield (t/ha)*
Sandy loam	10.0
Silty loam	7.4
Loam	12.5
Clay loam	13.9
Fine clay	13.4
Heavy clay	3.4
LSD (P<0.051)	*4.2*

Soil colour

Sweet potato yield was affected by soil colour, with dark brown and red soils having a lower yield than light brown, yellow and white soils (Table 49). Although the analysis of variance showed a significant effect of soil colour on yield, the large LSD (7.0 t/ha) did not allow for much discrimination between soil colours.

Table 49. Impact of soil colour on sweet potato yield 2009/10

Soil colour	*Yield (t/ha)*
White	10.2
Red	8.6
Yellow	16.1
Light brown	13.7
Dark brown	5.1
Black	15.2
LSD (P<0.051)	*7.0*

Soil slope

Sweet potato gave highest yield in lower soil slopes. A the slope increased from 8 to 16% yields reduced dramatically (Table 49).

Table 50. Impact of soil slope on sweet potato yield 2009/10

Soil slope class	*Yield (t/ha)*
0-2%	12.0
2-8%	15.1
8-15%	11.3
16-30%	6.6
>30%	3.8
LSD (P<0.051)	*6.6*

As some of the OFDTs were grown on terraced areas, the effect of terracing was tested for its impact on sweet potato yields. Yields on terraced soils were lower than those in flat and sloping soils (Table 51).

Table 51. Impact of topography on sweet potato yield 2009/10

Soil slope class	*Yield (t/ha)*
Low slope soils	14.2
High slope soils	11.2
Terraces	9.4
LSD (P<0.051)	*4.1*

Farmers' preferences for sweet potato clones

All tested sweet potato clones were judged by farmers as having good taste (Table 52). Taste and numerous tubers were the only positive characteristic attributed to local sweet potato varieties (Table 52). The released variety Hohrae 3 had the most positive comments and was described as having the added positive attributes of large tubers, easy to sell, having a short growing season in addition to high yield and and good taste.

Table 52. Reasons for farmers (%) to replant sweet potato varieties in 2009/10.

Characteristic	*Hohrae 3*	*CIP 4*	*CIP 8*	*CIP 17*	*Local*
Tastes good	22	16	14	12	14
Big tubers	27	5	4	3	
Good price	9	1	1	0	
Short season	19	2	1	2	
Good colour	1	0	0	1	
Big yield	6	0	1	1	
Many tubers	0	0	0	3	3

The yellow fleshed sweet potato CIP 17 was appreciated for good flesh colour and excellent taste. From anecdotal evidence, CIP 17 seems to have better colour and taste than all other varieties. When asked which variety the farmers themselves would like to plant, they chose Hohrae 3 and CIP 17. These are both attractive yellow flesh tubers with sweet taste. One comment about CIP 17 was that it was so sweet, when eaten as breakfast, farmers did not need to add sugar to the coffee.

When further questioned, farmers appeared to prefer Hohrae 3 as a sweet potato for sale, and CIP 17 for their own consumption.

Conclusions

This year's research confirmed the suitability of Hohrae 3 for increasing food production on East Timorese farms. Although CIP 17 was highly desired by farmers in terms of taste and colour, its lower yields compared to Hohrae 3 does not warrant CIP 17 to be released as a named variety. Although CIP 8 was the highest yield of the new test varieties, it was less preferred than Hohrae 3 in terms of farmers' preferences and seemed not to be superior to Hohrae 3 in any character.

2.3 Cassava

Cassava (*Manihot esculenta Crantz*) is grown in East Timor mainly as a source of food. Cassava roots are eaten fresh after boiling or steaming and sometimes processed into dry chips. Cassava leaves are also boiled and eaten as a vegetable. Most farm households have a small number of plants intercropped with other species, although large (200m^2 or more) monoculture crops are found in some Districts. Farmers dig roots and harvest leaves from the plant on a needs basis after approximately one year of growth.

2.3.1 Replicated cassava trials

The results from the 2008/09 season were collected too late to be included in the 2009 Annual Research Report and are presented here in the 2010 Annual Research Report. Replicated trials were conducted at 5 sites during 2008/09 using the same set of clones tested in the previous year. For the first time, a replicated cassava trial was planted at the newly established research station at Loes in the District of Liquica.

Materials and methods

Replicated cassava trials were conducted during 2008/2009 at stations in Maliana, Baucau, Alieu, Betano and also at Loes. Each trial was a randomized block design with three replicates at each of the four established sites but at the new site at Loes, only two replicates were possible. The trials were planted from November 2008 through to January 2009 (Table 53) and harvested 10-12 months later.

Table 53. Cassava planting and harvest details, 2008/09

Location	*Number of entries*	*Planting date*	*Harvest date*	*Mean yield (t/ha)*
Maliana	20	20/11/2008	12/09/2009	11.1
Baucau	20	25/11/2008	04/11/2009	9.1
Aileu	20	19/11/2008	15/10/2009	18.5
Betano	25	16/12/2008	10/11/2009	23.9
Loes	20	30/01/2009	12/01/2010	48.7

A common set of 20 clones from the list of those tested in 2007/08 were again tested at all sites in 2008/09. However at Betano, an extra 5 clones were included. All trials included the same local varieties, Mantega , Merah and Etu Hare.

Plot dimensions were 5m by 5m with a 30cm walkway between each plot. Plant spacing was 1m by 1m square, resulting in 25 plants per plot. At harvest, roots of 20 plants were dug for yield determination. The remaining 5 plants were left for field day observations and for fresh stem production. At harvest, fresh weight of tubers and their starch content were measured immediately. Sample tubers were then taken for determination of HCN content in the laboratory.

At the time of harvest at Aileu, Betano and Maliana, a farmer field day was conducted. A total of 63 farmers were involved in measuring yields and visually inspecting tubers and cassava plants *in situ.* A taste test of uncooked tubers was conducted among the farmers and they were then asked which varieties they would like to plant in their own farms.

Results

Aileu

The results of the Aileu trial are presented in Table 54. Root yields were again relatively good. The site average of 18.5 t/ha in 2009 was higher than the 15.8 t/ha produced in 2008.

The highest yielding varieties in Aileu in 2008 were again Ai-luka 4 (Ca 015), Ca036 and 042, all of which had significantly higher yields than most other varieties. They were not however significantly higher than Ca 007 or Rayong 72. Although Ai-luka 2 produced a yield higher than the site average , it was not significantly better than either of the best local varieties (Mantega and Merah). And of the set of Thai varieties tested, only Rayong 72, had significantly higher yield than either, the site average, or any of the local checks. Rayong 60 which had a very poor yield in 2008, produced yields similar to that of the locals in 2009. The lowest yield at Aileu in 2009 was produced by Rayong 3 with just 9.5 t/ha.

The measured starch contents were similar to those obtained in 2008 and when total starch yield was calculated, Ai-luka 4, Ca 007, 036, 042 and Rayong 72 all had significantly higher potential starch yields of any of the local varieties tested.

Table 54. Cassava variety evaluation trial results, Aileu, 2008/09.

Code	*Variety name*	*Root yield (t/ha)*	*Yield advantage over average of locals (%)*	*Starch content (%)*	*Starch yield (t/ha)*
Ca 007	CMM 96-36-224	23.7	69	31.2	7.4
Ca 013	CMM 96-25-25	18.4	32	23.5	4.4
Ca 014	OMM 96-01-93	19.1	36	24.4	4.8
Ca 015	Ai-luka 4	28.5	103	31.4	9.1
Ca 016	*Mantega-Aileu*	14.2	*	27.2	3.9
Ca 017	*Merah-Aileu*	16.3	*	26.7	4.3
Ca 025	Gempol	17.8	27	24.9	4.4
Ca 026	Ai-luka 2	19.6	40	28.5	5.6
Ca 036	CMM 97-02-36	28.3	102	28.8	8.2
Ca 040	CMM 97-07-145	17.8	27	25.5	4.5
Ca 042	CMM 97-02-181	29.5	111	24.0	7.1
Ca 060	*Local Etuhare*	11.4	*	28.8	3.3
Ca 101	Hanatee	17.3	24	30.3	5.2
Ca 102	Rayong 1	11.8	-16	28.0	3.3
Ca 104	Rayong 3	9.5	-32	28.9	2.8
Ca 105	Rayong 5	14.8	6	32.2	4.8
Ca 106	Rayong 60	15.4	10	30.2	4.7
Ca 107	Rayong 72	23.4	67	31.5	7.4
Ca 108	Rayong 90	15.8	13	30.9	4.9
Ca 109	KU 50	17.6	26	29.7	5.4
Site average		*18.5*		*28.3*	*5.3*
Fprob		0.001		0.001	0.001
LSD(P<0.05)		6.4		4.3	2.2

Maliana

The average cassava root yields at Maliana in 2008-09 (11.2 t/ha) were lower even than those recorded at this site in 2007-08 (13.4 t/ha) and much lower than the 35 t/ha recorded in 2006-07. There were however some significant differences in yields between varieties (Table 55). The highest yields were produced by KU 50 and Rayong 5 and these were significantly higher than most of the other varieties tested, but not better than the local Mantega which produced a relatively high yield of 16.2 t/ha. Maliana was the only site in 2008-09 at which Ai-luka 2 performed badly (5.4 t/ha). The other Indonesian variety, Gempol also yielded very poorly in

2008-09 as it did in the previous year at Maliana. However, both Ai-luka 4 and Rayong 72, maintaining their general consistency across sites and years, produced yields slightly higher than the site average in 2008-09.

As mentioned in the methods there was unfortunately no starch measurements obtained from the 2008-09 Maliana trial. However there was a farmer field day conducted and HCN contents of fresh tubers was measured, the results of which are discussed in following sections.

Table 55. Cassava variety evaluation trial results, Maliana, 2008/09.

Code	*Variety name*	*Root yield (t/ha)*	*Yield advantage over average of locals (%)*
Ca 007	CMM 96-36-224	12.0	19
Ca 013	CMM 96-25-25	14.7	45
Ca 014	OMM 96-01-93	8.7	-14
Ca 015	Ai-luka 4	12.3	22
Ca 016	*Mantega-Aileu*	16.2	*
Ca 017	*Merah-Aileu*	7.1	*
Ca 025	Gempol	3.2	-68
Ca 026	Ai-luka 2	5.4	-46
Ca 036	CMM 97-02-36	9.0	-11
Ca 040	CMM 97-07-145	11.1	10
Ca 042	CMM 97-02-181	8.7	-14
Ca 060	*Local Etuhare*	6.9	*
Ca 101	Hanatee	7.8	-23
Ca 102	Rayong 1	8.9	-12
Ca 104	Rayong 3	10.3	2
Ca 105	Rayong 5	18.1	79
Ca 106	Rayong 60	12.1	20
Ca 107	Rayong 72	14.3	41
Ca 108	Rayong 90	13.4	33
Ca 109	KU 50	22.0	118
Site average		*11.2*	
Fprob		0.001	
LSD(P<0.05)		7.0	

Baucau

Although higher than in the previous year, average yields (9.1 t/ha) at Baucau were once again the lowest of all the replicated cassava trials conducted in 2008-09. As opposed to results from 2007-08, there were however significant differences between varieties. The highest yields were produced by Ca 007 and the local Mantega (this had the lowest yields at Baucau in 2007-08). The newly released varieties Ai-luka 2 and 4, Rayong 72 and the Indonesian variety Gempol (Ca 025) also yielded significantly higher than most of the other varieties tested.

As in 2007-08, starch content (%) was quite variable ranging from 15.5 % for Ca 042 to 27.9% for Ca 007. A combination of high yield and high starch content resulted in Ca 007 having the highest estimated starch yield (4 t/ha) in 2008-09 whereas in 2007-08 it had the lowest (0.4 t/ha).

Table 56. Cassava variety evaluation trial results, Baucau, 2008/09

Code	*Variety name*	*Root yield (t/ha)*	*Yield advantage over average of locals (%)*	*Starch content (%)*	*Starch yield (t/ha)*
Ca 007	CMM 96-36-224	14.3	70	27.9	4.0
Ca 013	CMM 96-25-25	9.2	9	16.1	1.4
Ca 014	OMM 96-01-93	3.7	-56	22.3	0.8
Ca 015	Ai-luka 4	12.4	47	25.0	3.1
Ca 016	Mantega-Aileu	14.0	*	26.8	3.7
Ca 017	Merah-Aileu	5.9	*	22.6	1.3
Ca 025	Gempol	13.9	65	23.3	3.2
Ca 026	Ai-luka 2	12.3	46	23.2	2.9
Ca 036	CMM 97-02-36	6.9	-18	21.3	1.5
Ca 040	CMM 97-07-145	6.0	-29	21.3	1.4
Ca 042	CMM 97-02-181	7.8	-8	15.5	1.2
Ca 060	Local Etuhare	5.4	*	25.9	1.4
Ca 101	Hanatee	5.6	-34	21.8	1.3
Ca 102	Rayong 1	10.1	21	23.6	2.5
Ca 104	Rayong 3	5.2	-38	23.9	1.2
Ca 105	Rayong 5	9.6	14	24.3	2.3
Ca 106	Rayong 60	5.1	-40	18.0	0.9
Ca 107	Rayong 72	13.7	63	25.3	3.6
Ca 108	Rayong 90	9.2	10	25.8	2.4
Ca 109	KU 50	11.0	31	19.7	2.2
Site average		9.1		22.7	2.1
Fprob		0.001		Ns	0.001
LSD(P<0.05)		4.9			1.4

Betano

There was relatively poor plant establishment at Betano in the 2008-09 trial. The average plant number at harvest was 14 per plot compared with a range of 18 to 24 at the other sites. The varieties, Ca10, 21, 40 and the local Etuhare were particularly affected by the yellowing and stunting symptoms which generally occur in all cassava planted at this site. As in previous years, most varieties eventually grow through this problem and produce very good yields, even if total plant number per plot is reduced. The average yield at Betano in 2008-09 was 23.9 t/ha, down on the previous year (36.8 t/ha) but still more than that obtained at other sites (except for the new site at Loes). `

The highest yields were observed in Ca 007, 009, Rayong 72, Rayong 60 and Ai-luka 2. All of these also had good yields in 2007-08. However other varieties such as Ca 36 and 40, which had relatively high yields at Betano in the previous year, produced only 14 and 16 t/ha respectively in 2008-09. Ai-luka 4 (33 t/ha) did not perform as well as in 2007-08 (47 t/ha) but still out-performed the best local Mantega (25 t/ha).

Starch content of varieties tested at Betano in 2008-09 were much the same as in 2007-08 in terms of site average and range. The high yielding varieties, Ca 007 and 009, which produced the lowest starch content in 2007-08, also had the lowest starch content in 2008-09. A combination of high tuber yield and relatively high starch content resulted in Ai-luka 2, and the Thai varieties, Rayong 72 and KU 50 having estimated starch yields significantly higher than any of the local varieties and most of the other varieties tested.

Table 57. Cassava variety evaluation trial results, Betano, 2008/09.

Code	*Variety name*	*Root yield (t/ha)*	*Yield advantage over average of locals (%)*	*Starch content (%)*	*Starch yield (t/ha)*
Ca 007	CMM 96-36-224	40.9	273	15.3	6.4
Ca 009	CMM 96-36-269	44.9	309	19.6	9.3
Ca 010	OMM 96-01-69	8.9	-19	26.2	2.4
Ca 013	CMM 96-25-25	21.5	96	19.6	4.3
Ca 014	OMM 96-01-93	12.5	14	19.9	2.5
Ca 015	Ai-luka 4	33.2	203	20.4	6.7
Ca 016	Mantega-Aileu	25.3	*	25.2	6.3
Ca 017	Merah-Aileu	3.3	*	25.4	2.1
Ca 021	Bogor 1	8.7	-37	25.1	2.2
Ca 025	Gempol	19.3	76	23.5	4.8
Ca 026	Ai-luka 2	40.5	269	28.3	11.6
Ca 032	CMM 97-01-158	5.7	-59	24.2	1.4
Ca 036	CMM 97-02-36	13.6	24	25.1	3.4
Ca 040	CMM 97-07-145	14.7	34	20.0	3.3
Ca 042	CMM 97-02-181	16.1	47	23.7	3.8
Ca 060	Local Etuhare	4.3	*	21.7	2.9
Ca 101	Hanatee	30.9	182	23.4	7.2
Ca 102	Rayong 1	33.5	205	24.6	8.3
Ca 103	Rayong 2	27.7	153	22.8	6.0
Ca 104	Rayong 3	27.6	152	26.6	7.8
Ca 105	Rayong 5	7.7	-30	27.7	2.2
Ca 106	Rayong 60	40.0	265	25.6	10.3
Ca 107	Rayong 72	41.5	278	27.2	11.4
Ca 108	Rayong 90	28.6	161	25.8	7.6
Ca 109	KU 50	37.2	239	28.4	10.7
Site average		23.9		23.8	5.8
Fprob		0.001		0.001	0.001
LSD(P<0.05)		15.7		4.8	4.2

Loes

The trial site at the newly developed research station at Loes was established on heavy clay soils which had not been cropped for a number of years. Consequently, the average cassava yield obtained from this 'fresh' site were exceptionally high at 48.7 t/ha. In fact the lowest yields obtained at Loes (16 t/ha from Ca 014 and the local Merah) were higher than the best yielding variety at Baucau, and also the site average at Maliana.

Ai-luka 2 produced the highest yield at 73.2 t/ha and together with Rayong 90 and Ca 042 was significantly higher than the best local, which as in most trials in 2008-09, was Mantega with 38.4 t/ha. These yields are as high as the best yields achieved at Betano in previous years and it will be interesting to see if they can be maintained in the future.

Average starch contents at Loes were similar to those obtained at all the other sites in 2008-09. Ai-luka 4 again had a relatively high starch content at 27.9% and this resulted in a massive potential starch yield of 20.6 t/ha. This estimated starch yield is higher than the fresh tuber yield of most varieties at the other sites.

Table 58. Cassava variety evaluation trial results, Loes, 2008/09.

Code	Variety name	Root yield (t/ha)	Yield advantage over average of locals (%)	Starch content (%)	Starch yield (t/ha)
Ca 007	CMM 96-36-224	58.1	96	21.9	12.8
Ca 013	CMM 96-25-25	64.3	117	27.2	17.5
Ca 014	OMM 96-01-93	16.2	-45	23.9	4.3
Ca 015	Ai-luka 4	73.2	147	27.9	20.6
Ca 016	Mantega-Aileu	38.4	*	30.8	11.6
Ca 017	Merah-Aileu	16.1	*	18.2	2.9
Ca 025	Gempol	37.9	28	23.5	9.0
Ca 026	Ai-luka 2	51.1	73	25.4	13.1
Ca 036	CMM 97-02-36	65.5	121	24.0	15.0
Ca 040	CMM 97-07-145	52.8	78	20.0	10.5
Ca 042	CMM 97-02-181	69.1	133	25.0	17.3
Ca 060	Local Etuhare	34.2	*	17.8	4.9
Ca 101	Hanatee	43.4	47	23.7	10.3
Ca 102	Rayong 1	39.8	34	26.1	10.5
Ca 104	Rayong 3	52.8	78	25.4	13.7
Ca 105	Rayong 5	53.8	82	31.3	16.9
Ca 106	Rayong 60	29.8	1	28.9	8.9
Ca 107	Rayong 72	50.5	71	25.8	13.0
Ca 108	Rayong 90	71.7	142	23.6	17.1
Ca 109	KU 50	55.2	86	26.5	14.5
Site average		48.7		24.8	12.2
Fprob		0.01		ns	0.02
LSD(P<0.05)		29.3		*	8.4

2.3.2 Cassava performance across sites and years

Of all 17 introduced varieties tested at all sites in 2008-09, only Ca 014 failed to out-yield the average of the three local varieties. After performing very well in the early years of testing (particularly at Betano), Ca 014 now has a long-term yield advantage of just 29%. However, all other cassava clones which have performed well across sites in previous years produced relatively high yields again in 2008-09.

Although tested now in only 12 trials (from the season of 2006-07 to the present), Rayong 72 from Thailand has the highest long-term yield advantage at 116%. However the two newly released varieties, Ai-luka 4 and 2 (which have now been tested in 23 trials over a 8 year period), continue to maintain significant yield advantages of 93 and 57% respectively. The varieties Ca 036, Ca 042 (which have been included in OFDTs for a number of years) (Table 59), and Ca 013 also produced relatively high yields across all sites in 2008-09 and all have a long-term yield advantage over locals of more than 50%. However one of the locals, Mantega, after a relatively good performance in 2007-08 has again produced some reasonable yields in 2008-09 (particularly at Baucau and Maliana). In fact, it's average yield across all sites was better than a number of the introduced varieties. The Thai variety Rayong 2, which was a very poor performer at Betano and Maliana in 2007-08 was only tested at the one site (Betano) in the 2008-09 trials and, although it yielded better in 2008-09 (in fact was slightly above the site average and Mantega), was still only a mediocre performer in comparison to other varieties. Rayong 60 which in 2007-08, yielded well at the lower altitude sites at Betano and Maliana but relatively poorly at Aileu and Baucau, again produced yields in 2008-09 which tended to follow this pattern *ie* very poor at Baucau, below average at Aileu, but above average at Maliana and very good at Betano.

The starch contents of varieties tested in replicated trials have now been measured in almost all trials conducted since the 2006-07 season. Average starch contents over this period have also been included in Table 59. Although as the standard deviations indicate, there is obviously some variation between years and locations, in general it appears that all the newly introduced varieties from Thailand have relatively high average starch contents (ranging from 25.3-28.2 %). Ai-luka 4 and the local Mantega variety also have good average starch contents. While Ca 007 has maintained consistently high yields over a number of years, it appears to produce lower amounts of starch relative to other varieties. The variety Ca 014 also has a relatively poor average starch content.

The overall outcome from the three farmer field days conducted at Aileu, Betano and Maliana is also summarized in Table 59. Although farmers were asked to rate each variety on a scale of 'sweetness', the data is not included because of the fact, as in previous taste tests, there is huge variation in perception of sweetness between individuals as well as between locations. One farmer can rate a variety as very bitter while his neighbour can taste the same tuber and score it as very sweet. Averaging such variable scores results in almost all varieties being rated with a 'mixed' response. What has been presented in Table 59 is the combined percentage of farmers (of the total of 62 farmers who attended the three field days at Aileu, Maliana and Betano) who selected a particular variety as one which they would actually like to plant in their own fields.

From Table 59, it can be seen that there was a clear preference for Ai-luka 2 amongst farmers. A third of all farmers also selected the other recently released variety, Ai-luka 4. As in previous evaluations, it seems farmers preferences are guided by a combination of yield performance and perceived taste. For example, the local Etu-hare which apparently is of very good eating quality, was selected by 23% of farmers even though it had relatively poor yields. However on the other hand, Rayong 72 was also selected by a significant number of farmers (19%). This preference seems to be based largely on it's excellent yields, since it generally considered not a particularly 'sweet' variety. Even Ca 007, which has been rated 'bitter' in a number of previous taste tests, was selected by some farmers (6%) as a cassava variety they would like to plant. However, no farmers selected Ca 014 or the Thai varieties, Ca104, 105, 106 and 109.

Table 59. 2009 mean yields (t/ha) and long term yield advantage and starch contents

Code	*Variety*	*2009 Mean yield (t/ha)*	*Long term % yield advantage*	*Long term % starch content (SD in brackets)*	*% Farmers selecting this variety in 2009*
Ca 015	Ai-luka 4	29	93	26.8 (4.9)	31
Ca 007	CMM 96-36-224	27.9	69	21.4 (6.8)	6
Ca 107	Rayong 72	27.1	116[1]	27.9 (5.0)	19
Ca 109	KU 50	26.7	84[1]	27.4 (6.1)	0
Ca 108	Rayong 90	25.1	61[1]	27.6 (4.9)	3
Ca 026	Ai-luka 2	24	57	24.5 (3.3)	52
Ca 042	CMM 97-02-181	23.2	72	24.8 (4.1)	5
Ca 013	CMM 96-25-25	22.9	70	23.0 (4.3)	2
Ca 036	CMM 97-02-36	21.7	54	26.0 (3.4)	5
Ca 016	Local Mantega	20.4	*	26.6 (4.4)	16
Ca 106	Rayong 60	19.8	43[1]	26.5 (5.5)	0
Ca 102	Rayong 1	19.5	62[1]	25.3 (4.8)	6
Ca 101	Hanatee	19.4	35[1]	26.1 (3.8)	11
Ca 104	Rayong 3	19.1	71[1]	28.0 (6.5)	0
Ca 105	Rayong 5	18.5	62[1]	28.2 (4.7)	0
Ca 040	CMM 97-07-145	18.3	49	25.0 (5.5)	2
Ca 025	Gempol	17	39	24.2 (5.2)	8
Ca 014	OMM 96-01-93	11.8	29	22.3 (4.2)	0
Ca 060	Local Etu Hare	10.9	*	24.5 (5.7)	23
Ca 017	Local Merah	9.3	*	24.0 (4.2)	19
Fprob		0.001			
LSD (P<0.05)		7.5			

[1] These varieties tested only from period 2006 to 2009. Other varieties tested from 2001 to 2009

HCN contents of tested cassava varieties

As with previous years there was considerable variation in measured HCN contents between sites (Table 60). The average HCN content in Betano was very high relative to the other three sites and also in comparison with the average HCN content measured at Betano in 2008 (35ppm). There was also a very large range of HCN contents measured at Betano (30 to 300 ppm) which resulted in statistically significant differences between varieties. Highly significant differences between varieties were observed at Aileu. Although the range and average HCN content measured at Aileu in 2008-09 was similar to that observed in 2007-08, there were some varietal differences between years at this site (*eg* Ai-luka 4 recorded 100ppm in 2007-08 but only 50ppm in 2008-09). Both the Loes and Baucau sites recorded similar averages in 2008-09, but the HCN contents in Baucau had a very narrow range with no significant differences between varieties while those at Loes were highly significant.

Analysis across all sites at which HCN was measured in 2008-09, reveals that Ca 007 produced a significantly higher HCN content than most other varieties. Rayong 60 and Rayong 72 also had HCN contents that were significantly higher than other varieties. Surprisingly, the local variety Mantega which is generally praised for it's 'sweet' eating quality produced a relatively high average HCN content in 2008-09, largely due to a very high content recorded at Betano (217 ppm). This result merely confirms the highly variable nature of HCN measurements between both location and year.

Table 60. HCN contents across sites in 2009

Code	*Variety*	*Aileu*	*Betano*	*Baucau*	*Loes*	*Predicted mean all sites*
Ca 007	CMM 96-36-224	100	300	50	200	159
Ca 013	CMM 96-25-25	30	83	19	30	42
Ca 014	OMM 96-01-93	50	125	50	50	70
Ca 015	Ai-luka 4	50	130	43	50	70
Ca 016	Mantega-Aileu	50	217	43	50	94
Ca 017	Merah-Aileu	50	70	37	35	49
Ca 025	Gempol	20	97	33	30	46
Ca 026	Ai-luka 2	37	75	43	23	46
Ca 036	CMM 97-02-36	100	250	50	50	118
Ca 040	CMM 97-07-145	100	254	43	30	98
Ca 042	CMM 97-02-181	30	183	33	50	76
Ca 060	Local Etuhare	50	55	40	20	43
Ca 101	Hanatee	100	158	57	100	104
Ca 102	Rayong 1	100	167	36	23	87
Ca 104	Rayong 3	200	30	52	50	90
Ca 105	Rayong 5	50	147	47	15	69
Ca 106	Rayong 60	100	267	60	23	120
Ca 107	Rayong 72	100	250	83	30	124
Ca 108	Rayong 90	100	113	50	25	76
Ca 109	KU 50	100	125	60	35	84
Site average		76	159	47	46	
Fprob		0.001	0.01	ns	0.001	0.01
LSD(P<0.05)		9	151		18	62

Conclusions

The results of the replicated cassava variety trials conducted in 2008-09 were generally consistent with those obtained in the previous year. The released varieties Ai-luka 2 and 4 continue to yield well and out-perform local varieties. More importantly, they (particularly Ai-luka 2) are being selected by farmers as their most preferred varieties. However a significant proportion of farmers attending the field days organized in 2008-09 still choose local varieties, confirming the importance of eating quality as a desired characteristic in cassava.

The older SoL varieties Ca 36 and Ca 42 (which have been tested in OFDTs now for a number of seasons) as well as Ca 007 and Ca 013, continue to yield relatively well. Similarly, of the more recently introduced varieties from Thailand, Rayong 72, Rayong 90 and KU 50 have once again yield quite well in 2008-09. However with the possible exception of Rayong 72, none of these varieties (Thai or the older SoL varieties) appear to 'grab' the interest of farmers involved in on-station field days. This would seem to be largely due to perceived eating quality. In recent years the local variety, Mantega, has been producing respectable yields and is highly desired by farmers. It is suggested that this variety should be included as the local control in all future cassava OFDTs and if it continues to yield relatively well in comparison to the introduced varieties, consideration should be given to multiplying up planting material and making this variety more readily available to farmers in Timor-Leste. In lieu of any other obvious candidates, this could provide an opportunity for SoL/MAF to officially release this cassava variety for cultivation in Timor-Leste.

There is currently no market for starch or other processed cassava products in Timor-Leste however there is a possibility that such markets could develop over time. Therefore, because of their continued consistent yield performance and relatively high starch contents, all the Thai varieties should continue to be included in SoL replicated trials. However, Ca 014 with its continuing poor yield performance, should be dropped. The variety Ca 007 has now been tested for a number of years and although it does produce good yields, these are no better than a number of other of the introduced varieties and Ca 007 does not appear to have either good eating qualities or high starch content, so there is an argument for dropping this variety also from the list. This would allow the introduction of other varieties with more desirable characteristics (*eg* eating quality or adaptation to higher altitudes)

2.3.3 Cassava OFDTs 2009-2010

Data from the 2009-2010 OFDTs was not available for evaluation and inclusion in the 2009-2010 Annual Research Report and will be included in the 2010-2011 report

2.4 Rice

2.4.1 Rice replicated trial, 2010

Rice (*Oryza sativa* L.) varieties sourced from IRRI in the Philippines have been evaluated in replicated trials since 2006. Test entries entered on-farm trials located in different agro-ecological zones across Timor-Leste. A variety with particularly broad adaptation was identified through this process and released in 2007 as Nakroma (SoL, 2007).

During the wet season of 2009-2010, one replicated trial was installed in Betano to evaluate 20 varieties. These were compared with the released variety Nakroma and three locally popular varieties (President, Membrano, Nonaporto). The varieties codes are detailed in Table 61

Table 61. Codes details of trialled rice varieties, Betano wet season 2009/10

Codes	*Original codes / names*
Angelica	IR.61979.138.1.3.2.3(Angelica)
IR 393	IR.39357.71.1.2.2
IR 529	IR.52952 B.3.3.2
IR 547	IR.54742.31.9.26.15.2
IR 580	IR.58088.16.2.2
IR 772	IR.01A108(IR.77298.5.6)
Matatag 1	IR.69726.116.1.3(MATATAG 1)
Matatag 2	IR.69726.29.1.2.2.2(MATATAG 2)
Matatag 3	IR.68305.18.11(NSICRC 118)(MATATAG3)
Matatag 9	IR.73885. 1.4.3.2.1.G(MATATAG 9)
MS 13	IR.68144.2B.2.2.3(MS 13)
Nakroma	PSBRC 54
NSIC 110	IR.71606.1.1.4.2.3.1.2(NSICRC110)
NSIC 112	IR.72102.4.159.1.3.3.3(NSICRC 112)
PSBRC 80	IR.62141.114.3.2.2.2.(PSBRC 80)
PSBRC 82	IR.64683.87.2.2.3.3(PSBRC 82)
RHS.OZA	RHS.334.28CX.5CX.OZA
Local Membramo	Membramo
Local President	President
Local Nonaporto	Nonaporto

Methodology

The trial consisted of 3 replicates with complete randomized plots, each being 3.40 × 2.50 m in size. Twenty day old seedlings were transplanted into hills were spaced by 20 x 25cm. This corresponded to maximum plant densities of about 20 plants/m². No fertilizer was applied. The crop was planted in March and harvested 3 months later (Table 62):

Table 62. Planting and harvest details of the Betano rice varietal trial, 2010

Location	*Season*	*No. of entries*	*No. of replicates*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)**	*Mean yield (t/ha)*
Betano	Wet	20	3	3 Mar 10	5 June 10	137	875	5.7

* Total rainfall from planting to harvest date

Yields, yield advantages and yield components

Seeds were soaked in water for two days then sundried for a day for buds to appear (one day) before sowing into a nursery. Young plants were transplanted into the plots 20 days afterwards. At harvest, the whole plot except the two edge rows was cut by hand. For each plot, the features of three sampled plants were measured in order to obtain averages for the number of tillers per plant, the number of panicles per plant, the length of panicle and stems and the number of seeds per panicle. The grain was sun-dried to an approximate 12% moisture content before being threshed and weighed for yield and seed weight determination.

The data was analysed using GenStat Discovery 3 in order to determine varietal effects. As no row nor column effect was detected, an ANOVA One-Way in Randomized Blocks was used.

Yield advantages were calculated from the resulting predicted means over the average of the local varieties. The existence and degree of correlation between the predicted means of the yields and of the other parameters were then identified using a Simple Linear Regression. The percentage of variability accounted for is equivalent to an adjusted R^2.

Farmers' preferences

Taste tests were organised during a farmer field day a few weeks after harvest. Farmers tasted cooked rice samples of the top 10 varieties, the plots edges rows production being used for this purpose. The varieties names were hidden by numbers. 50 people (22% of women) participated to the test. The participants were asked whether they liked the varieties and three favourites they would be willing to plant. The questionnaire otherwise included questions about eating characteristics such as oiliness, fragrance, stickiness and whether they preferred that, after cooking, the grain stayed separate or if the rice became porridge-like. All questions were to answer with a yes or no.

To analyse farmers' preferences, a General ANOVA was run with Variety*Gender as the treatment factors and with the participants as the blocking one. Correlations with Simple Linear Regressions were then calculated over the varieties predicted means using GenStat.

Results

Yields, yield advantages and yield components

Table 63 presents the results for all tested varieties, as well as the overall yield advantages over the local checks.

The site average yield of 5.7 t/ha was the highest of the five trials conducted since 2006 (overall trials average: 3.1 t/ha), with local varieties performing well. Significant differences for grain yield between varieties were found with a low coefficient of variation (10%). PSB RC 82, IR 547, the local President, PSBRC 80, the local Membrano and Angelica performed significantly better than the other varieties. The MAF recommended variety Nakroma yielded approximately 10% below the locals. However, even the best yielding varieties presented low yield advantages due to this year good performances of the local varieties.

No significant correlation was found between yields and the individual yield components presented in Table 63.

Table 63. Rice yields, yield advantages and yield components, Betano 2010

Variety	*Yield (t/ha)*	*Yield advantage over locals (%)*	*No tillers per plant*	*Stems with panicles (%)*	*Panicle length (cm)*	*No seeds/ panicle*	*Weight of 100 seeds (g)*	*Plant height at harvest (cm)*
PSBRC 82	7.0	12.5	16	93	24.8	127	1.91	112
IR 547	6.5	5.0	15	94	23.6	147	2.41	85
Local President	*6.4*	3.1	*12*	*94*	*24.5*	*127*	*2.27*	*135*
PSBRC 80	6.3	1.7	14	93	24.7	136	1.74	92
Local Membramo	*6.3*	1.4	*15*	*95*	*24.9*	*133*	*2.01*	*95*
Angelica	6.1	-1.2	14	94	24.4	115	1.65	109
IR 772	6.0	-3.1	16	93	26.0	140	1.67	72
Local Nonaporto	*5.9*	-4.5	*14*	*96*	*24.9*	*138*	*1.74*	*142*
Matatag 9	5.8	-5.7	18	92	24.4	129	2.26	91
IR 529	5.7	-8.5	18	94	23.5	77	2.09	94
RHS.OZA	5.6	-9.2	10	94	24.1	155	1.97	92
Nakroma	5.5	-10.7	14	92	24.2	120	2.41	86
Matatag 3	5.5	-11.1	18	96	24.2	90	2.02	78
Matatag 2	5.4	-12.9	14	92	22.9	138	1.50	76
NSIC 112	5.4	-13.0	14	97	25.4	115	2.26	73
MS 13	5.4	-13.5	15	96	23.7	141	1.49	79
NSIC 110	5.2	-16.5	17	95	23.0	131	1.80	79
Matatag 1	4.7	-24.4	16	95	23.8	125	1.79	140
IR 393	4.7	-24.8	13	94	24.3	131	1.92	100
IR 580	4.5	-27.5	14	93	26.6	127	1.78	126
F prob	*<0.001*		*0.007*	*0.922*	*0.323*	*0.170*	*0.065*	*<0.001*
LSD (p<0.05)	*0.9*		*4*	*ns*	*ns*	*ns*	*ns*	*16*
%CV	*10*		*15*	*4*	*6*	*21*	*19*	*10*
Mean site	*5.7*		*15*	*94*	*24.4*	*127*	*1.93*	*98*
Mean locals	*6.2*		*14*	*95*	*24.8*	*133*	*2.01*	*124*

Farmers' preferences

Table 64 summarizes the farmers field day results while Figure 28 displays the correlations between farmers' preferences and the varieties eating characteristics.

Table 64. Farmers' preferences (%), rice FFD, Betano 2010

Variety / *(%)*	*"Like"*	*"Separate grains" (not "porridge-like")"*	*"Sticky"*	*"Fragrant"*	*"Oily"*	*"Wish to plant"*	*"Wish to plant" Women only*	*"Wish to plant" Men only*	*Yield (t/ha)*
PSBRC 82	44	70	40	36	32	56	100	46	7.0
IR 547	62	20	68	48	68	26	11	29	6.5
Loc.President	*82*	*72*	*50*	*76*	*62*	*58*	22	*66*	*6.4*
PSBRC 80	60	30	58	48	50	48	67	44	6.3
Loc.Membramo	*28*	*74*	*34*	*36*	*28*	*12*	*0*	*15*	*6.3*
IR 772	28	68	34	32	14	12	11	12	6.0
Loc.Nonaporto	*36*	*76*	*28*	*18*	*16*	*22*	*22*	*22*	*5.9*
Matatag 9	42	12	48	34	42	12	33	7	5.8
IR 529	50	64	48	48	42	30	11	34	5.7
Nakroma	62	68	44	46	40	30	22	32	5.5
l.s.d. (p<0.001)	*19*	*17*	*18*	*19*	*18*	*18*	*31**		
%CV	*97*	*77*	*101*	*113*	*118*	*149*	*146*		

* Var.Gender p = 0.002

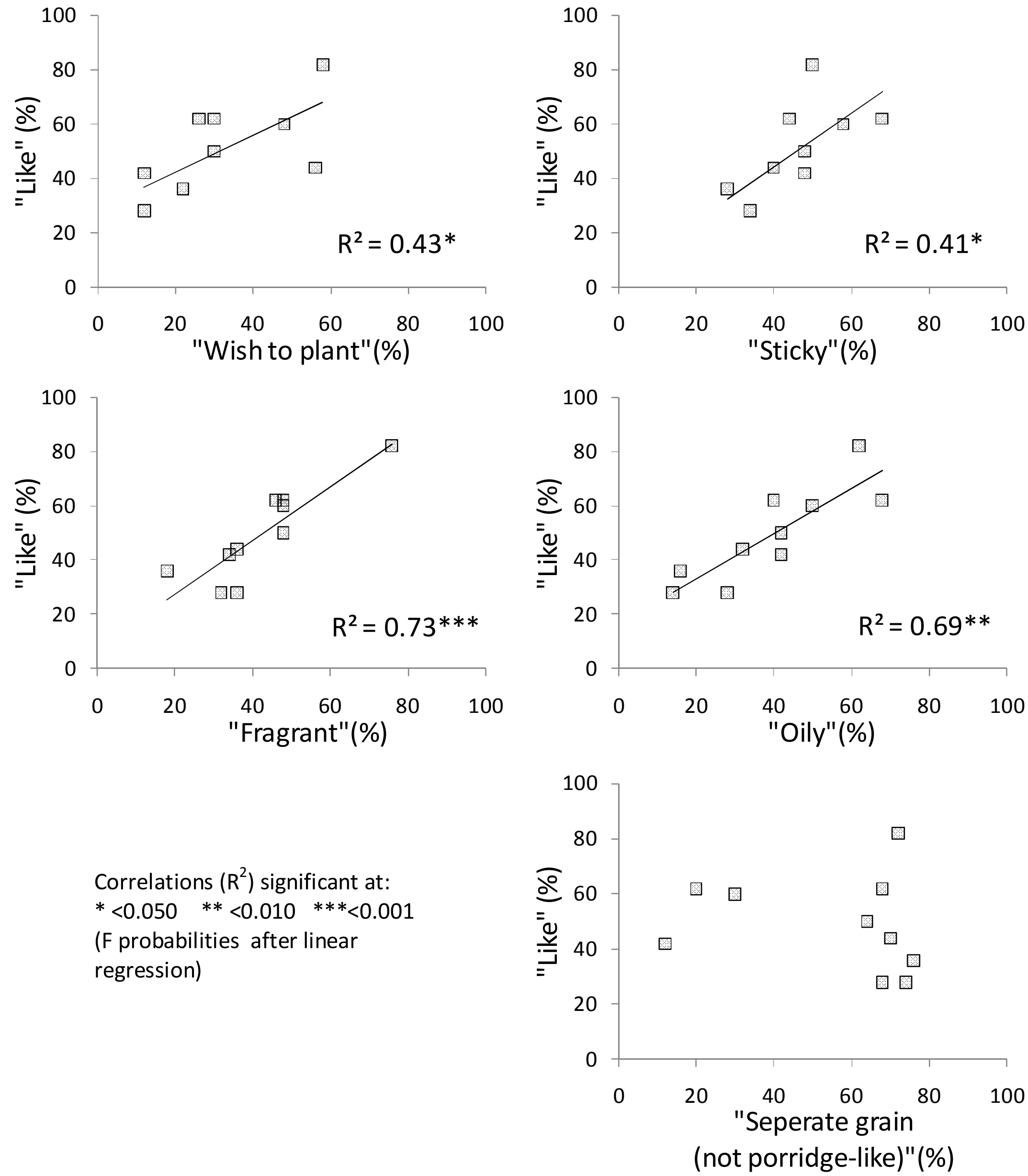


Figure 28. Correlations between farmers' preferences and rice varieties*

* Farmer field day, Betano, 2010

The first graph shows the correlation between farmers' willingness to plant a variety and its taste ("Like"), proving again that eating characteristic are an essential component to farmers' adoption of new varieties. This year's farmer field day confirmed that for rice, fragrance and oiliness of the grain are the most important taste features for farmers (strong correlation of "Fragrant" and "Oily" with "Like", Figure 28). Sticky grain also seemed to be favoured. It is considered a different characteristic than a porridge-like aspect after cooking, the later being found uncorrelated with farmers' preferences.

The varieties which was most preferred by farmers (60-80% "wish to plant") were Local President (by far considered the most fragrant and only second in term of "oiliness"), PSBRC 82 and PSBRC 80. Next came IR 529, Nakroma, IR 547 and Local Nonaporto with 30-20% of farmers willing to plant them. Local Membrano, IR 772 and Matatag 9 were the least appreciated varieties. Interestingly, IR 547 was first or second preferred for all important eating characteristics and ranked second after Local President: along with Nakroma and PSBRC 80, 60% farmers liked IR 547, however this variety was not among those most farmers wished to plant. On the other hand, PSBRC 82 had only average taste qualities but was one of the top 3 favourite varieties.

No gender impact was found for any eating characteristic but an effect of the Gender.Variety interaction was identified for the "Wish to plant" criteria. This concerned two varieties: Local President was more often chosen by men (66% against 22% of the women), and PSBRC 80 for which the reverse was observed (all women choose this variety against less than half the men), even though this variety was less fragrant and oily than Local President.

Conclusions

The results of the 2010 farmer field day confirmed that the taste of rice is an essential criteria for farmers' adoption of new varieties. Fragrance and oiliness were the most important eating characteristics. In that regard, the reference was the local variety known as Local President variety, the eating standards of which PSBRC 80 and IR 547 were the closest too. However, IR 547 was not the preferred variety, demonstrating that other criteria are still to be identified for optimum adoption by farmers. The preferred introduced varieties were Local President, PSBRC 80 and 82 which also all performed with the highest yields in 2010 (about 6.5 t/ha). IR 772 followed in term of yield but had the poorest taste according to farmers. Another high yielding variety was Angelica, the eating qualities of which still need to be investigated.

2.4.2 Rice replicated trials, multi-year and multi-location analysis

Materials and methods

Five successful wet season rice variety trials were implemented by SoL over the period from 2006 to 2010 (4 years) at 3 different sites (Maliana, Betano, Aileu), testing the performances of 25 varieties (including 5 locally used varieties as controls). Some varieties were not included in all trials and some trials were not conducted at every site every year.

The entire dataset, presented in Table 65, comprises 101 data points, i.e. variety per environment combinations. An environment (here synonymous of trial) is defined by a site and year. All data points are ANOVA or REML predicted means from 3 replicates, 4 in one occasion (Aileu 2008/09).

Table 65. Rice mean yields and yield advantages 2006-2010

Variety	*Yield (t/ha)*					*Overall 2006-2010*	
	Maliana 2006/07	*Betano 2007/08*	*Aileu 2007/08*	*Aileu 2008/09*	*Betano 2009/10*	*Average yield (t/ha)*	*St. dev*
Angelica	3.4	1.8	3.4	2.2	6.1	3.4	1.7
IR 393	4.3	0.4	2.3	1.6	4.7	2.6	1.8
IR 529	4.6	1.8	2.6	0.9	5.7	3.1	2.0
IR 547	5.2	1.7	3.7	1.5	6.5	3.7	2.2
IR 580	4	1.2	2.6	0.5	4.5	2.6	1.7
IR 64	4.7					4.7	-
IR 772	5.1	0.9	3.9	1.5	6.0	3.5	2.2
Matatag 1	4	0.7	1.1	1.3	4.7	2.3	1.8
Matatag 2	5.1	1.7	4.3	1.7	5.4	3.6	1.8
Matatag 3	2.9	0.5	2.8	1.4	5.5	2.6	1.9
Matatag 9	4.5	1.6	3.2	1.2	5.8	3.3	2.0
MS 11	2.6	0.3	2.8	0.9		1.7	1.2
MS 13	5.2	1.4	1.8	1.4	5.4	3.0	2.1
Nakroma		1.8	2.6	1.2	5.5	2.8	1.9
NSIC 110	4.4	1.5	2.7	1.2	5.2	3.0	1.8
NSIC 112	5.3	0.8	3.4	1.1	5.4	3.2	2.2
PSBRC 64	3.9	1.7	3.5	1.5		2.6	1.2
PSBRC 80	5.3	1.7	3.4	1.7	6.3	3.7	2.1
PSBRC 82	4	1.8	3.2	2.1	7.0	3.6	2.1
RHS.OZA	2.2	0.9	3.1	1.1	5.6	2.6	1.9
Local Do'ot				*0.2*		*0.2*	-
Local Meloban			*3.5*	*1.9*		*2.7*	*1.1*
Local Membramo		*1.0*			*6.3*	*3.6*	*3.7*
Local Nonaporto					*5.9*	*5.9*	-
Local President		*1.6*			*6.4*	*4.0*	*3.4*
Average site yield (t/ha)	*4.2*	*1.3*	*3.0*	*1.3*	*5.7*		
Average yield locals (t/ha)	-	*1.3*	*3.5*	*1.1*	*6.2*		

Cross-site analyses were conducted using biplots (GGE BiPlot program) in order to evaluate the performances and consistency of the tested varieties across years and locations (genotype / environment). A limitation of the procedure is that only datasets with less than 5% missing data points could be analysed. In addition, datasets resulting in higher percentages of variance explained by the biplot principal components analysis were preferred. The most extensive selection on which to run a biplot analysis included 19 varieties in all 5 environments. The set of data included 92 data points out of a total of 101. Three missing data had to be accounted for, however this did not impact significantly on the results.

Results

The average yield of the entire dataset (5 environments, 101 data points) was 3.1 t/ha (st.dev = 1.9) against 3.0 t/ha for the local checks alone (4 environments, 8 data points, i.e. 8% of the entire dataset, st.dev=2.4). Yield averages from trial to trial varied from 1.3 t/ha to a maximum of 5.7 t/ha for the 2010 Betano trial. In Betano and Aileu, both low and high yields were recorded.

Among the 25 varieties, 19 were tested in all 5 trials or in 4 of them. Assuming that those trials represent random samples of environments, the comparison of the varieties overall results can be made, as presented in Table 66.

Table 66. Rice mean yields and yield advantages over 2006-2010 (4 cropping years)

Variety	*No. of trials*	*Mean St. dev.*	*Mean yield (t/ha)*	*Yield advantages (%)**	*2010 status*
IR 547	5	2.2	3.7	24	Continue testing. To be multiplicated for OFDTs.
PSBRC 80	5	2.1	3.7	22	Continue testing. Currently being tested on OFDTs.
Matatag 2	5	1.8	3.6	21	Continue testing. To be tested on OFDTs.
PSBRC 82	5	2.1	3.6	20	Continue testing. To be tested on OFDTs.
IR 772	5	2.2	3.5	15	Continue testing. To be multiplicated for OFDTs.
Angelica	5	1.7	3.4	13	Continue testing. To be tested on OFDTs.
Matatag 9	5	2.0	3.3	8	Continue testing.
PSBRC 64	4	1.2	3.3**	8	Continue testing. Seeds to be re-imported.
NSIC 112	5	2.2	3.2	6	Continue testing.
IR 529	5	2.0	3.1	4	Continue testing.
Nakroma	4	1.9	3.1**	2	Released in 2007. Standard for OFDT testing.
MS 13	5	2.1	3.0	1	To be discarded.
NSIC 110	5	1.8	3.0	-1	To be discarded.
IR 393	5	1.8	2.6	-12	To be discarded.
Matatag 3	5	1.9	2.6	-13	To be discarded.
RHS.OZA	5	1.9	2.6	-14	To be discarded.
IR 580	5	1.7	2.6	-15	To be discarded.
MS 11	4	1.2	2.5**	-18	To be discarded.
Matatag 1	5	1.8	2.3	-22	To be discarded.

* Calculated over the local varieties overall average = 3.0 t/ha, st.dev. = 0.57 (5 varieties representing 8 datapoints over 4 environments)

** Missing value replaced by mean site to avoid under or over-estimation due to high and low yielding sites.

4 varieties performed over 3.5 t/ha on average, which corresponded to +20%-+25% yield advantages over the locals. Among those varieties is PSBRC 80 which was included in the ODFTs 2009 program. PSBRC 82 which also proved to be good tasting was including in the 2010 OFDTs, along with Nakroma (standard), Angelica and Matatag 2.

The released variety Nakroma yielded only slightly above locals on research stations. However, its testing on OFDTs proved that this variety is exceptionally broadly adapted, often achieving production in many locations of the country where local varieties fail.

The biplot investigating the performances of 19 varieties in all 5 available environments is plotted in Figure 29. The biplot shows the varieties means stability (vector with arrows) versus the environments (vector without arrow), components which accounted for 70% of the variation encountered.

Results show that some similarities could be found in the last Betano trial and in the two Aileu ones, while the two other environments gave different results. Overall, three of the five top yielding varieties PSB RC 80, Matatag 2 and IR 547 appeared to be among the most consistent varieties across environments. The other best yielding varieties, PSBRC 82 and Angelica, showed significantly higher variations. This was due to their much better performances compared to the rest of the varieties in the Aileu 2009 trial.

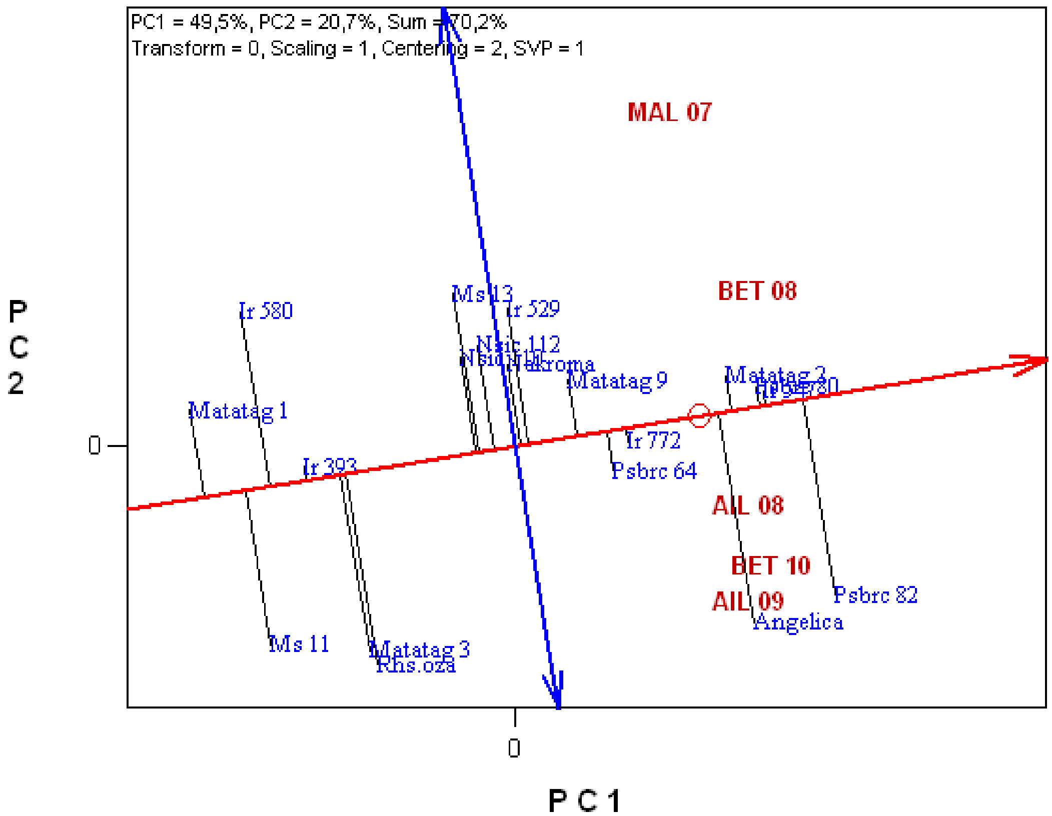


Figure 29. **BiPlot analysis of 19 rice varieties in 5 environments, 2006-2010**

Conclusions

Over a four year period, SoL conducted 5 successful varietal rice trials on 25 varieties, representing a total of 101 individual data points (variety per environment combinations). Results varied significantly both by genotype (varieties) and environment (locations and years).

The collected data allowed identifying half a dozen high yielding varieties which performed with an overall +15% to +25% yield advantage over the local checks. The suitability of the best tasting and most consistent of them are currently further investigated in the on-farm testing program, along with the released variety, Nakroma.

2.4.3 Rice On-Farm Demonstration Trials (OFDTs) 2009-2010

Rice On Farm Demonstration Trials (OFDTs) were established in 5 districts and 10 Sub-Districts of East Timor in the 2009/10 season. The trial objective was to determine if a promising rice variety, identified in replicated trials and tested on-farm for the first time the previous year performed well on farmers' fields with no extra changes to inputs or agronomy.

Materials and methods

70 OFDTs were established in four of the six agro ecological zones (AEZs) in East Timor. These included the Sub-Districts of Aileu, Atabae, Balibo, Baucau, Liquica, Maliana Ossu, Vemase, Venilale and Viqueque. They were monitored by twelve researchers. Farmers received 5kg bags of the recommended variety, Nakroma as well as 100g of PSBRC 80 seed. They supplied their own seed for establishing a plot of the local variety which was used as a check for the new varieties. As a hybrid variety was being widely used in the Sub-District of Ossu, this replaced Local for all OFDTs established in that Sub-District.

Seeds were usually first planted in a nursery before seedlings were transplanted to a paddy field. As in previous years, actual area planted to each variety (plot size) varied according to each farmer's bunded paddy area. In most cases, Nakroma, PSBRC 80 and whatever local variety the farmer generally used were grown side by side in one paddy. Where possible, a 5m x 5m area was used. However at some sites smaller sample sizes were taken. Much of the process for establishing rice OFDTs was similar to that described in the maize OFDT chapter.

Researchers visited the sites an average of 5.9 times from planting to harvest. At each visit they recorded different information about the OFDT. These data collection protocols monitored progress of the trial/demonstration. In-season measurements included plant condition, identification of pests and diseases, wilting and other plant symptoms.

After harvest, the wet threshed grain was weighed. A sample of the grain was also weighed, then dried and weighed again. The ratio of dry grain to wet grain from this sample was used to convert the weight of the harvested plot into a dry weight equivalent. All of the weights quoted in the Results and Discussion section are for paddy rice (dry, threshed, un-milled weights).

Analysis

Data from the protocols was first entered into an MS Excel spreadsheet database before being transferred for further analysis to GenStat Discovery Edition 3. Rice yield data was analyzed by ANOVA (Unbalanced Linear Model) with variety and AEZ as constant factors in the model once the other location factors had been tested. However this model was not as robust as with the other crops tested on farm due to the absence of trials in two of East Timor's six AEZs.

The influence of a wide range of factors on rice yields was tested. In turn, each factor was added to the model, one at a time. If they were significant, the factor was kept in the model, and if they were non-significant the factor was discarded. Once a significant factor was identified, the interaction of that factor and variety was also tested for significance at the $P < 0.05$ level.

Results and discussion

Testing environments

Rice OFDTs were conducted on a wide range of soil textures, pH, slope and elevation. Elevation of OFDT sites ranged from about sea level to almost 1,100m in Aileu Sub-District. Almost half were planted at sites less than 100m. However 37% were planted at sites over 500m.

The average soil pH across the OFDT test sites was 7.4, ranging from 6 to 9. While none of the sites could be described as acid in content, a high proportion of 22% of sites could be defined as alkaline soils (pH 8.0 or above). Over 75% of soils were classified as clays.

Trial losses

While Nakroma was harvested in over 90% of trials, PRSRC 80 had harvest data recorded in 80%. Reasons reported for trial losses included insufficient water at the time of transplanting, flooding, rat damage and having farmers harvesting and mixing the plots in the absence of OFDT staff.

Variety

The hybrid variety used in Ossu Sub-District yielded lower than almost any other variety x Sub-District average. The test varieties also tended to be lower yielding in Ossu due to disease incidence there. With no variety representative of a local check in this Sub-District, all data from there was excluded from further analysis. Similarly there was no plot of Local successfully harvested in Liquica and this was also excluded.

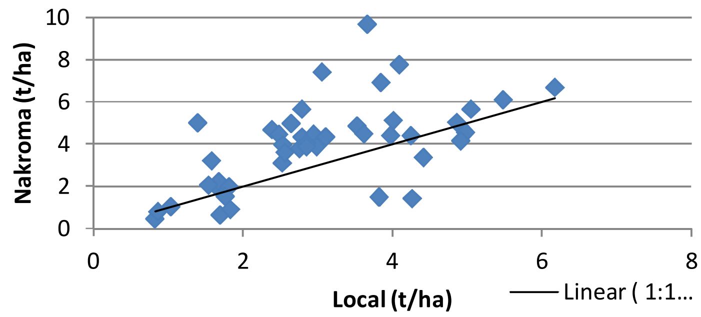
Like last year, Nakroma again proved to have a significant yield advantage over local varieties but PSBRC 80, while better yielding failed to reach statistical significance (Table 67).

Table 67. Rice yields of OFDT (excluding Ossu and Liquica in 2009/10)

Variety	*Mean yield (t/ha)*			*Yield advantage (%)*		*LSD*
	Local	Nakroma	PSBRC 80	Nakroma	PSBRC 80	*(p=0.05)*
2008/09 (71 sites)	3.2	3.8	3.3	18	4	0.5*
2009/10 (51 sites)	2.9	3.8	3.5	32	21	0.7

*significant for a pair wise comparison between mean yields of Nakroma and local only

Figure 30 demonstrates graphically the yield relationship between the local and new varieties at each site. It can be seen from the graphs that with Nakroma and PSBRC 80 most of the data points lie above the 1:1 line that is plotted through the aggregate of local yield data. While both varieties have a similar number of points below the line, Nakroma has a greater number of sites that yielded far more than the local variety. This is borne out in the ANOVA analysis where PSBRC 80 fails to reach significance in yield difference over local varieties.



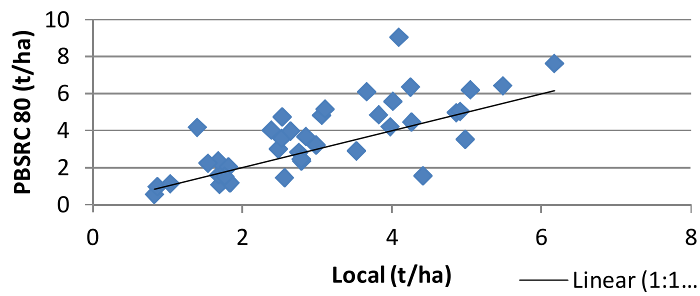


Figure 30. Yield of 2 test populations versus the locals 2009/10

A significant difference in yield between Sub-Districts was evident (F Pr. <0.001). All varieties yielded best in Aileu Sub-District and worst in Balibo (Table 68). There was no significant interaction between variety and Sub-District. This suggests that the higher yield of Nakroma is consistent across Sub-Districts and there is no reason to recommend different varieties for different Sub-Districts.

While Nakroma had some of the highest yield advantages over Local in Bobonaro District, the opposite was the case for PSBRC where Local outperformed it in all Sub-Districts tested there. In most OFDTs tested in Bobonaro the previous year, PSBRC 80 had an impressive yield advantage over Local but these came from a Sub-District not included in the current year's trials.

Table 68. Mean yields (t/ha) of rice OFDT in SoL Sub-Districts, 2009/10

District	Sub-District [1]	Sub-district mean yield (t/ha)	Yield of local, (t/ha)	Yield of Nakroma (t/ha)	Yield of PSBRC 80 (t/ha)	Yield advantage of Nakroma (%)	Yield advantage of PSBRC80 (%)
Aileu	Aileu	5.1 (6)	4.1	5.3	5.9	29	42
Baucau	Baucau	3.2 (7)	2.6	3.4	3.6	30	41
	Vemasse	2.7 (5)	2.3	3.1	*	34	*
	Venilale	4.0 (8)	3.6	4.6	3.8	23	4
Bobonaro	Atabae	3.3 (5)	3.0	4.3	2.5	43	-19
	Balibo	1.6 (3)	1.3	2.4	0.8	91	-34
	Maliana	3.4 (5)	3.1	4.1	2.9	34	-7
Viqueque	Viqueque	3.0 (12)	2.6	3.2	3.2	24	23

[1]The total number of trials in this Sub-district is in brackets ( )
* Not planted

Agro Ecological Zones (AEZ) and yield

Yield results for each variety in each AEZ are presented in Table 69. There was a significant effect of AEZ on rice yield but there was no statistically significant interaction between variety and AEZ. In contrast to yield data from some other crops in which OFDTs were established, yield data tended to increase with increasing elevation.

Yields tended to be lowest near the coasts (AEZ 1 and AEZ 6). The highest yields recorded for all varieties occurred at the AEZ with the highest elevation range (AEZ 3). This is similar to data recorded from the previous year where AEZ 4, in the same elevation range but towards the south of the island rather than the north, recorded the highest yields. AEZ 3 also had the highest number of OFDTs established, almost double that of any other. The next best performing AEZ for Local and Nakroma, AEZ 2 was that with the next highest elevation.

Table 69. Rice OFDT mean yield by AEZ, 2009/10

AEZ Class (See Maize OFDT)	*Local (t/ha)*	*Nakroma (t/ha)*	*PSBRC 80 (t/ha)*	*Yield Advantage Nakroma over Local*	*Yield advantage PSBRC 80 over Local*
1 Northern coast	2.6	3.5	2.6	36	2
2 Northern slopes	3.0	4.2	2.9	37	-6
3 Northern uplands	3.3	4.3	4.4	30	34
6 Southern coast	2.6	3.2	3.2	24	23

Agronomic factors affecting yield

The influence of a wide range of characters was tested for affecting the yield of rice (Table 70). Most were found to have an influence on grain yield, and these include Variety, AEZ, Sub-District and soil pH.

Table 70. Significance of factors affecting rice yield, OFDTs 2007 to 2010

Factor	*Significance (p=0.05)*		
	2007/08	2008/09	2009/10
Variety		✓*	✓
AEZ	×	✓	✓
Sub-District		✓	✓
Elevation	✓	×	✓
pH	×	×	✓
Soil texture	×	✓	×
Soil colour	×	✓	✓

*significant for a pair wise comparison between mean yields of Nakroma and Local only

Elevation

There was a significant effect of elevation on yield (F Pr. <0.001). In line with observations made with AEZ, yield tended to increase with increasing elevation. This is in contrast to the results obtained from other OFDT chapters in this report although similar to those experienced with peanuts. While yield reached its peak with peanuts around 700m, rice yields tended to be highest between elevations of 900 and 1000m.

Soil pH

Soil pH impacted rice yield in 2009/2010 (Table 71). However it was only those sites at pH 6, which included only 6% of trials harvested, that differed significantly from sites at other pH levels. This years' trials did not have the same extremes in pH compared to previous years. Yield at other pH levels tended to be consistent apart from pH 8.5 for which there was only one observation. No interaction of pH and variety occurred.

Table 71. OFDT yield by soil pH for all rice varieties, 2009/10

Soil pH	6.0	6.5	7.0	7.5	8.0	8.5	9.0
% of OFDTs harvested	6	8	20	42	20	2	2
Mean yield (t/ha)	5.9	3.4	3.2	3.1	3.6	2.1	3.5
LSD (P<0.05)				*1.8*			

Soil colour

Soil colour had a significant effect on rice yield across the test sites. In general as the soil became darker in colour, the yield increased (Table 72). The exception to this was yellow colored soil which produced the highest yield but this was recorded in only 2 locations. Having black soil (rai metan) is a common way of saying fertile soil in Tetun, so this observation confirms the farmer's experience. No interaction of soil color and variety was evident.

There was no effect of soil texture on yield.

Table 72. Effect of soil colour of rice yield 2009/10

Soil color	*% of OFDTs harvested*	*Yield (t/ha)*
White	14	2.5
Red	4	4.9
Black	10	4.0
Yellow	4	5.7
Dark brown	20	3.4
Light Brown	49	3.3
LSD (P<0.05)		

Effect of farmer management on yield

The increasing use of tractors to cultivate rice paddies continued in 2010 with 85% of farmers now using tractors as a result of the ongoing MAF agricultural mechanization program (Table 73). As in previous years, the use of tractors had no effect on subsequent rice yields.

In 2010, the vast majority of farmers continued the practice of soaking seeds before sowing. As in the previous two years, higher rice yields were recorded at the few sites where seeds weren't pre-germinated prior to planting but with only two sites where this occurred, this cannot be regarded as indicative of an actual effect.

Table 73. Significance of management factors affecting OFDTs from 2007 to 2010

Factor		2007/08		2008/09		2009/10	
		% farmers using	Yield (t/ha)	% farmers using	Yield (t/ha)	% farmers using	Yield (t/ha)
1.	Cultivate with buffalo	54	4.5	19	4.0	13	3.9
	Cultivate with horse	11	3.5	2	3.3	2	1.2
	Cultivate with tractor	34	3.5	79	3.3	85	3.4
	LSD (0.05)		ns		ns		ns
2.	Pre-germinate seeds	97	4.3	98	3.5	96	3.3
	No pre-germination	3	5.0	2	4.9	4	5.4
	LSD (0.05)		ns		ns		1.4
3.	Broadcast seeds	4	6.8	4	4.7	6	3.8
	Transplant seedlings	96	4.2	96	3.3	94	3.4
	LSD (0.05)		1.6		1.0		ns
4.	Transplant less than 2 weeks	6	5.3	24	3.1	28	3.1
	Transplant 2-4 weeks	58	4.3	51	3.2	62	3.3
	Transplant more than 4 weeks	35	4.0	25	3.7	11	4.7
	LSD (0.05)		ns		ns		1.0
5.	Plant in lines	47	4.4	65	3.1	80	3.3
	Plant random	53	4.2	35	4.2	20	3.7
	LSD (0.05)		ns		0.5		ns
6.	Wide planting distance	15	3.1	34	3.2	30	3.6
	Close planting spacing	85	4.5	66	3.6	70	3.3
	LSD (0.05)		0.9		ns		ns
7.	Applied fertilizer	3	4.4	30	3.1	10	3.4
	No fertilizer used	97	4.3	70	3.6	90	3.0
	LSD (0.05)		ns		ns		ns
8..	No weeding	36	4.2	42	3.4	26	2.6
	Weeded once	43	4.3	38	3.5	42	3.7
	Weeded more than once	22	4.7	21	2.8	34	3.7
	LSD (0.05)		ns		ns		0.7

The unexpected result from the two previous years in which the small minority of farmers who simply broadcast seeds had higher yields than those who went to the trouble of transplanting seedlings, was repeated again in these trials. Although this difference was not significant in 2009/10 and broadcast data from the three years was derived from only a small number of observations, further investigation of possible reasons why this occurred is warranted.

The number of farmers transplanting later than the recommended time in the nursery (app. 3 weeks) continued to decline from 44% transplanting after 4 weeks in 2006/07 to 11% in 2009/10. However, over the three years, there was no benefit found in terms of increased yield by transplanting early, albeit with increasingly unbalanced comparisons.

Similarly, there was a steady increase in the number of farmers planting in lines over time, but like the previous year, yields from trials where farmers continued to plant randomly were higher than those planted in lines. There was however not a significant difference in yield between line and random planting or between wide and close spacing in 2009/10.

Although a significant number of OFDTs established had fertilizer applied, most came from Ossu Sub-District where hybrid rice was widely grown in 2009/10. These were excluded from this analysis as there was not a representative local. Fertilizer was applied at five other sites but it is likely to have been sub-optimal as yields were actually lower than those where fertilizer was not recorded.

Most farmers weeded at least once in 2009/10 and it had a significant impact on yield. There was no effect of the number of extra times the ground was weeded. A number of programs in Timor-Leste are encouraging the use of SRI (system for rice intensification) and ICM (integrated crop management) methodologies which assist with the weeding process.

Farmer's preference for rice populations

From all the OFDTs, farmers gave reasons why they would chose to re-plant each variety another year. Nakroma received the most positive feedback. Most of the reasons given for farmers' desire to continue using Nakroma included good establishment, high productivity, short tillers and good grain size.

PSBRC 80 also had similar comments made about it although the production of Nakroma was perceived to be higher than PSBRC 80.

Local varieties also received some positive comments about their production characteristics. Others found that plants were susceptible to lodging. While some farmers recognized the lower production with local varieties, many wanted to continue planting some as they had always planted it and saw it as adapted to, or of their land.

Conclusions

In 2009/10, Nakroma once again demonstrated its yield superiority over existing local varieties across the country as well as PSBRC 80.

Although PSBRC 80 produced yields which failed to reach significance for yield advantage over local controls, it appeared to be favorably received by farmers and has been included in subsequent OFDTs.

Data recorded on farmers management over the period from 2006-09 suggest that despite farmers gradually adopting recommended practices (*e.g.* using tractors, transplanting earlier, planting in lines and applying fertilizer etc), this had not been translated into significant yield improvement. This indicates the need for greater emphasis on both agronomic research and extension to assist farmers to successfully apply improved rice growing methods and therefore fully realize the demonstrated yield potential of new varieties such as Nakroma.

Although the exact cause was not apparent, a disease or pest burden impacted in rice yields from OFDTs established in Ossu Sub-District. What is most interesting from this impact was the much greater resilience of Nakroma and PSBRC in the face of such an attack when compared to the hybrid variety that was planted. In fact anecdotal evidence from farmers gave accounts of all rice crops being destroyed over a large area in Ossu apart from the oasis of green that remained containing Nakroma.

2.5 Peanuts

2.5.1 Replicated trials, 2009-2010

Peanut (*Arachis hypogaea* L.) lines tested by SoL were sourced from ICRISAT in India. Peanut variety trials have been conducted for a number of years which allowed the selection of a big-seeded variety, Utamua (PT 05) for release in 2007.

During the 2009-2010 cropping season, four peanut replicated trials were conducted at Aileu, Baucau, Betano, and Loes. However lack of rainfall at Betano severely affected the viability of the trial conducted there. Characteristics of the varieties used in the trials are as presented in Table 74. Local checks were similar to the previous years' trials.

Table 74. Variety details, replicated peanut trials, 2009/10

Code	*Name*	*Botanical type*	*Seed skin colour*
Utamua (PT 05)	ICGV 88438	Spanish bunch	Brown
PT 10	Local Darasula	Timorese local	Brown
PT 11 *	ICGV 95058	Spanish bunch	Brown
PT 12 *	ICGV 96172	Spanish bunch	Brown
PT 13 *	ICGV 95069	Spanish bunch	Brown
PT 14 *	ICGV 96165	Virginia	Red
PT 15 *	ICGV 97128	Virginia	Brown
PT 16 **	ICGV 98378	Spanish bunch	Brown
PT 17 **	ICGV 98379	Spanish bunch	Brown
PT 18 **	ICGV 98381	Spanish bunch	Brown
PT 19 **	ICGV 98375	Spanish bunch	Brown
PT 20 **	ICGV 99017	Spanish bunch	Brown
PT 21	Local Mean Betano	Timorese local	Red
PT 22	Local Bo'ot Betano	Timorese local	Brown
PT 23	Local Bo'ot Loes	Timorese local	Brown

* Medium-duration cycle ** Foliar disease resistant

Methodology

Yields, yield advantages and yield components

Trials were held in Aileu, Baucau, Betano, and Loes during the wet season of 2009-2010. A total of 11 new varieties were tested in each trial with three local varieties. The main purpose of the latter was to act as check varieties.

Trials consisted of 3 replicates apart from Aileu which had two. Complete randomized blocks were used apart from in Loes, with each plot measuring 5 x 5m in size. Planting hills (one seed per hill) were spaced at 45 x 15cm (Aileu), 40 x 15cm (Baucau and Betano) and 40 x 20 (Loes) corresponding to maximum plant densities of 17, 16 and 12 plants/m² respectively. Neither fertilizer nor irrigation was applied apart from at Aileu where 15 kg/ha of N and P was applied given that the lack of station area does not allow for fallow. Trials were planted between November and December 2009 and harvested from April to July (Table 75).

Table 75. Planting and harvest details of peanut varietal trials, 2009/10

Location	*Number of entries*	*Number of replicates*	*Planting date*	*Harvest date*	*Mean yield (t/ha)*
Aileu (Kintal Portugal)	15	2	22/12/2009	Mid May 2010	0.18
Baucau (Fatumaca)	15	3	29/12/2009	Mid May 2010	1.0
Manufahi (Betano)	15	3	15/12/2009	Mid June 2010	0.10
Liquica (Loes)	15	3	10/11/2009	End April 2010	1.7

A number of parameters were recorded during plant growth, starting with emergence rates. Flowering as well as the impact of diseases was monitored. In some locations, the percentage of plants presenting rotten roots was also recorded.

At harvest, all plants were dug, dried and weighed. The weight of fresh and then dry pods were measured as well as some of the yield components. Yield and plant densities were measured from the whole plot. Yield components (pod and seed dry weight, number of seeds per pod, percentage of good pods) were obtained from plot samples of 100 pods. The number of pods per plant, the shelling percentages (from dry weights) and the seed yield (without shell) were obtained from the previous parameters.

Data at each site were analysed separately using GenStat Discovery Edition 3 where analysis of variance was used or GenStat Discovery Edition 2 where REML analysis was used in order to determine varietal effects. The analysis performed depended on the presence of row and/or column effects on yield (Table 76).

Table 76. Statistical tests used in the analysis of the 2009/10 peanut varietal trials

Station	*Row/Col effects*	*Test*	*Type*
Aileu	Row	REML	AR1 Random on Row
Baucau	Column	REML	AR1 Random on Column
Betano	No	ANOVA	One-way in Randomized blocks
Loes	No	ANOVA	One-way with no blocking

Yield advantages were calculated from the resulting predicted means over the average of the local varieties. The existence and degree of correlation between the predicted means of the yields and of the other parameters were then identified using a Simple Linear Regression. As yield ranges differed greatly from one trial to another, individual regressions were run (as opposed to running one regression over all data sets) in order to determine whether correlations were significant. The percentage of variability accounted for is equivalent to an adjusted R^2.

Results

Yields and yield advantages

Table 77 presents the dry pod yields at each site for all tested varieties, as well as the overall yield advantages over the local checks.

Table 77. Peanuts yields and yield advantages, 2009/10

Variety	*Yields (t/ha)*				*Averages*			*Yield advantages (%) within site*			
	Aileu	*Baucau*	*Betano*	*Loes*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*Aileu*	*Baucau*	*Betano*	*Loes*
PT 13	0.49	1.5	0.07	2.1	0.93	1.05	39	539	114	-19	-1
PT 12	0.47	1.4	0.22	1.5	0.65	0.90	19	513	100	154	-30
PT 23	*0.1*	*0.5*	*0.08*	*2.8*	*1.28*	*0.86*					
PT 16	0.05	0.9	0.05	2.4	1.12	0.86	14	-35	29	-42	13
PT 15	0.35	0.8	0.09	2.1	0.89	0.83	11	357	14	4	-3
PT 11	0.22	1.4	0.12	1.5	0.73	0.80	6	187	100	38	-33
PT 18	0.29	1.0	0.04	1.7	0.75	0.76	1	278	43	-54	-21
PT 14	0.09	1.3	0.20	1.4	0.70	0.75	-1	17	86	131	-35
PT 22	*0*	*0.8*	*0.09*	*2.1*	*0.96*	*0.74*					
PT 19	0.08	1.3	0.07	1.3	0.72	0.70	-7	4	86	-19	-38
PT 10	0.17	0.6	0.12	1.9	0.83	0.70	-8	122	-14	38	-12
PT 21	0.10	0.8	0.09	1.6	0.72	0.66					
Utamua (PT 05)	0	1.2	0	1.4	0.77	0.66	-13		71		-33
PT 17	0.27	1.0	0.04	0.9	0.47	0.55	-27	252	43	-54	-59
PT 20	0.04	0.8	0.15	1.1	0.51	0.53	-30	-48	14	73	-48
F/Chi Sq Prob.	*<0.001*	*<0.001*	*<0.001*	*n.s.*							
l.s.d.	*0.18*	*0.4*	*0.06*								
%CV / Wald/df	*7.2*	*4.7*	*37*	*40*							
Mean site	0.18	1.0	0.10	1.7	0.76	0.75					
Mean locals	*0.08*	*0.7*	*0.09*	*2.1*	0.95	0.75					

Variation among sites was very noticeable with Aileu and Betano stations yielding particularly poorly. This variation was reinforced by the mean yield across all sites of 0.75 t/ha being similar to the standard deviation. Utamua performed particularly poorly this year with no yield in Aileu or Betano. This is likely attributable to lack of rain at these sites, particularly in Betano where all varieties were compromised by drought stress. There was no rainfall for the first week after planting with 44.5 mm in the second week. This was followed by another week with no rainfall followed by a fourth week where 13.5 mm fell. Such conditions would be particularly adverse on large seeded varieties such as Utamua which tend to require a moister environment for germination. Establishment rates were much lower in Aileu and Betano with the majority of plots having less than 5 plants/m² while the opposite was the case in Baucau and Loes despite the lower seeding rate at Loes.

The top yielding varieties were PT 13 and PT 12 with 1.05 and 0.9 t/ha, which corresponds to yield advantages of 39% and 19% respectively above locals. PT 12 ranked similarly across three sites and PT 13 was the highest yielding in Aileu and Baucau. The local Loes variety (PT 23) was comparable to PT 12 on the overall yield list. However this was skewed by a very high productivity in its home location where it yielded best of all varieties. On the other research stations it was one of the poorest performers.

Yield components and other parameters

The predicted means for the yield components and other parameters associated with the yield are detailed in Table 78.

Table 78. Peanut yields and yield components, replicated trials 2009/10

Trial	*Variety*	*Yield (t/ha)*	*Plants /m² at harvest*	*Pods /plant*	*Pod weight (g/100)*	*Seeds / 100 pods*	*Trial*	*Yield (t/ha)*	*Plants /m² at harvest*	*Pods /plant*	*Pod weight (g/100)*	*Seeds / 100 pods*
AILEU	PT 13	0.49	7	17	129	161	**BAUCAU**	1.5	11	25	113	180
	PT 12	0.47	7	13	122	157		1.3	9	29	141	167
	PT 23	*0.13*	*5*	*9*	*112*	*176*		*0.9*	*9*	*25*	*124*	*212*
	PT 16	0.05	6	17	88	159		0.5	9	10	140	218
	PT 15	0.35	8	10	116	163		0.8	8	20	151	183
	PT 11	0.22	5	19	95	165		1.4	8	28	147	182
	PT 18	0.29	5	14	117	136		1.0	10	15	142	153
	PT 14	0.09	4	16	76	116		1.3	9	27	157	185
	PT 22	*0.00*	*6*	*8*	*113*	*164*		*0.7*	*11*	*15*	*138*	*197*
	PT 19	0.08	7	5	96	169		1.3	10	24	128	157
	PT 10	0.17	7	18	130	175		0.6	11	12	135	186
	PT 21	*0.10*	*6*	*6*	*155*	*221*		*0.8*	*10*	*16*	*140*	*203*
	Utamua	0.00	1	*	*	*		1.2	9	24	217	189
	PT 17	*0.27*	*5*	*20*	*120*	*152*		*1.0*	*9*	*19*	*138*	*171*
	PT 20	*0.04*	*8*	*13*	*98*	*176*		*0.8*	*8*	*20*	*130*	*160*
	MEAN	0.18	6	13.2	112	163		1.0	9	21	143	183
	χ^2 prob	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*		*<0.001*	*n.s.*	*<0.001*	*<0.001*	*0.002*
	lsd	*0.18*	*0.9*	*4.2*	*27*	*37*		*0.4*	*-*	*8.4*	*20*	*35*
	Walf/df	*7.2*	*48*	*2.9*	*5.7*	*4.3*		*4.7*	*1.2*	*4.1*	*11*	*2.4*
BETANO	PT 13	0.07	6		84	160	**LOES**	2.1	5	20	157	223
	PT 12	0.22	4		121	172		1.5	4	14	174	252
	PT 23	*0.08*	*6*		*105*	*179*		*2.8*	6	*19*	*196*	*250*
	PT 16	0.05	4		90	124		2.4	5	12	143	195
	PT 15	0.09	5		94	183		2.1	5	18	179	201
	PT 11	0.12	4		97	173		1.5	4	22	157	223
	PT 18	0.04	2		67	90		1.7	5	18	138	182
	PT 14	0.20	6		105	177		1.4	4	18	129	193
	PT 22	*0.09*	*2*		*122*	*191*		*2.1*	6	*8*	*211*	*283*
	PT 19	0.07	5		98	155		1.3	3	22	136	200
	PT 10	0.12	6		106	180		1.9	4	9	180	217
	PT 21	*0.09*	*5*		*102*	*188*		*1.6*	4	*16*	*214*	*272*
	Utamua	0.00	0		*	*		1.4	4	14	194	173
	PT 17	*0.04*	*2*		*102*	*171*		*0.9*	2	*22*	*145*	*174*
	PT 20	*0.15*	*5*		*105*	*191*		*1.1*	3	*18*	*106*	*151*
	MEAN	0.10	4		100	167		1.7	4	17	164	213
	F prob	*<0.001*	*<0.001*		*n.s.*	*n.s.*		*n.s.*	*0.007*	*n.s.*	*<0.001*	*0.001*
	lsd	*0.1*	*2.3*		*-*	*-*		*-*	*2*	*-*	*44*	*57*
	%CV	*37*	*32*		*23*	*26*		*40*	*28*	*41*	*16*	*16*

Most yield and yield components had significant varietal differences within station. Loes, the best yielding station and despite large differences in yield between varieties was was an exception in not having significant differences in overall yield. This was partly due to a failure to randomise the plots throughout the different replicates at planting time. Consequently a far less robust statistical analysis was possible as site differences could not be extrapolated. Pods per plant also proved non significant at Loes but this component was not measured from plant samples at that location, instead being calculated from the 100 pod weight. In line with overall yield, both pod weight and the number of seeds per pod was also greatest at Loes. Plant density was among the lowest at Loes.

Little correlation was found between the yield components and overall yield throughout the research stations. While Betano did have significant F probability values for most yield components when investigated using linear regressions, the percentage of variability accounted for (adjusted R^2) was only about 30%. Loes, with the lowest seeding rate had a strong correlation between plant density at harvest and yield (Figure 31). The R^2 value was 0.76 when the plant density per plot was used as opposed to the m^2 value.

Surprisingly, only Baucau had a significant correlation between pods per plant and yield (Figure 32). It is possible that not all plants counted at harvest had produced pods. Utamua had a high pods per plant ratio in Baucau in contrast to previous experience. Like previous years, Utamua had the highest pod weight of the test varieties in both locations where it was harvested (in Loes the pods of local varieties were slightly heavier).

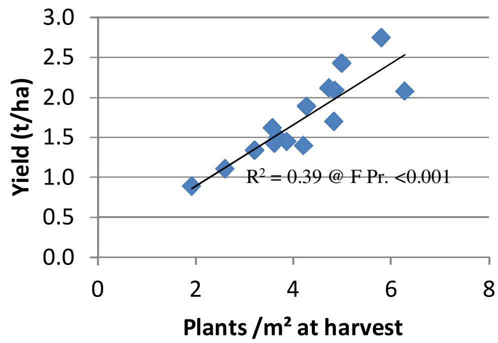


Figure 31. Correlation between yield and plant density at Loes research station

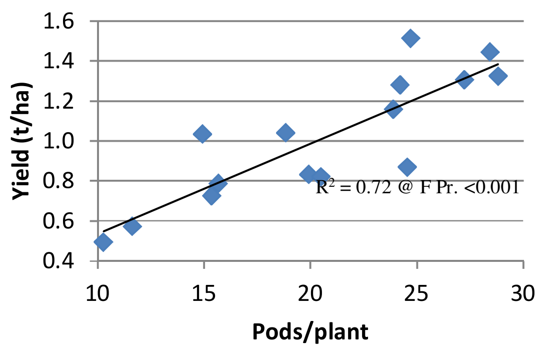


Figure 32. Correlation between yield and pods per plant at Baucau research station

Conclusions

With a dramatic reduction in overall yield experienced it was difficult to have a lot of confidence in the varietal differences observed. In Betano for example, there was a big contrast observed between plots that held some moisture within them after the infrequent rainfall and those that dried out quickly in relation to the viability of plants that grew there. There was also an absence of high correlations between yield and yield components on a number of occasions.

The poor results for Utamua are disappointing and raise questions about its ability to thrive in low rainfall environments, particularly around planting. However data from previous years have consistently showed its yield advantage over local varieties and with such proven benefits, poor results from one batch of seeds should not be overemphasised.

PT 12 continued to be one of the highest yielding varieties in three of the four research stations. Its relatively poor performance at Loes stand in contrast with very good yields achieved for local varieties grown there.

The good performance of local varieties at Loes coupled with the fact that overall yield achieved there was multiples of that achieved at other locations resulted in only half the introduced varieties out yielding local varieties when averaged across the four sites.

2.5.2 Replicated trials, multi-year and multi-location analysis

Materials and methods

Twenty one successful peanut trials (including two dry season trials) were implemented over the period from 2005 to 2010 (5 years) at 5 different sites (Aileu, Baucau, Betano, Loes and Maliana), testing the performances of 17 varieties. Some varieties were not included in all trials (in particular local additions) and some trials were not performed at every site every year. Mean yields by available site are presented in Table 79.

Mean site yield performances varied from 0.10 t/ha to a maximum of 3.1 t/ha (Betano 2010 and Baucau 2007 respectively) with about half the sites performing within the 1.0-1.5 t/ha range. In both Aileu and Betano, wet season yields varied according to the amount of received rainfall.

With the exception of GN11 which was discarded after one evaluation due to its very poor performance, all imported varieties performed well overall with mean yields ranging from 1.2t/ha (PT20) to 1.4t/ha (PT15). This corresponds to yield advantages of 7-26% over the mean of 5 local varieties. Local checks represented 19% of all varieties tested. The released variety Utamua had an overall yield at 1.3 t/ha (20% above locals).

Table 79. Peanut mean yields and yield advantages over 2005, 2006, 2008, 2009, 2010

Variety	*Number of trials*	*Mean yield (t/ha)*	*St. dev*	*Yield advantages*
PT 15	21	1.4	0.9	26
PT 14	21	1.4	0.8	24
PT 16	21	1.4	0.9	23
PT 11	21	1.4	0.9	21
PT 12	21	1.4	0.8	21
PT 13	21	1.3	0.8	20
Utamua	20	1.3	0.9	20
PT 18	21	1.3	0.8	17
PT 19	21	1.3	0.7	13
PT 17	21	1.2	0.7	8
PT 20	21	1.2	0.9	7
Loc. Bo'ot Loes	10	1.3	0.9	
Loc. Darasula	21	1.1	0.6	
Loc. Maliana	1	1.0	-	
Loc. Mean Betano	11	1.0	0.7	
Loc. Bo'ot Betano	11	0.8	0.8	
GN 11	1	0.3	-	
Locals	38	1.1	0.7	
All sites	225	1.3	0.8	

Cross-site analyses were conducted using BiPlots (GGE BiPlot program) in order to evaluate the performance and consistency of the tested varieties across years and locations (genotype / environment). A limitation of the procedure implied that only near complete datasets could be analysed.

Results

As combining the results from all years included in Table 79 presented too high a degree of variability to be visually represented, data included trials from the two most recent years in this analysis. This dataset included 150 data points (location and season × variety combinations) out of a total of 285. The same fifteen entries were used in each of the ten trials (Table 80). 47% of variability within this data was accounted for in the BiPlot. A biplot visualising how varieties performed by environment (year/season and location) is represented by Figure 33. Data on this Biplot is partitioned by quadrant.

Table 80. Variety yields across research stations in 2009 and 2010

	W9 BET	W9 LOE	W9 BAU	W9 MAL	W9 AIL	D09 LOE	W10 AIL	W10 BAU	W10 BET	W10 LOE
Utamua	0.7	3.1	1.6	1.5	0.6	1.5	0.0	1.2	0.0	1.4
PT10	0.9	1.8	1.1	0.7	0.4	1.2	0.2	0.6	0.1	1.9
Pt11	1.4	2.2	1.6	1.4	0.3	1.6	0.2	1.4	0.1	1.5
Pt12	1.6	3.0	1.5	1.8	0.3	1.6	0.5	1.4	0.2	1.5
Pt13	1.5	3.2	1.3	0.9	0.6	1.1	0.5	1.5	0.1	2.1
Pt14	0.9	2.0	1.0	1.4	0.6	1.1	0.1	1.3	0.2	1.4
Pt15	1.3	3.7	1.1	0.9	0.4	1.3	0.4	0.8	0.1	2.1
Pt16	1.7	3.6	1.3	1.8	0.5	1.7	0.1	0.9	0.1	2.4
Pt17	0.6	1.7	1.4	1.5	0.3	1.5	0.3	1	0.0	0.9
Pt18	1.4	2.1	1.4	1.6	0.4	1.1	0.3	1	0.0	1.7
Pt19	1.7	2.2	1.4	1.3	0.4	1.0	0.1	1.3	0.1	1.3
Pt20	1.6	2.2	1.5	0.6	0.5	1.2	0.0	0.8	0.2	1.1
PT22	0.7	2.5	0.3	0.8	0.4	0.8	0.0	0.8	0.1	2.1
PT21	1.6	2.6	0.8	0.9	0.4	1.0	0.1	0.8	0.1	1.6
PT23	0.7	2.9	1.2	1.3	0.5	1.4	0.1	0.5	0.1	2.8
Average	1.2	2.6	1.2	1.2	0.4	1.3	0.2	1.0	0.1	1.7

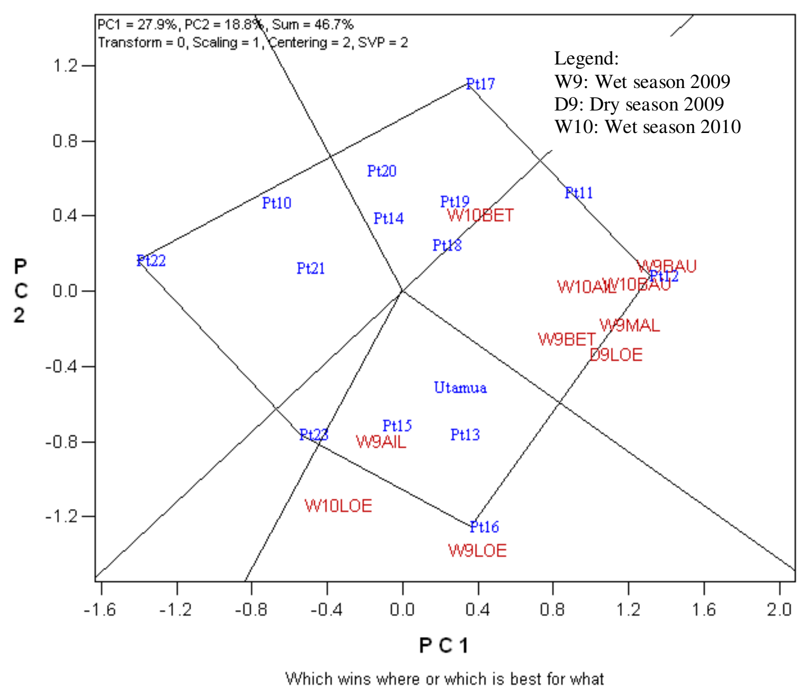


Figure 33. Which won where BiPlot analysis, peanut varieties, 2009/10

PT 11 but in particular PT 12 performed well in the majority of environments. In all of the remaining environments, bar one, Utamua, PT 13, PT 15 and PT 16 performed well. The remaining varieties, included all local varieties were found to perform below average in all environments.

The same data was analysed using another operation which tested stability as well as performance of all varieties across environments (Figure 34). The BiPlot displays the variety means (along the line with two arrows) versus the environment (line with one arrow) with mean yield found at the point of intersection of these two lines. The closer a variety to the arrow on the latter line, the better its performance. The further a variety appears from the line, the more variable its performance. A circle representative of an average location is located along the environment vector.

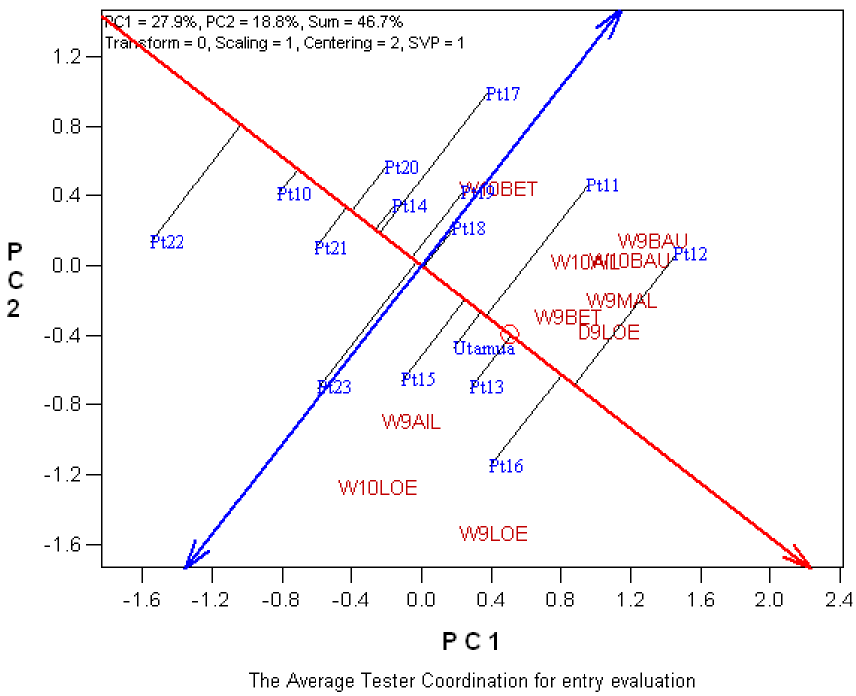


Figure 34. Performance and stability BiPlot analysis, peanuts, 2009/10

It can be seen that although PT 12 gives the greatest overall performance it yield across environments is one of the most variable. The most consistent of varieties with above average yield is Utamua. This is demonstrated by the short vector from the environment line as well as the proximity of the point of intersection of that vector and line with the average location symbolised by the red circle.

Environments could be grouped in two based on the BiPlot analysis. One included both wet season trials conducted at Loes research station. In both years Loes yielded better than any other station (Table 80). The only other environment included in this group was the Aileu trial in 2009. It is unclear why it would be included in a similar environment category as the Loes wet season trials as it was the lowest yielding trial in 2009. The dry season trial in Loes out performed all the wet season trials in 2010. Given the limited viability of the 2010 wet season trial at Betano, it is not surprising that it was not grouped together with any of the other nine environments examined in the BiPlot analysis.

Conclusions

Over 5 years, SoL conducted 21 successful replicated peanut variety trials on 15 varieties, representing a total of 285 individual data points (season × variety combinations). Results varied significantly both by genotype (varieties) and environment (locations and years). As it can be expected, available moisture appears to be a critical factor of the later component.

The collected data allowed selecting, releasing and confirming the Utamua variety as suitable according to production (measured over four years as +25% over locals with exceptional consistency across location for 2008-2009), taste and suitability (OFDTs). Although the 2010 trials were less not as emphatic in support of Utamua, it still remained the most consistent above average yielding variety when assessed over the last ten trials.

A number of the other varieties that have proved promising over the years were assessed on On Farm Trials (OFDTs). However there were not any that proved to have a definitive advantage over varieties already available, in particular, Utamua. The above varieties have now been replaced by a new set of entries which began evaluation in 2010. Results for these varieties are awaited before progressing to OFDTs.

2.5.3 New peanut observational trials

Materials and methods

Forty five new peanut entries were imported from ICRISAT, India late in 2009 for evaluation in Timor-Leste. These were selected by ICRISAT breeders for their resistance to early and late blight and adaptation to conditions similar to those found in Timor. To simplify their identification, the new entries were nominated SoL codes from PT 101 to 145. Their characteristics are detailed in Table 81.

Table 81 New peanut population details, 2010

Code SoL	Identification ICRISAT	Medium-duration	Foliar disease resistant	Branching habit		Botanical type		Seed color	
				Sequential	Alternate	Spanish bunch	Virginia	Tan	Red
PT101	ICGV 99027		X	X		X		X	
PT102	ICGV 99028		X	X		X		X	
PT103	ICGV 99029		X	X		X		X	
PT104	ICGV 99030		X	X		X		X	
PT105	ICGV 99031		X	X		X		X	
PT106	ICGV 99032		X	X		X		X	
PT107	ICGV 99033		X	X		X		X	
PT108	ICGV 99036		X		X		X		X
PT109	ICGV 99046		X	X		X			X
PT110	ICGV 99050		X		X		X	X	
PT111	ICGV 99051		X		X		X	X	
PT112	ICGV 99052		X		X		X	X	
PT113	ICGV 99053		X	X		X		X	
PT114	ICGV 99054		X	X		X		X	
PT115	ICGV 99057		X	X		X			X
PT116	ICGV 97069	X		X		X		X	
PT117	ICGV 97087	X		X		X		X	
PT118	ICGV 97090	X		X		X			X
PT119	ICGV 97091	X		X		X			X
PT120	ICGV 97092	X		X		X		X	
PT121	ICGV 97093	X		X		X		X	
PT122	ICGV 97094	X		X		X		X	
PT123	ICGV 97098	X		X		X		X	
PT124	ICGV 97120	X		X		X			X
PT125	ICGV 98077	X		X		X		X	
PT126	ICGV 98087	X		X		X			X
PT127	ICGV 98088	X		X		X		X	
PT128	ICGV 98089	X		X		X		X	
PT129	ICGV 98099	X		X		X		X	
PT130	ICGV 98100	X		X		X		X	
PT131	ICGV 97100	X			X		X	X	
PT132	ICGV 97131	X			X		X	X	
PT133	ICGV 97135	X			X		X	X	
PT134	ICGV 97137	X			X		X	X	
PT135	ICGV 97142	X			X		X	X	
PT136	ICGV 98180	X			X		X	X	
PT137	ICGV 98184	X			X		X	X	
PT138	ICGV 98187	X			X		X	X	
PT139	ICGV 99167	X			X		X	X	
PT140	ICGV 99169	X			X		X	X	
PT141	ICGV 99171	X			X		X	X	
PT142	ICGV 99174	X			X		X	X	
PT143	ICGV 00061	X			X		X	X	
PT144	ICGV 00064	X			X		X		X
PT145	ICGV 00065	X			X		X		X

The small quantities of available seed allowed the planting of single replicate observation plots at two sites: at Betano and Loes research stations during the wet season of 2009/10. Planting details are as shown in Table 82. Plots were larger in Betano but they were less densely planted. The plots were neither fertilized nor irrigated. At harvest, the number of live plants per plot were recorded as well as pod production.

Table 82. Planting and harvest details of peanut varietal trials, 2010

Site	No. of entries	Plot size (m)	Planting distance (cm)	Planting date	Harvest date	Days to maturity	Rainfall (mm)[a]	Mean yield (t/ha)
Betano	44	2.5 × 5	40×15	22 Jan 2010	20 Jul 2010	180	1160	0.3
Loes	43	2 × 2	20×15	6 Jan 2010	17 May 2010	131	425	2.8

[a] Total rainfall from planting to harvest dates

Results and discussion

The trial in Betano suffered from extreme drought after planting which strongly affected early plant stand (average emergence rate at 10 days: 45 %). Plant densities at harvest were of 5.1 plants/m^2 in Betano and 13.5 plants/m^2 in Loes. All varieties germinated except three in Betano. Unseasonal rains in late June and July postponed the harvest in Betano.

Although these were observational trials, some characteristics were used to reduce the number of entries for replicated trials to be conducted at a later date. Dry pod weights from each plot were measured. Yields were much higher at Loes than Betano with the mean site yields of 2.8 t/ha and 0.3 t/ha respectively as detailed in Table 83.

Table 83. Yields of new peanut varieties, observation trials 2010

*Variety **		*Yields (t/ha)* Betano Wet'10	*Loes Wet'10*	*Mean*
PT 137	X	0.62	5.10	2.86
PT 136	X	0.88	3.20	2.04
PT 101	X	1.10	1.60	1.35
PT 117	X	0.98	1.65	1.32
PT 107	X	0.82	2.35	1.58
PT 141	X	0.43	4.00	2.22
PT 138	X	0.05	5.70	2.87
PT 143	X	0.50	3.45	1.98
PT 124	X	0.17	4.75	2.46
PT 131	X	0.05	5.25	2.65
PT 128	X	0.61	2.30	1.45
PT 132	X	0.05	4.70	2.37
PT 133	X	0.10	4.40	2.25
PT 110	X	0.35	3.00	1.68
PT 105		0.68	1.40	1.04
PT 122	X	0.13	3.95	2.04
PT 139	X	0.11	4.00	2.06
PT 134	X	0.08	4.10	2.09
PT 140	X	0.10	3.95	2.03
PT 108	X	0.09	3.95	2.02
PT 126	X	0.11	3.80	1.96
PT 116		0.39	2.35	1.37
PT 145		0.48	1.85	1.17
PT 130	X	0.16	3.15	1.66
PT 114		0.51	1.45	0.98
PT 125	X	0.18	3.00	1.59
PT 142	X	0.00	3.85	1.93
PT 104		0.50	1.45	0.97
PT 112		0.27	2.45	1.36
PT 106		0.37	1.95	1.16
PT 123	X	0.10	3.15	1.63
PT 109		0.15	2.90	1.53
PT 127		0.58	0.68	0.63
PT 135	X	0.00	3.45	1.73
PT 129		0.44	1.20	0.82
PT 113		0.33	1.60	0.96
PT 102		0.28	1.70	0.99
PT 111		0.18	-	0.18
PT 120		0.24	1.80	1.02
PT 115		0.03	2.50	1.27
PT 119		0.18	1.35	0.76
PT 118		0.10	1.60	0.85
PT 144		0.00	1.75	0.88
PT 121		0.13	0.05	0.09
PT 103		-	-	-
Site average		0.31	2.83	1.57
Site st. dev.		0.3	1.3	0.7

* Varieties noted 'X' will be integrated in next year replicated trials.

Twenty five of the potentially best entries will be included in replicated trials during the 2010/2011 wet season. Simultaneously, the remaining entries will be re-evaluated in observational trials across 4 sites.

2.5.4 Peanut OFDTs 2009-2010

Peanut OFDTs were established in 16 Sub-Districts of East Timor during the wet season of 2009-2010. The objective of the OFDTs was to see how Utamua, a variety released in 2007 plus two new varieties PT15 and PT16, chosen on the basis of the results from research station trials, performed compared with locally grown varieties. All varieties were cultivated by farmers, in farmers' fields at different locations, using local agronomy.

Utamua is a large seeded peanut variety from India, released by MAF for use by subsistence farmers. The establishment of peanut OFDTs is also a way of distributing small quantities of Utamua seed (released and recommended by MAF) to farmers for their consideration and potential adoption as a food or cash crop. Five kilograms of Utamua seed was distributed to each farmer who participated in peanut OFDTs in 2009.

Materials and methods

Peanut OFDTs were established in four adjacent 25m^2 plots containing the test varieties and the local check in a similar manner to that described in the maize OFDT chapter. The Research Assistants requested farmers to use their traditional planting system with the only exception being advice that pre-soaking of the Utamua seed prior to planting assists in achieving good plant stands.

157 peanut OFDTs were established across all major agro-ecological zones (AEZs) in 16 Sub-Districts across Timor-Leste, in 7 Districts (Aileu, Ainaro, Baucau, Bobonaro, Liquica, Manufahi and Viqueque) during the wet season of 2009-2010. One Research Assistant was present in each Sub-District, with two in Baucau Villa and Aileu Villa. 132 OFDTs were harvested with yield data collected for Utamua and 129 for local varieties. Shortage of seed was the main factor in having a reduced number of OFDT sites of 55 for PT15 and 50 for PT16 from which yield data was collected.

Soil pH, color and texture were measured along with other site characteristics using the methodology described in the maize OFDT chapter. Yields were expressed as sun dried unshelled pods unless otherwise stated.

Researchers visited the sites an average of 5.6 times from planting to harvest. At each visit they recorded different information about the OFDT. These data collection protocols monitored progress of the trial/demonstration. In-season measurements included plant condition, identification of pests and diseases in each plot, wilting and other plant symptoms.

At harvest, staff recorded the fresh weight of pods from the whole plot (25m^2). A sub-sample of 5 plants was taken from each plot with the number of pods per plant counted. In addition a sample of 50 pods was weighed at harvest and when dried. The number and weight of seeds from this sample was also recorded. The ratio of dried pod to the pod fresh weight was used to convert the total fresh weight of pods to amount of dry pod weight per plot, and then converted to tons per hectare.

Analysis

Data from the protocols was first entered into an MS Excel spreadsheet database before being transferred for further analysis to GenStat Discovery Edition 3. Peanut yield data (dry weight in pods, t/ha) was analyzed by ANOVA (Unbalanced Linear Model) with variety and AEZ as constant factors in the model once the other location factors of District and Sub-District had been tested. Plant density was used as a covariant. The ANOVA output was used to test for significant interactions between variety and AEZ. The influence of a wide range of factors on peanut yields was tested using an unbalanced ANOVA design. In turn, each factor was added to the model, one at a time. If they were significant, the factor was kept in the model, and if they were non-significant the factor was discarded. Once a significant factor was identified, the interaction of that factor and variety was also tested for significance at the $P < 0.05$ level.

Results

Testing environments

Peanut OFDTs were conducted on a wide range of soil textures, pH, slope and elevation. Elevation of OFDT sites ranged from almost sea level to over 1,300m in Liquidoe Sub-District. The range of elevation of OFDT sites in 2009/10 was similar to 2008/09 (Table 84). 81% of sites were planted at elevations less than 750 meters above sea level (masl).

Table 84. Distribution of peanut OFDT sites by elevation (masl), 2007-2010

Elevation (m)	*Locations 2007-08 (%)*	*Locations 2008-09 (%)*	*Locations 2009-10 (%)*
0-150	23	36	36
150-350	9	17	21
350-550	16	15	10
550-750	14	10	14
750-950	19	14	11
950-1150	10	6	5
1150-1350	7	2	4
>1350	2	0	0

Soil pH, elevation and texture

The average soil pH across the OFDT test sites was 6.8, ranging from 5 to 9. Approximately 6% of sites can be defined as acid soils (pH 5.5 or less) and approximately 8% of the sites described as alkaline soils (pH 8.0 or above). The majority of the sites (85%) had soil pH values between 6.0 to 7.5 inclusive (Table 85).

Table 85. Distribution of soil pH across peanut OFDT sites, 2007-2010

Soil pH	*Locations 2007-08 (%)*	*Locations 2008-09 (%)*	*Locations 2009-10 (%)*
4.5	3		
5.0	3	5	1
5.5	11	14	5
6.0	15	10	20
6.5	18	21	19
7.0	20	17	23
7.5	13	20	23
8.0	13	10	6
8.5	3	3	1
9.0	1	1	1

Soil pH differed statistically between Sub-District, as in other years (Table 86).

Table 86. Soil pH and elevation of peanut OFDT locations, 2008/09 and 2009/10

District	*Sub-District*	*Elevation 2008-09*	*Soil pH 2008-09*	*Elevation 2009-10*	*Soil pH 2009-10*
Aileu	Aileu	930	5.6	732	6.7
Aileu	Laulara			1204	6.2
Aileu	Liquidoe	1117	5.3	1285	5.8
Aileu	Remexio	961	5.3	1020	5.8
Ainaro	Hatu-Udo	178	6.9	227	7.3
Baucau	Baucau	499	6.9	494	7.0
Baucau	Vemasse	617	6.6	532	6.0
Baucau	Venilale	818	8.0	708	7.7
Bobonaro	Balibo	142	7.0	253	7.0
Bobonaro	Maliana	310	7.4	203	6.8
Liquica	Liquica	374	6.3	277	7.4
Liquica	Maubara	337	6.4	94	7.1
Manufahi	Alas	41	7.3	75	7.0
Manufahi	Same	368	6.9	191	7.4
Manufahi	Turiscai	1134	5.7		
Viqueque	Ossu	500	6.1	480	6.0
Viqueque	Viqueque			43	6.5
Viqueque	Watu Lari	15	6.6		
LSD (P<0.05)				201	0.58

There was a general trend of the higher altitude Sub-Districts having lower soil pH values. The regression (Figure 35) suggests that the higher the elevation, the lower the pH. The rate of the decline in pH was approximately 1 unit of pH per 1000m of elevation. Like the previous year, Venilale Sub-District had the highest pH and was the most distant from the regression line. Omission of Venilale from the regression results in mean elevation of each Sub-District explaining over half of the variation in soil pH across Sub-Districts. The Aileu Sub-Districts with the highest elevations had some of the lowest pH measurements.

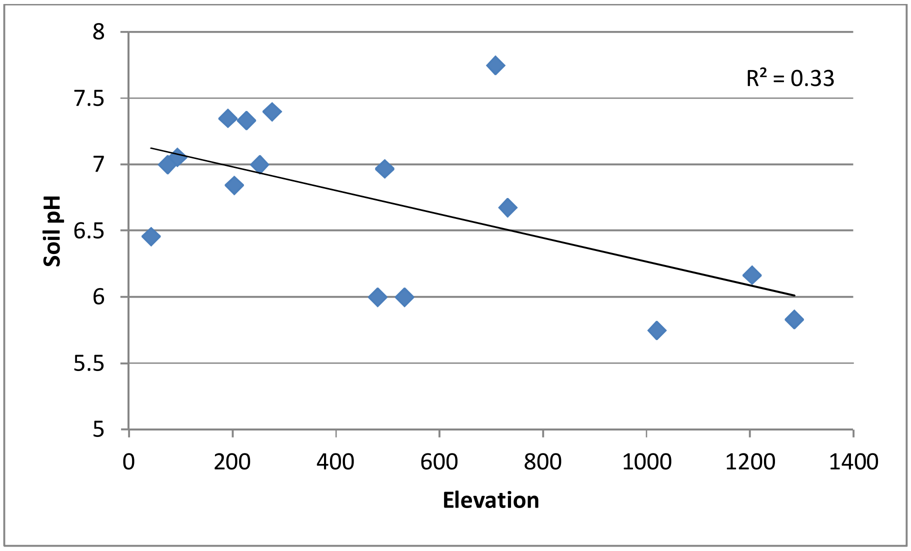


Figure 35. Effect of elevation on soil pH for peanut OFDT sites, 2009/10

In contrast to the previous year there was a significant proportion of sandy loam soils recorded. Fine clay and clay loams were also recorded in a large number of peanut OFDTs (Table 87).

Table 87. Distribution of soil texture of peanut OFDT, 2008/09 and 2009/10

Soil texture	*Locations (%) 2008/09*	*Locations (%) 2009/10*
Sandy	3	2
Sandy Loam	9	25
Silty Loam	10	8
Loam	16	15
Clay Loam	29	20
Fine Clay	25	23
Heavy Clay	8	6

Trial losses

While trial losses of 14% were lower than the losses recorded in previous years, shortages of seed for the newer varieties of PT15 and PT16 meant that they were not included at as many sites. Reasons reported for trial losses included not having rain after planting and animal predation on crops. Other factors reported were that farmers did not follow planting directions and that the plots were harvested in the absence of the OFDT staff.

Variety

Only Utamua produced a significantly higher yield over local varieties with a 43% yield advantage (Table 88). Figure 36 shows that Utamua outperformed local varieties at almost all sites. In contrast to last year the other introduced varieties actually underperformed against the locals although not to a significant degree. Seed size was a main driver in increasing the yield of Utamua over the other test varieties.

Table 88. Yield components of OFDT varieties across all on-farm trials, 2009/10

Variety	*Yield (t/ha) (yield adv)*	*Plant density (plants/m^2)*	*Seed size (g/100 seeds)*	*Yield per plant (g/plant)*
Local	2.4	8.2	65	44
PT15	2.3 (-6%)	8.7	68	37
PT16	2.3 (-7%)	9.1	68	32
Utamua	3.5 (43%)	7.7	103	62
LSD (P<0.05)	0.66	*ns*	10	15

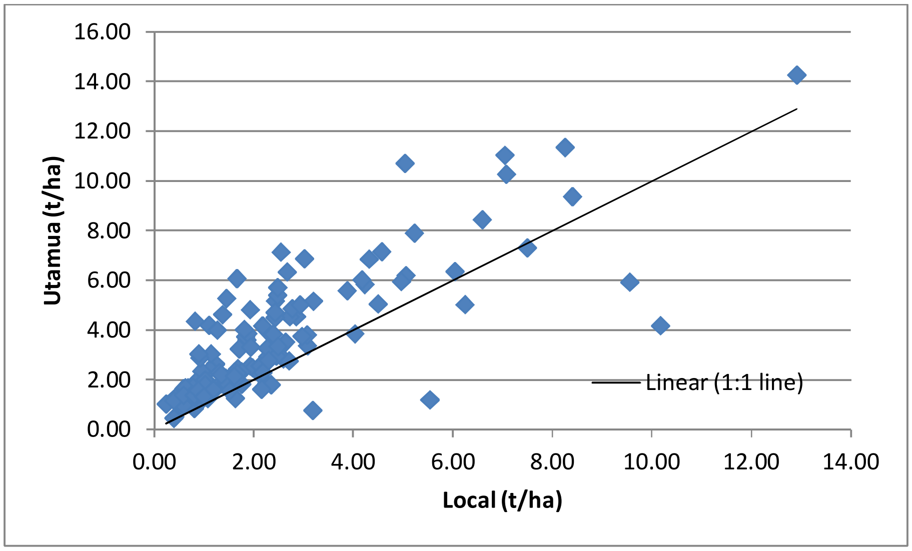


Figure 36. Yield of Utamua versus the local population at all sites in 2009/10

Yield components

Yield continued to increase in all varieties with increasing plant density apart from outliers. There was no interaction between plant density and variety on yield. Using a polynomial squared model in GenStat it was only at the extreme plant densities that yield was negatively impacted upon (Figure 37). The regression equations for the varieties were as follows;

Local	Yield (t/ha) = 0.936 t/ha + 0.234*Density – 0.003*Density^2
Utamua	Yield (t/ha) = 1.992 t/ha + 0.234*Density – 0.003*Density^2
PT15	Yield (t/ha) = 0.629 t/ha + 0.234*Density – 0.003*Density^2
PT16	Yield (t/ha) = 0.573 t/ha + 0.234*Density – 0.003*Density^2

Like last year, the issue of poorer plant density experienced with Utamua in previous years was not apparent. Both seed size and yield per plant were significantly greater with Utamua than with any of the other varieties. This may suggest that farmers have changed agronomic practices to adapt the Utamua seed to local conditions. Like 2008/09, half of the farmers soaked seeds before planting which may benefit in the establishment of Utamua seeds in particular due to their large size.

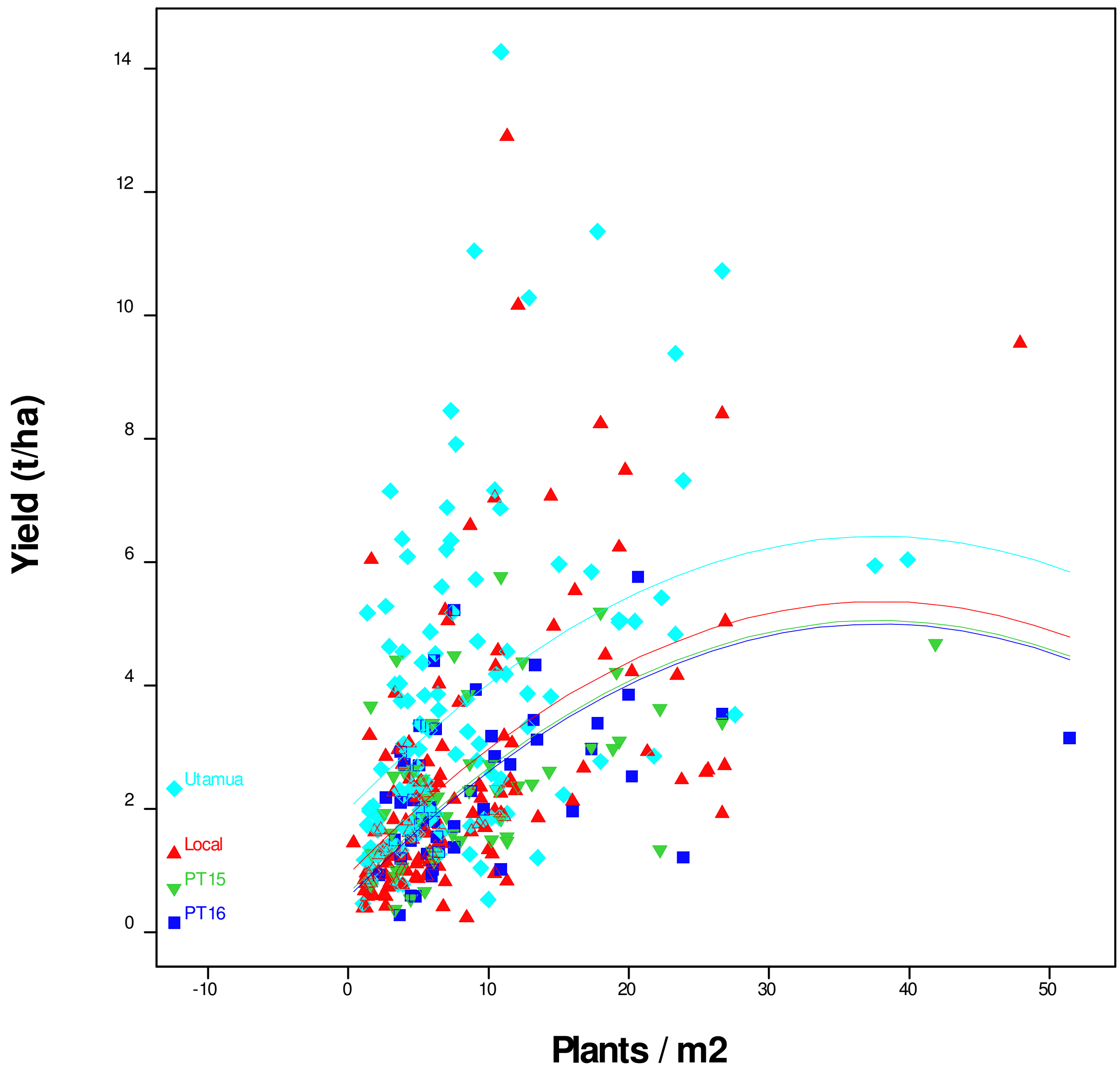


Figure 37. Regression graph of yield against plant density for each variety

All yield components for PT15 and PT16 were not significantly different from locals. Both plant density and seed size tended to be higher from PT15 and PT16 when compared to locals but the yield per plant was lower.

Districts

The differences of yield in trial Sub-Districts are detailed in Table 89. Some Sub-Districts had much higher yields than the previous years. Utamua outperformed all other varieties in all Sub-Districts apart from Liquidoe and Viqueque. Baucau Sub-District yielded best with both Utamua (7.6 t/ha) and Local (5.1 t/ha) varieties. Utamua yielded over 5 t/ha in Hatudo, Remexio and Same.

Unlike in the previous year but in common with other years, Sub-District was found to significantly affect yield and a significant interaction between Sub-District and variety (F pr. < 0.001) was found. However with the limited amount of yield data recorded for PT15 and PT16 excluded from the analysis no such interaction was found between Utamua and Local. This suggests that the higher yield of Utamua is consistent across Sub-Districts. It was found that the strong variety X Sub-District interactions was affected through the relationship of Utamua to both PT15 and PT16.

There were three Sub-Districts with no yield data for either PT15 or PT16. Of those with data recorded PT15 yielded higher than local varieties in six Sub-Districts with PT16 higher in seven. There was no significant varietal effect with Utamua excluded from the analysis.

Table 89. Peanut OFDT predicted mean yields by Sub-District, 2009-2010

District	*Sub-District*	*Mean yield of Local (t/ha)*	*Mean yield of PT15 (t/ha)*	*Mean yield of PT16 (t/ha)*	*Mean yield of Utamua (t/ha)*	*Yield advantage of Utamua (%)*
Aileu	Aileu	2.5	1.7	1.7	2.5	0
	Laulara	0.9	*	*	1.7	87
	Liquidoe	2.9	4.6	4.6	3.9	34
	Remexio	4.1	3.8	5.3	5.3	31
Ainaro	Hatu-Udo	2.3	2.9	2.4	5.3	134
Baucau	Baucau	5.1	1.9	2.4	7.6	49
	Vemasse	2.6	2.6	2.8	4.0	57
	Venilale	2.0	2.0	2.1	2.6	27
Bobonaro	Balibo	2.0	2.5	2.7	3.3	60
	Maliana	1.6	0.8	0.7	2.1	29
Liquica	Liquica	2.4	3.2	*	3.8	60
	Maubara	1.7	1.8	1.6	2.0	20
Manufahi	Alas	1.6	*	*	2.1	31
	Same	3.8	2.0	1.7	5.9	54
Viqueque	Ossu	1.7	*	*	2.7	61
	Viqueque	1.7	3.4	2.0	2.9	77
LSD (P<0.05)			2.4			

AEZ

Predicted means for peanut yields were significantly influenced by AEZ. There was no variety x AEZ interaction. As such, Utamua can be recommended as a high yielding variety in all AEZs (Table 90)

Very little PT15 or PT16 was grown in the Southern AEZs. Yields tended to be more consistent for all varieties in the Northern AEZs. AEZ 5 tended to give the highest yields. This was particularly the case for Utamua where there was virtual uniformity in yield between the Northern AEZs but a large increase in the Southern AEZ 5.

Table 90. Predicted mean peanut OFDT yields and yield advantage by AEZ

AEZ	*Mean yield of Local (t/ha)*	*Mean yield of PT15 (t/ha)*	*Mean yield of PT16 (t/ha)*	*Mean yield of Utamua (t/ha)*	*Yield advantage of Utamua (%)*
1- Northern coast (0-100m)	2.3 (16)	2.3 (8)	2.3 (8)	3.5 (16)	51
2- Northern slopes (100-500m)	2.8 (20)	2.7 (10)	2.5 (5)	3.5 (23)	26
3- Northern uplands >500m	2.4 (42)	1.8 (28)	2.1 (29)	3.4 (41)	45
4- Southern upland >500m	1.7 (3)	* (0)	* (0)	3.0 (3)	79
5- Southern slopes (100-500m)	3.0 (22)	3.0 (3)	2.7 (4)	4.8 (22)	60
6 Southern coast (0-100m)	1.9 (15)	3.2 (3)	1.9 (1)	2.8 (15)	48

Figures in brackets indicate number of trials harvested

Elevation had a significant impact on yield. There was not any interaction recorded between variety and elevation for yield. A regression graph displaying this information indicated that yields increased with increasing elevation up to about 700 meters and fell off thereafter

(Figure 38). Lack of data at some of the higher elevations makes this assumption difficult to substantiate.

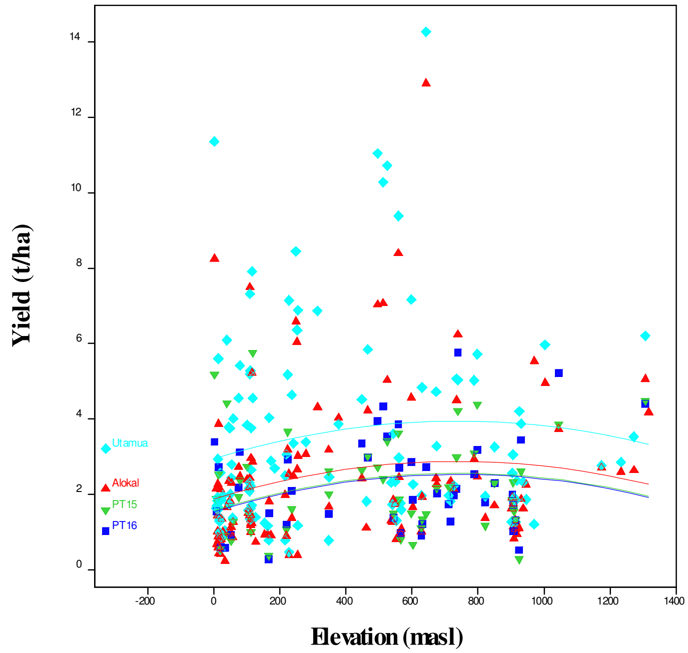


Figure 38. Effect of elevation on yield for each variety

Agronomic factors

Using an Unbalanced ANOVA model with Variety and AEZ as permanent factors and plant density as a covariate, it was found that many other factors also had a significant effect on yield (Table 91).

Table 91. Various factors affecting peanut OFDT yields, 2007-2010

Factor	*F pr. 2009-2010*	*Significant 2009-2010*	*Significant P<0.05 2008-2009*	*Significant P<0.05 2007-2008*
Variety	<0.001	✓	✓	✓
AEZ	0.008	✓	✓	✓
Sub-District	<0.001	✓	✓	✓
Number of seeds per hill	<0.001	✓		
Planting distance	0.002	✓	×	✓
Soil pH	-	×	✓	✓
Soil color	-	×	×	×
Soil texture	<0.001	✓	✓	✓
Number of staff visits	<0.001	✓	×	✓
Random or line planting	-	×	×	×
Slope class	0.008	✓	×	✓
Number of weeding events	-	×	×	×
Mixed planting of monoculture	-	×	×	×
Tools used for land preparation	-	×	✓	✓
Gender	-	×	×	×
Seed soaked before planting	-	×	×	×

Seeds per hill

The average yield of all varieties was significantly affected by the number of seeds planted per hill. There was also a significant interaction recorded between variety and the number of seeds per hill. Predominantly one seed per hill was planted (Table 92). However where 2 seeds per hill were planted there was a significant increase in yield. Surprisingly Utamua along with local varieties performed best at 2 seeds per hill while PT15 and PT16 had higher yields using just one seed. Although Utamua is a larger seeded variety than the others tested it had a similar number of seeds per hill planted.

Table 92. Influence of seeds per hill on OFDT peanut yields, 2009/10.

Seeds per hill at planting	*Number of OFDTs*	*Average yield of four tested varieties (t/ha)*
1	102	2.5
2	22	3.9
3	3	1.9
LSD (P<0.05)		*1.0*

Soil pH

Soil pH did not record a significant impact on yield. There was a trend observed for higher yields to occur in more acid soils. This was in contrast to that observed the previous year. Soil color also proved insignificant.

Soil texture

Soil texture had a significant effect on peanut yield in 2009–2010 as in previous years (Table 93). In contrast to the previous year the loam soil groups tended to yield much better than the clay soil groups. This may be a reflection of the La Niña year experienced where rainfall continued throughout the dry season. Silty loam had a significant yield advantage albeit with a lower number of trial sites.

Table 93. Effect of soil texture on peanut OFDTs, 2009-2010

Soil texture	*Yield t/ha*	*Locations (%)*
Sandy	2.6	18
Sandy Loam	2.8	21
Silty Loam	4.5	9
Loam	3.3	15
Clay Loam	2.6	2
Fine Clay	2.2	26
Heavy Clay	2.1	10
LSD (P<0.05)	*0.9*	

Number of staff visits

The number of times the research assistants visited the farmers had a significant effect on yield. The highest yield corresponded with when RAs visited the farms on most occasions. There was not however a linear relationship between the number of staff visits and yield (Table 94).

Table 94. Effect of number of staff visits on farm maize yield 2009/10

Number of visits	*Average yield (t/ha)*	*Percent of observations*
1	2.8	5
2	0.8	5
3	3.1	4
4	2.3	5
5	3.6	11
6	2.9	25
7	3.4	19
8	2.3	21
9	3.4	6
LSD (P<0.05)	*1.2*	

Use of fertilizer

No farmers included in the peanut OFDTs in 2009/10 reported the use of fertilizer, either organic or non-organic.

Slope of land

Slope class was found to significantly affect yield. The vast majority of trial sites were in just one class (0-2%). Although there was not a linear relationship between slope and yield, the latter did tend to increase with increasing slope. A significant increase was observed at slope class 16-30% where all varieties yielded well.

Farmer preferences

Field days were held at OFDT sites during the year and farmers were interviewed regarding the peanut varieties under evaluation. They were asked to provide information on what characteristics were found in the local and test varieties that would encourage them to re-plant. Farmers preferred to grow each of the test varieties for different reasons (Table 95). Over 200 farmers participated in peanut OFDT farmer field days. However PT15 and PT16 were not evaluated at a number of them.

Table 95. Reasons farmers (%)* would replant maize varieties, 2009/10

Characteristic	*Local*	*PT15*	*P16*	*Utamua*
Overall choice	*33*	*18*	*30*	*43*
High yield	41	47	59	98
Taste	80	84	67	72
Plant survival	56	63	63	88
Seeds per pod	55	34	40	54
Seed size	16	9	10	99
Days to maturity	81	77	86	65
Ease of harvest	41	72	60	79
Ease of Shelling	72	78	74	79
Saleability	64	46	39	96
Total respondents	*203*	*128*	*128*	*203*

*Many farmers made more than one choice from each criterion

After the harvest of a peanut OFDT, the research assistants provided the assembled farmers with the opportunity to comment on whether or not they would plant the varieties again, and why. Utamua was the most popular choice overall. Local varieties had a higher overall ranking than either PT15 or PT16.

Most farmers were happy to replant Utamua because of its large seed size and overall yield. This contrasted with much lower scores for other varieties. Utamua also had a much greater saleability ranking than the other varieties even though seed is often sold by volume rather than weight. PT15 was preferred on taste and PT16 on days to maturity but apart from these traits, Utamua or Local ranked higher.

Utamua also ranked highest on ease of harvest and ease of shelling. It also ranked surprisingly well on the number of seeds per pod.

As well as farmer field day data, comments from most farmers hosting OFDTs were also solicited after their harvest. Like the FFDs, almost all comments about Utamua were positive. Many included big seeds as well as, good yields, good taste with oily seeds that lasted for a long time.

The characteristics of PT15 were compared with that of local varieties. Ease of shelling and the number of seeds per pod were also praised as well as taste. Criticism of PT15 included poor yields, susceptibility to disease and small seed size. PT16 was also compared to Local. It was praised for good production, ease of shelling, taste and color. Like PT 15, on a couple of occasions PT16 was found to have very soft seeds. Also some similar comments were made about susceptibility to disease and small seeds.

Local varieties elicited the greatest variety of responses on why they would be replanted. A sweet taste and good productivity ranked high on the list of responses why farmers would continue using local seed. High oil levels also rated favorably. A general liking for local varieties also featured in responses. More specifically, the fact that a local variety was ‘rai nain’ or from that land was again this year often quoted as a reason for continuing to grow it. Already being adapted to the land was also mentioned. Low yield was stated on many occasions as a reason for not continuing to grow a local variety often contrasting it with Utamua.

Conclusion

A further year of testing continued to show the high level of adaptation of the released peanut variety Utamua in all parts of Timor over many years. Utamua consistently showed a yield advantage over the local varieties in almost all Sub-Districts. PT15 and PT16 had much less yield data recorded. Both yielded disappointingly, being lower than local varieties.

Like last year, the poor plant density found with Utamua in previous years was not repeated with it being similar to local varieties this year. This may be attributed to the greater use of soaking of seed before planting which has been recommended based on previous experience.

The significant yield advantage of Utamua in all agro-ecological zones and Sub-Districts of Timor-Leste and across different seasons continued to be evident. Utamua is a high yielding peanut variety that is valued by farmers not just for its consistent high yield but also its good taste, large seeds and keeping quality.

With almost universal approval achieved of Utamua crops being grown, the challenge remains in finding another peanut variety that can match or exceed Utamua in the various traits of importance. The other varieties tested this year failed to produce favorable results but it is hoped that a new set of varieties which have begun the evaluation process may provide such a variety.

2.6 Climbing bean

2.6.1 Climbing bean replicated trials, 2010

Climbing beans (*Phaseolus vulgaris* L.) are commonly grown in Timor and constitute, at higher altitudes, a significant proportion of protein in the diet of subsistence farmers. Red bean soup is a classic Timorese side dish. Surplus beans are also sold in local markets and can provide a valuable source of income. During the wet season, climbing beans are grown in association with the main maize crop which physically supports the vines. During the dry season, climbing beans are usually grown on poles.

SoL implemented observational trials on climbing beans in three sites during 2009. The first replicated variety trials were conducted during the wet season of 2009-2010.

Materials and methods

A set of 16 varieties originating from Rwanda and first tested in 2009 was trialled in 2010, along with local checks. Six trials, established in locations ranging from 685 to 1660 masl, were implemented in six different sub-districts (five districts). Two replicates were established except in Venilale were only one was planted. Due to the small amount of available seed, the entries were planted on small 1m^2 plots. Each variety was planted in 3 hills about 1m apart with 2 seeds per hill (3 in Maubisse). Two-meter wooden tripods were positioned over the hills to allow the plants to climb up. The trials were planted later than usual (February rather than in November-January) because of some seed damage. A systemic insecticide (Furadan) was therefore used against bean fly infestation, a pest which can be disastrous when the crop is planted late. A few replantings were needed for some entries. No fertilizer nor irrigation was used, except in Aileu were 15 kg/ha of N and P were applied mid-February. The pods were harvested up to three times to account for different maturation dates. Each time, the number and weight of fresh and dry pods and seeds were recorded. Trial details are presented in Table 96.

Table 96. Climbing bean trial details, wet season 2009/10

Location	*Sub-District (District)*	*Elev'n (masl)*	*No. entries*	*No. reps*	*Planting date (2010)*	*Days to maturity*	*Rainfall (mm)**	*Mean yield (t/ha)*
Aileu QP	Aileu-Villa (Aileu)	972	21	2	01 Feb	110-170	950	0.18
Lisalara	Maubara (Liquiça)	685	21	2	10 Feb	85-90	620	0.13
Horhae Ki'ik	Maubisse (Ainaro)	1658	21	2	19 Feb	110-130	1160	0.92
Holarua	Holarua (Manufahi)	1252	24	2	18 Feb	75-115	1100	0.25
Ossu	Ossu (Viqueque)	978	21	2	01 Feb	85-100	1880	0.32
Venilale	Venilale (Viqueque)	850	20	1	14 Feb	120-135	920	0.36

* Total rainfall from planting to harvest for each site. Note: from site to site, average annual rainfall ranges from 1900 mm (Ossu) to 2700 mm (Aileu) and average annual temperatures from 21.5 °C (Maubisse) to 27.5 °C (Venilale).

In Lisalara, Maubisse, Holarua and Ossu, the total number of plants, pods and seeds were recorded at each harvest in order to calculate the yield components of plant density at harvest, pods per plant and seeds per pod. The weight of 100 seeds was calculated from the whole plot production (after shelling and drying) and from the total number of seeds per plot.

The data of the replicated trial were analysed separately using One-way ANOVAs in Randomized blocks in GenStat Discovery 3 in order to determine varietal effects. No row or column effect were detected in the yields.

Yield advantages were calculated from the resulting predicted means over the average of the local varieties.

The existence and degree of correlation between the predicted yield means and of the other parameters were then identified using Simple Linear Regressions. A first regression with 'Trials' as Groups (with 'separate lines' as the final model) was initially run over all the data in order to determine whether the regression slopes were significantly different from zero within each trial dataset (t tests on the parameters estimates). If it appeared to be so, individual regressions were then run on the corresponding trial data in order to determine whether the actual correlation was significant. The percentage of variability accounted for was then equivalent to an adjusted R^2.

Results

The yields and yield advantages for each site are presented in Table 97 and Table 98.

Table 97. Climbing bean yields, 2010

Yield (t/ha) / *Variety*	*Aileu*	*Lisalara*	*Maubisse*	*Holarua*	*Ossu*	*Venilale*	*St. dev.*	*Average yield (t/ha)*	*Yield adv. (%)*
RWV 1348	0.21		4.28	0.47	0.48	0.60	1.72	1.21	235
Decelaya	1.12	0.04	2.68	0.37	0.53	0.29	0.97	0.84	132
Mwirasi	0.33	0.01	3.63	0.32	0.13	0.44	1.39	0.81	124
G 2331	0.85	0.08	2.70	0.21	0.25	0.33	1.00	0.74	104
MAC 28	0	0	3.65	0.16	0.11	0.35	1.45	0.71	97
YOL X	0.23	0.03	2.96	0.10	0.29	0.59	1.12	0.70	94
Umubano	0.28	0	1.91	0.32	1.10	0.22	0.73	0.64	77
RWV 1002	0.26	0	2.66	0.16	0.33	0.21	1.01	0.60	67
Vuninkingi	0.06	0	2.12	0.62	0.25	0.45	0.79	0.58	61
RWV 1892	0.00	0.02	2.27	0.08	0.39	0.52	0.87	0.55	51
Gasilida	0.24	0.02	2.20	0.18	0.14	0.25	0.84	0.50	40
Hawinurare	0.28	0.04	2.03	0.34	0.08	0.26	0.76	0.50	39
RWV 1129	0.07	0.02	2.09	0.32	0.33	0.19	0.79	0.50	39
RWV 2409	0.18	0.11	2.00	0.15	0.05	0.29	0.76	0.47	29
Loc. V. Castro						*0.45*	-	*0.45*	*24*
CAB 19		0	1.73	0.20	0.06	0.09	0.74	0.42	15
Loc. Leber		*0.38*					-	*0.38*	*6*
Loc. Turiscai	*0.36*	*0.01*	*0.68*	*0.27*	*0.54*		*0.26*	*0.37*	*3*
Loc. V. 69						*0.34*	-	*0.34*	*-7*
Loc. Maubisse	*0*	*0.01*	*1.17*	*0.31*	*0.09*		*0.49*	*0.32*	*-13*
Loc. V. 96						*0.30*	-	*0.30*	*-16*
CAB 2	0	0	0.92	0.08	0	0.33	0.37	0.22	-39
Loc. Same				0.17			-	0.17	-52
P value	*0.002*	*<0.001*	*0.083*	*0.620*	*0.100*				
l.s.d.	*0.5*	*0.1*	*l.s.*	*n.s.*	*n.s.*	*(obs.)*			
%CV	*74.6*	*133.6*	*52.9*	*61.4*	*92.9*				
Mean site	0.26	0.04	2.32	0.25	0.29	0.34	0.85	0.58	
Mean locals	*0.18*	*0.13*	*0.92*	*0.25*	*0.32*	*0.36*	*0.29*	*0.36*	

The overall yield across locations was 0.6 t/ha, with a high variation within site (high CV%) and across sites. Maubisse performed the best, and Lisalara the least where only the local entry (Local Leber) performed reasonably well. The variety Venilale Castro was the other promising local check.

The imported varieties performed very differently with yield advantages ranging from +230% to -50% compared with the locals. The highest overall yields were obtained by RWV 1348, Decelaya and Mwirasi with 1.2-0.8 t/ha, which corresponded to yield advantages of about +100% over the locals. Other varieties which performed well this season were G 2331, Mac 28, YOL X and Umubano. The CAB varieties performed the poorest due to the seeds poor viability (poor germination, even with seemingly intact seeds).

Table 98. Climbing bean yield advantages per site, 2010

	Yield advantages (%) over locals					
Variety	*Aileu*	*Lisalara*	*Maubisse*	*Holarua*	*Ossu*	*Venilale*
RWV 1348	17		363	-49	52	65
Decelaya	519	-73	190	-60	66	-20
Mwirasi	81	-90	293	-66	-60	20
G 2331	366	-42	193	-77	-20	-9
MAC 28	-100	-100	295	-83	-67	-4
YOL X	28	-75	221	-89	-9	62
Umubano	52	-100	107	-65	247	-39
RWV 1002	43	-100	188	-83	5	-43
Vuninkingi	-68	-100	129	-33	-22	23
RWV 1892	-100	-86	146	-92	23	44
Gasilida	30	-84	139	-81	-56	-31
Hawinurare	53	-73	120	-63	-74	-29
RWV 1129	-62	-86	127	-66	5	-49
RWV 2409	2	-18	117	-84	-83	-19
Loc. V. Castro						*23*
CAB 19		-100	88	-78	-83	-76
Loc. Leber		*190*				
Loc. Turiscai	*100*	*-94*	*-27*	*-71*	*71*	
Loc. V. 69						*-7*
Loc. Maubisse	*-100*	*-96*	*27*	*-66*	*-71*	
Loc. V. 96						*-16*
CAB 2	-100	-100	0	-92	-100	-10
Loc. Same				*-81*		

Yield components

Details of the yield components and of the number of days to maturity available for Lisalara, Maubisse, Venilale and Ossu are presented in Table 99.

The overall plant stand at harvest across sites was of 3.0 plant /m², against a planting density of 9 plants /m². The number of pods per plant varied greatly, from less than 2 to over 35, with an overall average of 6.8 pods per plant. The number of seeds per pod was fairly variable too, ranging from 1 to 7 with a overall average of 3.7 seeds per pod. Those three yield components were the lowest in the Lisalara trial. Conversely, the weight of 100 seeds was more consistent across site (overall average of 35g/100seeds).

No correlation between the yield and yield components could be detected except between the yield and the number of pods per plant in Maubisse (Figure 48), with 19% of the variation explained for (p value = 0.044). The varieties with the highest numbers of pods per plant on average were Decelaya (which performed best in this trial) and RWV 1002.

Table 99. Climbing bean yields and yield components, 2010

Site	Variety	Yield (t/ha)	Plants /m²	Pods /plant	Seeds /pod	Seed wt (g/100)	Days to mat.
LISALARA	*Loc. Leber*	*0.38*	*2.5*	*26.5*	*1.8*	*32.6*	*71*
	Decelaya	0.04	3.0	1.3	2.9	31.8	90
	RWV 1348						
	G 2331	0.08	3.5	2.8	2.3	25.3	90
	Umubano	0	0	-	-	-	-
	Mwirasi	0.01	2.5	1.3	1.7	38.0	92
	YOL X	0.03	2.0	1.4	3.2	32.4	92
	RWV 1002	0	0				
	Loc.Turiscai	*0.01*	*2.0*	*1.7*	*3.0*	*57.2*	*85*
	MAC 28	0	0	-	-	-	-
	RWV 1892	*0.02*	*1.5*	*0.5*	*1.8*	*30.1*	*91*
	Hawinurare	0.04	3.5	2.8	2.7	32.8	89
	Vuninkingi	0	0	-	-	-	-
	Gasilida	0.02	1.5	0.5	2.1	28.8	91
	RWV 2409	0.11	4.0	1.9	3.7	41.9	90
	RWV 1129	0.02	1.5	1.5	3.0	28.6	92
	CAB 19	0	0	-	-	-	-
	Loc. Mbs	*0.01*	*0.5*	*1.5*	*1.0*	*30.2*	*91*
	CAB 2	0	0	-	-	-	-
	Loc. Same						
	MEAN	0.04	1.6	3.6	2.4	34.1	89
	P value	*<0.001*	*0.332*	*0.063*	*0.543*	*0.779*	*<0.001*
	l.s.d.	*0.11*	*n.s.*	*n.s.*	*n.s.*	*n.s.*	*3*
	%CV	*134*	*119*	*152*	*59*	*46*	*2*
MAUBISSE	Decelaya	2.68	4.0	7.0	3.9	37.4	58
	RWV 1348	4.28	3.0	15.1	7.1	20.4	124
	G 2331	2.70	2.7	8.9	4.6	36.6	124
	Umubano	1.91	2.0	5.9	6.5	37.4	91
	Mwirasi	3.63	2.7	10.1	4.1	47.8	124
	YOL X	2.96	4.0	7.2	3.8	39.9	124
	RWV 1002	2.66	1.3	17.5	5.4	31.2	124
	Loc.Turiscai	*0.68*	*2.7*	*4.8*	*3.7*	*24.3*	*58*
	MAC 28	3.65	2.3	10.7	4.0	55.8	124
	RWV 1892	2.27	1.2	10.7	4.4	54.2	126
	Hawinurare	2.03	2.7	6.9	3.7	44.2	86
	Vuninkingi	2.12	1.7	11.1	5.7	23.8	124
	Gasilida	2.20	2.3	8.2	4.5	37.9	106
	RWV 2409	2.00	1.7	9.9	4.2	39.3	124
	RWV 1129	2.09	2.0	6.3	4.1	58.8	86
	CAB 19	1.73	2.0	10.5	5.4	21.5	124
	Loc. Mbs	*1.17*	*2.3*	*5.4*	*4.0*	*31.7*	*129*
	CAB 2	0.92	1.5	3.9	4.1	44.6	95
	MEAN	2.32	2.3	8.9	4.6	38.1	108
	P value	*0.083*	*0.001*	*0.009*	*<0.001*	*<0.001*	*0.002*
	l.s.d.	*l.s.*	*1.4*	*6.8*	*1.3*	*7.4*	*39*
	%CV	*53*	*29*	*39*	*14*	*9*	*17*

Site	Variety	Yield (t/ha)	Plants /m²	Pods /plant	Seeds /pod	Seed wt (g/100)	Days to mat.
HOLARUA	*Loc. Leber*						
	Decelaya	0.37	1.0	20.0	3.9	50.0	84
	RWV 1348	0.47	5.5	6.0	5.2	27.0	92
	G 2331	0.21	5.5	4.4	3.2	25.9	85
	Umubano	0.32	4.5	5.3	5.6	22.2	90
	Mwirasi	0.32	3.5	6.8	3.8	38.0	85
	YOL X	0.10	4.5	2.5	3.3	32.1	94
	RWV 1002	0.16	2.0	7.3	4.3	23.7	86
	Loc.Turiscai	*0.27*	*5.8*	*5.4*	*3.7*	*25.4*	*82*
	MAC 28	0.16	3.5	6.8	4.2	52.9	85
	RWV 1892	0.08	0.5	12.0	3.6	32.1	96
	Hawinurare	0.34	3.0	9.5	3.9	36.8	91
	Vuninkingi	0.62	5.0	9.5	5.0	27.5	94
	Gasilida	0.18	1.5	6.0	5.1	47.3	84
	RWV 2409	0.15	6.0	1.6	4.0	45.6	86
	RWV 1129	0.32	5.0	3.1	4.1	47.4	86
	CAB 19	0.20	4.5	5.3	3.3	28.0	76
	Loc. Mbs	*0.31*	*5.5*	*5.6*	*4.0*	*28.2*	*93*
	CAB 2	0.08	3.5	2.3	4.0	27.4	98
	Loc. Same	*0.17*	*3.5*	*5.7*	*2.9*	*33.6*	*78*
	MEAN	0.25	3.9	6.6	4.1	34.3	88
	P value	*0.620*	*0.003*	*0.025*	*0.014*	*0.031*	*0.003*
	l.s.d.	*n.s.*	*2.7*	*7.5*	*1.3*	*18.4*	*10*
	%CV	*61*	*33*	*58*	*16*	*27*	*5*
OSSU	Decelaya	0.53	1.0	36.0	6.5	33.9	
	RWV 1348	0.48	5.5	12.7	4.3	19.0	
	G 2331	0.25	5.5	3.9	3.9	30.6	
	Umubano	1.10	4.5	14.7	8.4	28.0	
	Mwirasi	0.13	3.5	2.8	3.4	38.8	
	YOL X	0.29	4.5	4.0	3.4	42.9	
	RWV 1002	0.33	2.4	15.2	3.6	24.1	
	Loc.Turiscai	*0.54*	*6.0*	*5.0*	*5.2*	*33.3*	
	MAC 28	0.11	3.5	3.9	2.5	40.1	
	RWV 1892	0.39	1.2	13.7	4.5	38.0	
	Hawinurare	0.08	3.0	2.0	-	-	
	Vuninkingi	0.25	5.0	5.5	3.3	27.7	
	Gasilida	0.14	2.8	5.9	3.0	33.0	
	RWV 2409	0.05	6.0	2.8	1.4	25.2	
	RWV 1129	0.33	5.0	11.2	1.5	44.5	
	CAB 19	0.06	4.5	3.3	2.2	23.5	
	Loc. Mbs	*0.09*	*5.5*	*3.7*	*1.6*	*30.0*	
	CAB 2	0	3.5	0	-	-	
	MEAN	0.29	4.0	8.1	3.7	32.0	
	P value	*0.100*	*0.037*	*0.027*	*0.633*	*<0.001*	
	l.s.d.	*n.s.*	*3.0*	*15.2*	*n.s.*	*12.7*	
	%CV	*93*	*35*	*89*	*81*	*14*	

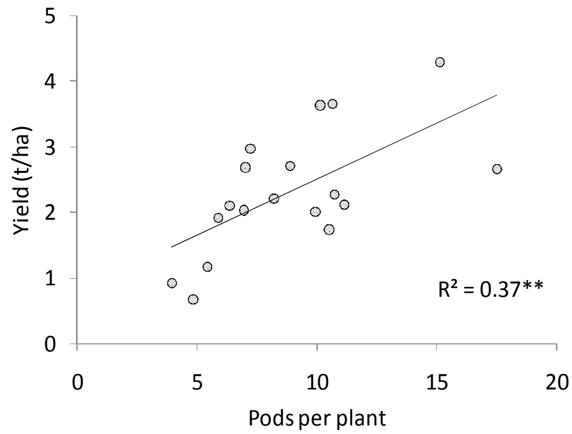


Figure 39. Correlation between yield and number of pods per plant, Maubisse, 2010

Days to maturity

The average number of days from planting to maturity was available for Lisalara, Maubisse and Holarua. The overall averages per variety (if tested in all three sites) are presented in Table 100.

Table 100. Days to maturity (predicted mean averages over 3 sites)

Variety	*Overall yield (t/ha)*	*Average days to maturity*
Loc. Turiscai	*0.37*	*75*
Decelaya	0.90	77
RWV 1129	0.69	88
Hawinurare	0.62	89
Umubano	0.83	90
Gasilida	0.64	94
CAB 2	0.25	96
G 2331	0.81	100
CAB 19	0.50	100
RWV 2409	0.58	100
Mwirasi	1.02	100
YOL X	0.85	103
Loc. Maubisse	*0.39*	*104*
RWV 1892	0.69	104
MAC 28	0.98	105
RWV 1002	0.79	105
Vuninkingi	0.75	109

No correlation was found between yield and maturity speed. Decelaya, which yielded among the best varieties, was also one of the quickest to reach maturity. The other high performing varieties were slower.

Conclusions

The results of these climbing bean trials installed during the 2009/10 wet season were encouraging. Despite the significant variation across sites, more than half of the test varieties were observed to perform better than the local checks. The highest yielding varieties were similar to the trials conducted during the 2008/2009 wet season and the poorest performing varieties confirming their low potential. The best varieties in 2009/10 were the varieties RWV 1348, Decelaya and Mwirasi with about +100% yield advantages over the local checks. Among the latter two varieties, Local Leber and Local Venilale Castro, did show some promise and will be further tested.

2.6.2 Climbing bean, multi-year and multi-location analysis

Materials and methods

Nine successful climbing bean variety trials (including 3 dry seasons) were implemented by SoL during 2009 and the wet season of 2010 at seven different sites (Maubisse, Turiscai, Venilale, Aileu, Lisalara, Ossu, Holarua), testing the performances of 23 varieties (including 7 locals). Some varieties were not included in all trials (in particular the recent local additions) and some trials were not conducted at every site every year.

The entire dataset comprised 155 data points, i.e. variety per environment combinations. An environment (here synonymous of trial) is defined by the site, year and season (for instance Maubisse dry season 2009, Ossu wet season 2010, etc). Half the data points were ANOVA predicted means from 2 replicates, the others were obtained from obervation trials (1 replicate).

Cross-site analyses were conducted using biplots (GGE BiPlot program) in order to evaluate the performances and consistency of the tested varieties across years and locations (genotype/environment). A limitation of the procedure is that only datasets with less than 5% missing data points could be analysed. In addition, datasets resulting in higher percentages of variance explained by the biplot principal components analysis were preferred.

Following those principles, the most extensive selection on which to run a biplot analysis included 12 varieties (exclusion of the locals) and all 9 environments. This dataset comprised 137 data points with 2 missing values (1.5%).

The existence and degree of correlation between the predicted means of the yields and other parameters for the nine sites (across two seasons) were identified using Simple Linear Regressions in Genstat Discovery 3. The percentage of variability accounted for was then equivalent to an adjusted R^2.

Results

The average yield of the entire dataset (9 environments, 155 data points) was 0.6 t/ha against 1.0 t/ha for the local checks alone (8 environments, 17 data points, i.e. 11% of the entire dataset). Yield averages from trial to trial varied from 0.13 t/ha to a maximum of 1.85 t/ha (Lisalara 2010 and Maubisse 2009 respectively). About half the sites performed within 0.25-0.53 t/ha.

Among the 23 varieties, 18 were tested 5 times or more. Their overall results are presented in Table 101.

Table 101. Climbing bean mean yields and yield advantages over 2009 and 2010

Variety	*Number of trials*	*St. dev*	*Mean yield (t/ha)*	*Yield advantages (%)**
MAC 28	9	1.71	1.28	30
Mwirasi	9	1.47	1.24	26
RWV 1348	8	1.31	1.19	21
Decelaya	9	1.03	1.01	3
RWV 2409	9	1.26	0.98	-1
YOL X	9	0.98	0.94	-4
Loc. Maubisse	*6*	*1.18*	*0.76*	*-22*
G 2331	9	0.80	0.74	-25
RWV 1002	9	0.91	0.73	-26
Gasilida	9	0.77	0.65	-34
RWV 1892	9	0.71	0.61	-38
Hawinurare	8	0.72	0.60	-39
Umubano	9	0.60	0.58	-41
Vuninkingi	9	0.64	0.56	-44
RWV 1129	9	0.65	0.55	-44
Loc. Turiscai	*6*	*0.47*	*0.54*	*-45*
CAB 2	9	0.71	0.51	-48
CAB 19	5	0.74	0.42	-58

* Calculated over the local varieties overall average = 0.98 t/ha, st.dev. = 1.12 (7 varieties representing 17 datapoints over 8 environments)

The imported varieties performed very differently with yield advantages ranging from +30 to -60% under or over the average of the locals. Excluding the varieties tested only once, the varieties which presented the highest overall yields were MAC 28, Mwirasi and RWV 1348 with about 1.2 t/ha on average. Decelaya, RWV 1348 and YOL Y performed average overall but still above the best and most extensively tested local variety (from Maubisse). The other introduced varieties performed poorly and will be discarded. Decelaya was the most consistant of the top yielding varieties.

Linear regressions were run over site average yields against site elevation, rainfall and average days to maturity. No correlation was found between the yields and the rainfall received by the trials. Otherwise, the correlation was found to be very strong and highly significant with the elevation (p=0.005 with adjusted R^2=0.6), and significant though to a lesser extent between yield and the number of days to maturity (Figure 40). Elevation and maturity speed were not found to be significantly correlated, however a trend can be observed. These results strongly suggest that the higher the site is located the longer the bean takes to mature and the higher the yields.

Figure 40. Correlations between yield and elevation/days to maturity, 2009-2010.

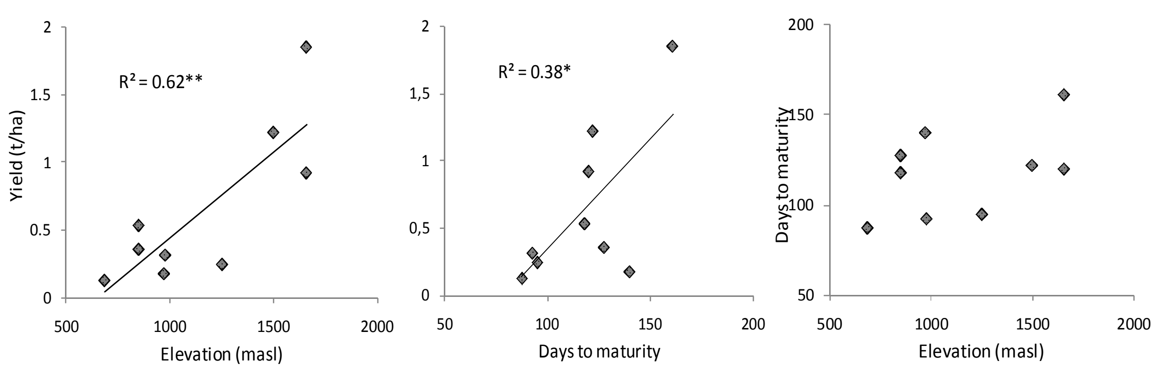


Figure 41 present the biplot resulting from the analysis of 12 varieties in all 9 environments. The biplot shows the variety's means stability (vector with two arrows) versus the environments (vector with one arrow), components which accounted for 55% of the variation encountered.

The varieties performances per environment differed significantly. Nevertheless, some similarities could be found between the two Venilale trials, the Ossu and Holarua ones, and, to a lesser extend, between the pair of dry season trials.

The variety which performed the best overall was RWV 1348, which yielded particularly well in both Venilale trials and in the Maubisse 2010 wet season trial. YOL X also performed well in the latter environment, and proved to be much more consistent across sites.

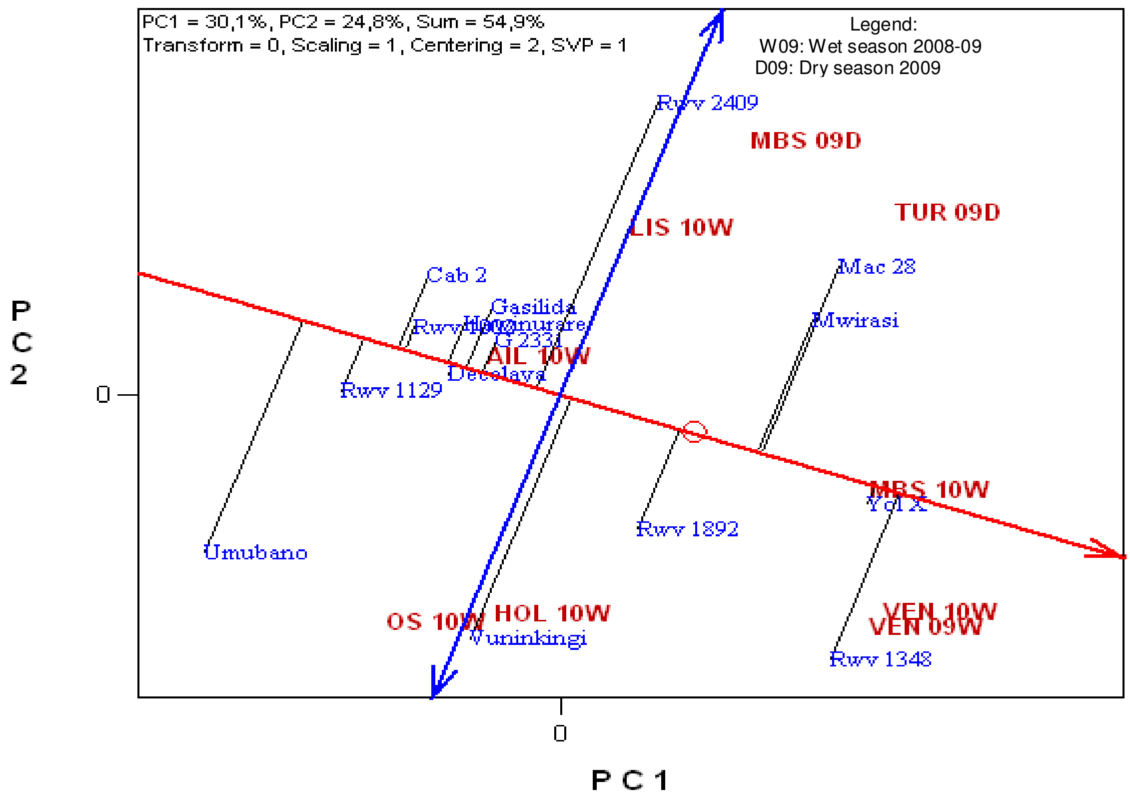


Figure 41. BiPlot analysis of 15 climbing bean varieties in 9 environments, 2009-2010

Conclusions

During the past two seasons, 9 successful varietal climbing bean trials were conducted on 23 varieties, representing a total of 155 individual data points (variety per environment combinations). Results varied significantly both by genotype (varieties) and environment (locations and years). There is evidence to indicate that elevation was a critical factor with climbing beans in higher elevation trials maturing later and had higher yields.

Even though variety performances were variable, the collected data allowed a first screening of number of varieties. The varieties which performed the best presented yield advantages of about 25% over locals. MAC 28, Mwirasi, RWV 1348, and Decelaya presenting the highest potential. The varieties which performed the poorest will be discarded in future trials and included varieties will undergo eating quality evaluations.

2.7 Temperate cereals

2.7.1 Wheat and barley replicated trials, 2009 and 2009/10

Replicated trials of wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgare* L.), were implemented for the first time by SoL during the dry season of 2009. Additional trials were conducted during the wet season of 2009-2010, mostly for disease screening purposes.

Wheat and barley (known locally as 'titboa' and 'aisnata' respectively, but both usually referred as 'trigo') are commonly grown in areas above 1600 masl in East Timor (about 5% of the country's area). They are mostly planted as dry season crops, alternating with maize which is grown during the wet season. Fields are planted in May in the last rains and harvested in August-September. Local varieties are about a meter tall and are probably descendants of Portuguese varieties. It is unknown when the most recent wheat or barley introductions were made.

Wheat and barley are eaten in a similar manner to maize. The grain is pounded to rice-size grit pieces and then boiled with green leafy vegetables and beans to be eaten as a thick porridge.

Materials and methods

The introduced wheat and barley varieties were sourced from Australia (Hermitage Research Centre, Warwick QLD and Australian Grain Technologies, Horsham VIC). Local varieties were from Maubisse (Table 102).

Table 102. Population details, replicated cereal trials, 2009-2010

Wheat varieties	*Barley varieties*
Barham	ND 22942
Yitpi	2ND 25454
Young	Bichy 2000
Yenda	2ND 25610
Janz	Grout
Livingston	Shepherd
Gladius	ND 19119-5-3
Chara	ND 23074
H46	ND 24519-1
Correl	ND 25316
Derrimut	Naked barley
Local Titboa Maubisse	2ND 25473
	Fitzroy
	Canela
	ND 24175
	Local Aisnata Maubisse

Note: Three varieties were discarded at the early stages of observation: Proctor (barley) and Silverstar (wheat) did not germinate, and Marembi (wheat) did not set grain. Marembi, a winter wheat, did not flower and remained vegetative throughout the testing periods. It was therefore concluded that spring wheat only should be tested for introduction and testing in Timor.

In 2009 and 2010, three replicated trials of each species were implemented in two sites (once in Rotutu, twice in Maubisse), with the addition of a demonstration plot for barley in a third location (Turiscai). 10 to 16 entries were tested.

Trials consisted of 3 replicates with complete randomized plots, each being about 1 to 2 m^2 with 6 or 7 rows. Rows were spaced at 15 cm and interrow spacing (two seeds per hill) by 7.5 cm. This corresponded to maximum plant densities of about 90 plants/m². With the exception of the barley dry season trial in Maubisse, the plots were not thinned. No fertilisation nor irrigation was applied in order to follow farmers' practices. Dry season trials were planted in May 2009 and harvested around August-September. Wet season trials were established during December 2009-March 2010 (Table 103).

Table 103.Planting and harvest details of cereal varietal trials, 2009 and 2010

	Location[a], harvest year	*Season*	*No of replicates/ entries*	*Planting date ('09)*	*Maturity & harvest period*	*Days to maturity*	*Rainfall (mm)[b]*	*Mean yield[c] (t/ha)*
WHEAT	Rotutu, 2009	Dry	3/10	23 May	Sept 09	100	n.a.	1.2
	Maubisse, 2009	Dry	3/12	25 May	Sept 09	115	0	1.1
	Maubisse, 2010	Wet	3/12	22 Dec	Mar-Apr 10	95	917	1.1
BARLEY	Turiscai, 2009	Dry	1/14	29 April	Aug-Sept 09	115	273	0.4
	Rotutu, 2009	Dry	3/16	23 May	Sept-Oct 09	100	n.a.	1.5
	Maubisse, 2009	Dry	3/16	13 May	Sept09	110	0	2.7
	Maubisse, 2010	Wet	3/16	22 Dec	Mar 10	95	917	1.2

[a] Rotutu (Manufahi): 1250 masl; Maubisse (Hohrae Kiik, Ainaro): 1660 masl; Turiscai (Matorek, Manufahi): 1160 masl
[b] Total rainfall from planting to maturity. In the Maubisse 2009 trial, the crops relied entirely on residual rainfall
[c] Yield of dry seeds after threshing

Yields and yield components

For the observation trial, only yields were recorded. For the replicated trials, at harvest, the number of tillers for three hills was first recorded, then three stems were used as samples to measure the length of the stem, ear, awn and total plant height. After this, the whole plot was harvested in order to obtain the fresh yield and the fresh stem weight. The plot production was recorded after drying and after threshing, to allow calculating moisture contents, threshing percentages and yields. Finally, the weight of seeds was obtained from a 100 random seed sample (dry, after threshing).

Disease and maturity speed

For the most recent replicated trial in Maubisse (2010 wet season), germination rates were evaluated two weeks after planting. Disease impact was evaluated after two to-three months. The date when 90% of the plot had reached maturity and could be harvested was also recorded to count the number of days to maturity.

The data of each trial were analysed separately using GenStat Discovery 3 or 2 for varietal effects. Depending on planting designs (regular or irregular grid) and on the presence of row and/or column effect in the yields, different tests were performed (Table 104)

Table 104.Statistical tests used in the analysis of the 2009 and 2010 cereal varietal trials

	Station	*Row/Col effects*	*Grid*	*Test*	*Type*
WHEAT	2009 Dry - Rotutu	Yes, Col	Irregular	REML	Power model (squared)
	2009 Dry - Maubisse	No	Regular	ANOVA	One-way in randomized blocks
	2010 Wet - Maubisse	No	Regular	ANOVA	One-way in randomized blocks
BARLEY	2009 Dry - Turiscai	-	-	-	Observation trial (one replicate)
	2009 Dry - Rotutu	No	Irregular	ANOVA	Unbalanced
	2009 Dry - Maubisse	Yes, both	Regular	REML	AR1 on Row & Col
	2010 Wet - Maubisse	No	Regular	ANOVA	One-way in randomized blocks

Yield advantages were calculated from the resulting predicted means over the average of the local varieties.

The existence and degree of correlation between the predicted means of the yields and of the other parameters were then identified using simple linear regressions. A first regression with

‘Trials’ as Groups (with ‘separate lines’ as the final model) was initially run over all the data to determine whether the regression slopes were significantly different from zero within each trial dataset (t tests on the parameters estimates). If it appeared to be so, individual regressions were then run on the corresponding trial data to determine whether the actual correlation was significant. The percentage of variability accounted for is then equivalent to an adjusted R^2.

Farmers’ preferences

In March 2010, farmers were invited to visit the trials in Maubisse. Seven participants (including one woman) were asked, before and during visiting the trials, which varieties of wheat and barley they liked most and why.

Results

General establishment was good and the trials encountered no major issues during growth. Bird predation occurred mostly during the dry season, just before harvest. Damage was limited, with the exception of the third replicate of the wheat trial in Maubisse (dry season) for which a few plots had to be excluded from the analysis. No other pest problem was recorded.

The wet season trials (Maubisse 2010) suffered from late overcast and rainy conditions. Most plots presented empty ears, especially in the barley trial. In wheat, grain filling also proved to be poor and rains at harvest resulted in a significant number of grains germinating on the ears prior to harvest (weathering).

Yields and yield advantages

The results of the trials are as shown is Table 105 and Table 106:

Table 105. Wheat yields and yield advantages, 2009 and 2009/10

	Yields (t/ha)			*Averages*			*Yield advantages (%) within site*		
Variety	*Rotutu 2009 Dry*	*Mbs 2009 Dry*	*Mbs 2010 Wet*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*Rotutu 2009 Dry*	*Mbs 2009 Dry*	*Mbs 2010 Wet*
Barham	-	1.1	1.6	0.4	1.3[a]	16	-	-2	45
Yitpi	1.2	1.3	1.4	0.1	1.3	16	7	15	26
Young	-	1.1	1.6	0.4	1.3[a]	14	-	-7	42
Derrimut	1.5	1.1	1.1	0.3	1.2	9	35	-5	-3
Gladius	1.5	0.6	1.4	0.5	1.2	5	37	-46	26
Loc. Titboa	*1.1*	*1.1*	*1.1*	*0.0*	*1.1*	*0*	*0*	*0*	*0*
Correll	1.6	1.1	0.6	0.5	1.1	-2	42	-4	-45
Livingstone	0.9	1.0	1.2	0.1	1.0	-10	-18	-16	5
H46	0.4	1.2	1.4	0.5	1.0	-11	-62	9	21
Janz	1.2	1.2	0.7	0.3	1.0	-12	5	2	-42
Chara	1.1	1.1	0.7	0.2	0.9	-18	-6	-7	-39
Yenda	1.5	0.9	0.4	0.5	0.9	-19	29	-24	-63
F prob	*<0.001*	*n.s.*	*0.004*						
l.s.d.	*0.5*	*-*	*0.6*						
*%CV / Walf/df**	*8.5**	*36.7*	*33.5*						
Mean site	1.2	1.1	1.1	0.1	1.1				

Notes: Mbs: Maubisse [a] Missing value replaced by site mean

Table 106. Barley yields and yield advantages, 2009 and 2009/10

Variety	*Yields (t/ha)*				*Averages*			*Yield advantages (%) within site*			
	Trc 2009 Dry	*Rtt 2009 Dry*	*Mbs 2009 Dry*	*Mbs 2010 Wet*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*Trc 2009 Dry*	*Rtt 2009 Dry*	*Mbs 2009 Dry*	*Mbs 2010 Wet*
Loc. Aisnata	-	*1.8*	*3.8*	*2.0*	*1.1*	*2.0*[a]	*0*	-	*0*	*0*	*0*
2ND 25316	0.6	2.3	3.6	1.2	1.3	1.9	-2	58	32	-6	-38
Shepherd	1.2	2.3	3.7	0.3	1.5	1.9	-6	203	28	-2	-85
ND 24519-1	0.6	1.9	2.7	1.6	0.9	1.7	-16	45	6	-30	-21
Bichy 2000	0.1	0.9	3.0	2.2	1.3	1.5	-22	-87	-49	-19	10
ND 24175	0.3	1.5	2.8	1.5	1.0	1.5	-22	-21	-14	-26	-24
ND 23074	0.1	1.7	2.5	1.8	1.0	1.5	-23	-74	-4	-33	-10
Fitzroy	0.7	1.9	3.0	0.4	1.2	1.5	-23	84	9	-20	-79
Grout	0.5	2.2	2.4	0.7	1.0	1.5	-27	32	26	-37	-64
Canela	0.0	0.9	2.6	2.0	1.2	1.4	-29	-89	-47	-30	0
2ND 25473	0.4	1.2	2.8	1.1	1.0	1.4	-29	5	-31	-25	-43
Naked barley	-	1.4	3.3	0.5	1.4	1.4[a]	-30	-	-21	-14	-74
2ND 25610	0.3	1.1	2.2	1.5	0.8	1.3	-36	-21	-36	-43	-26
ND 19119-5-3	0.1	1.8	1.9	1.3	0.8	1.3	-36	-74	2	-51	-36
2ND 25454	0.5	1.1	1.4	0.9	0.4	1.0	-51	32	-40	-62	-55
F prob		*0.001*	*0.001*	*0.011*							
l.s.d.		*0.8*	*1.6*	*1*							
*%CV / Walf/df**		*32.3*	*2.47**	*52.9*							
Mean site	0.4	1.5	2.7	1.2	1.0	1.5					

Notes: Rtt: Rotutu Mbs: Maubisse Trc: Turiscai (observation, yield advantage over site average)
[a] Missing value replaced by site mean

The overall yields were 1.1 t/ha for wheat and 1.5 t/ha for barley, with a much greater variation in the latter. The statistical tests revealed that the varieties yielded significantly differently at each site except in the Maubisse 2009 wheat trial. Maximum yields for wheat were 1.6 t/ha, while a third of the barley entries achieved yields between 2.0 and 3.8 t/ha.

Variety yields were fairly inconsistent across the trials. For barley, performance trends seemed to reverse between dry and wet season trials. Varieties which did well in previous dry season trials showed reduced tolerance to the conditions of the wet season which led to much weathering for wheat, to poor grain filling for barley, and to more diseases in general for both species.

Overall, the top yielding varieties for wheat were Barham, Yitpi and Young with 1.2 t/ha, which corresponded to overall yield advantages of about +20-+15% over the local check (which was remarkably consistent across trials). Derrimut and Gladius performed only slightly above the latter.

Among the 15 new varieties of barley tested, only two, Shepherd and 2ND 25316, performed about or as well as the local check with 1.9 t/ha. The local ‘Aisnata’ performed particularly well in the Maubisse trials. It yielded best in the 2009 dry season trial with 3.8 t/ha and second best in the 2010 wet season trial with 2.0 t/ha. Bichy 2000 and Canela, two varieties which were among the worst performers in the dry season trials, yielded the best, along with the local during the wet season.

For both species, moisture contents between fresh and dry ears were about 15% in the Rotutu and Maubisse dry season trials but reached 80% at harvest in the wet season reflecting the grain filling issues. Threshing percentages of dry species ranged between 65% and 80%.

Yield components

Table 107 and Table 108 detail the yield components which were recorded for wheat and barley respectively along with stem, ear and awn lengths.

Table 107. Yields and yield components, wheat, 2009 and 2009/10

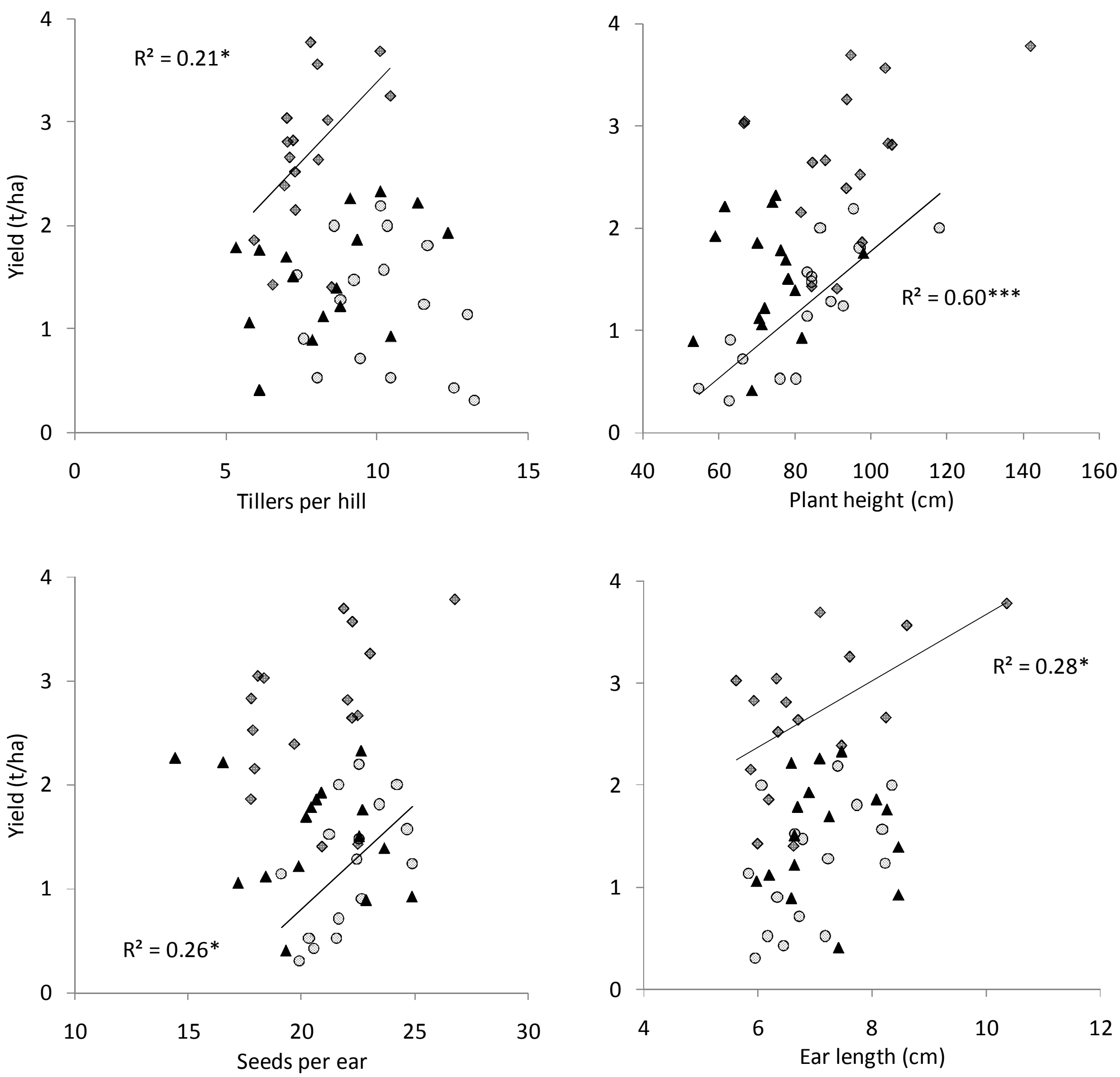
Trial	*Variety*	*Yield (t/ha)*	*No. tillers per hill*	*No. seeds per ear*	*Seed weight (g/100)*	*Stem fresh weight (t/ha)*	*Plant height (cm)*	*Stem length (cm)*	*Ear length (cm)*	*Awn length (cm)*
ROTUTU 2009 Dry	Barham									
	Young									
	Yitpi	1.2	5.6	25.0	4.3	1.5	66	54	5.9	6.7
	Derrimut	1.5	7.6	20.1	4.3	2.2	58	46	5.6	5.7
	Gladius	1.5	5.0	25.2	4.3	2.5	71	58	6.1	6.3
	Loc. Titboa	*1.1*	*6.0*	*25.6*	*4.0*	*1.7*	*76*	*67*	*8.3*	*0.8*
	Correll	1.6	3.3	28.2	4.2	1.8	72	59	7.0	6.6
	Livingston	0.9	6.1	28.0	3.9	1.3	62	49	6.2	6.1
	H46	0.4	4.3	27.0	3.9	1.5	56	46	5.1	5.1
	Janz	1.2	4.8	32.4	3.7	2.2	65	52	6.1	7.0
	Chara	1.1	8.0	29.1	4.4	2.6	69	55	6.6	7.6
	Yenda	1.5	5.5	33.9	4.3	1.3	68	54	6.7	7.0
	MEAN	1.2	5.6	27.5	4.1	1.9	66	54	6.4	5.9
	χ^2 prob	*<0.001*	*0.008*	*ns*	*ns*	*ns*	*0.004*	*0.003*	*<0.001*	*<0.001*
	lsd	*0.5*	*2.7*	*-*	*-*	*-*	*11*	*11*	*1.5*	*1.5*
	Walf/df	*8.5*	*2.5*	*1.5*	*0.9*	*1.2*	*2.7*	*2.8*	*4.2*	*9.4*
MAUBISSE 2009 Dry	Barham	1.1	3.7	27.7	4.8	1.8	68	60	6.4	1.9
	Young	1.1	3.0	27.0	4.4	2.0	62	52	4.2	5.7
	Yitpi	1.3	2.8	27.4	4.8	1.6	72	62	5.6	4.8
	Derrimut	1.1	3.7	30.2	4.4	1.9	69	58	4.8	6.2
	Gladius	0.6	2.4	21.1	5.0	1.7	74	63	4.6	6.1
	Loc. Titboa	*1.1*	*2.7*	*30.9*	*4.2*	*1.5*	*93*	*85*	*7.4*	*0.5*
	Correll	1.1	3.1	30.6	5.1	2.1	77	65	5.9	6.5
	Livingston	1.0	3.2	24.8	4.4	1.2	72	60	5.9	6.1
	H46	1.2	2.7	34.7	4.0	1.9	75	63	6.1	5.7
	Janz	1.2	3.4	29.9	3.9	2.2	76	64	4.8	6.8
	Chara	1.1	3.6	22.4	4.4	1.6	64	53	4.7	6.0
	Yenda	0.9	2.4	30.3	3.9	1.7	68	55	6.4	6.5
	MEAN	1.1	3.1	28.1	4.4	1.8	72	62	5.6	5.2
	F prob	*n.s.*	*n.s.*	*n.s.*	*<0.001*	*n.s.*	*0.010*	*<0.001*	*0.006*	*<0.001*
	lsd	*-*	*-*	*-*	*0.4*	*-*	*6*	*11*	*1.5*	*1.9*
	%CV	*36.7*	*32.5*	*32.1*	*5.4*	*37.2*	*10.6*	*10.9*	*16.2*	*21.5*
MAUBISSE 2010 Wet	Barham	1.6	6.8	12.1		8.5	69	59	6.1	4.0
	Young	1.6	6.9	15.3		7.3	70	59	5.9	5.7
	Yitpi	1.4	5.4	18.9		7.9	68	55	6.6	6.2
	Derrimut	1.1	7.6	20.6		5.5	64	53	7.6	3.8
	Gladius	1.4	8.3	9.0		6.0	58	49	5.9	3.6
	Loc. Titboa	*1.1*	*6.3*	*16.8*		*8.6*	*104*	*96*	*7.1*	*0.9*
	Correll	0.6	7.4	10.0		5.6	59	48	6.4	4.4
	Livingston	1.2	7.8	8.3		7.3	70	58	6.9	4.7
	H46	1.4	6.4	9.8		7.3	67	56	5.6	5.8
	Janz	0.7	5.3	15.3		4.9	59	49	5.4	4.6
	Chara	0.7	6.1	16.9		8.0	63	52	6.1	4.8
	Yenda	0.4	6.7	4.8		2.6	51	42	4.9	4.8
	MEAN	1.1	6.8	13.1		6.6	67	56	6.2	4.4
	F prob	*0.004*	*n.s.*	*0.037*		*0.013*	*<0.001*	*<0.001*	*0.003*	*<0.001*
	lsd	*0.6*	*-*	*9.1*		*3.0*	*7*	*7*	*1.1*	*1.2*
	%CV	*33.5*	*24.3*	*40.9*		*26.5*	*6.2*	*7.3*	*10.3*	*15.9*

Table 108. Yields and yield components, barley, 2009 and 2009/10

Trial	Variety	Yield (t/ha)	No. tillers per hill	No. seeds per ear	Seed weight (g/100)	Stem fresh weight (t/ha)	Plant height (cm)	Stem length (cm)	Ear length (cm)	Awn length (cm)
ROTUTU 2009 Dry	Shepherd	2.3	9.1	14.4		2.7	74	52	7.1	15.5
	2ND 25316	2.3	10.1	22.6		2.6	75	55	7.5	12.6
	Loc. Aisnata	*1.8*	*6.1*	*22.7*		*3.5*	*98*	*76*	*8.3*	*13.7*
	ND 24519-1	1.9	9.3	20.6		2.1	70	51	8.1	11.4
	Fitzroy	1.9	12.3	20.9		1.4	59	41	6.9	11.0
	Grout	2.2	11.3	16.5		2.4	62	41	6.6	14.0
	ND 24175	1.5	7.2	22.5		2.8	78	57	6.6	14.1
	2ND 25473	1.2	8.8	19.9		1.6	72	52	6.6	13.9
	ND 23074	1.7	7.0	20.2		2.3	78	57	7.2	13.8
	2ND 25454	1.1	5.8	17.2		1.8	71	54	6.0	11.4
	2ND 25610	1.1	8.2	18.4		1.6	71	53	6.2	11.6
	Naked barley	1.4	8.7	23.6		1.7	80	59	8.5	12.6
	Bichy 2000	0.9	7.9	22.8		1.0	53	35	6.6	12.1
	ND 19119-5-3	1.8	5.3	20.4		1.9	76	55	6.7	14.5
	Canela	0.9	10.4	24.9		1.4	82	60	8.5	13.0
	ND 22942	0.4	6.1	19.3		0.5	69	48	7.4	13.0
	MEAN	1.5	8.4	20.4		1.9	73.0	52.8	7.2	13.0
	F prob	*0.001*	*ns*	*0.029*		*0.004*	*<.001*	*<.001*	*0.046*	*0.007*
	lsd	*0.8*	*-*	*5.5*		*1.2*	*13*	*13*	*1.6*	*2.2*
	%CV	*32.3*	*35.5*	*15.4*		*36.0*	*10.5*	*14.1*	*13.3*	*10.0*
MAUBISSE 2009 Dry	Shepherd	3.7	10.1	21.9	5.1	5.4	95	71	7.1	16.4
	2ND 25316	3.6	8.0	22.2	5.6	7.2	104	82	8.6	13.7
	Loc. Aisnata	*3.8*	*7.8*	*26.7*	*4.7*	*9.0*	*142*	*116*	*10.4*	*16.3*
	ND 24519-1	2.7	7.1	22.5	6.0	6.8	88	69	8.2	11.8
	Fitzroy	3.0	8.4	18.4	5.1	4.7	67	50	5.6	10.6
	Grout	2.4	6.9	19.7	5.7	4.4	94	71	7.5	14.7
	ND 24175	2.8	7.0	22.0	6.3	9.5	106	84	6.5	15.0
	2ND 25473	2.8	7.2	17.8	6.3	8.3	105	84	5.9	15.1
	ND 23074	2.5	7.3	17.9	5.4	4.8	97	75	6.3	15.4
	2ND 25454	1.4	6.5	22.5	6.0	5.3	85	67	6.0	11.8
	2ND 25610	2.2	7.3	18.0	6.1	4.3	82	63	5.9	12.8
	Naked barley	3.3	10.4	23.0	4.5	5.2	94	75	7.6	11.5
	Bichy 2000	3.0	7.0	18.1	5.9	5.6	67	47	6.3	12.3
	ND 19119-5-3	1.9	5.9	17.8	6.1	6.7	98	78	6.2	12.8
	Canela	2.6	8.0	22.2	6.5	3.4	85	68	6.7	10.3
	ND 22942	1.4	8.5	20.9	6.4	3.4	91	72	6.6	13.6
	MEAN	2.7	7.7	20.7	5.7	5.9	93.6	73.1	7.0	13.4
	χ^2 prob	*0.001*	*ns*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
	lsd	*1.6*	*-*	*4.6*	*1*	*3.2*	*14*	*12*	*1.2*	*2.8*
	Walf/df	*2.5*	*1.0*	*2.9*	*5.3*	*3.9*	*15.0*	*14.5*	*10.4*	*4.6*
MAUBISSE 2010 Wet	Shepherd	0.3	13.2	19.9	2.8	7.1	63	46	5.9	10.4
	2ND 25316	1.2	11.6	24.9	4.4	9.3	93	74	8.2	11.1
	Loc. Aisnata	*2.0*	*10.3*	*24.2*	*3.2*	*12.1*	*118*	*98*	*8.3*	*11.4*
	ND 24519-1	1.6	10.2	24.7	3.8	7.4	83	64	8.2	11.6
	Fitzroy	0.4	12.6	20.6	2.3	2.9	55	40	6.4	8.8
	Grout	0.7	9.4	21.7	3.4	3.9	66	48	6.7	11.2
	ND 24175	1.5	7.3	21.2	4.8	9.8	84	68	6.6	10.3
	2ND 25473	1.1	13.0	19.1	4.3	8.8	83	65	5.8	12.1
	ND 23074	1.8	11.7	23.4	4.2	9.2	97	78	7.7	11.1
	2ND 25454	0.9	7.6	22.7	3.9	5.7	63	46	6.3	10.6
	2ND 25610	1.5	9.2	22.6	4.5	5.6	85	66	6.8	11.3
	Naked barley	0.5	10.4	21.6	3.0	6.6	80	63	7.2	10.3
	Bichy 2000	2.2	10.1	22.6	5.2	11.1	95	76	7.4	12.5
	ND 19119-5-3	1.3	8.8	22.4	4.8	7.4	90	69	7.2	13.5
	Canela	2.0	8.6	21.7	3.8	5.4	87	70	6.1	10.6
	ND 22942	0.5	8.0	20.3	3.8	6.3	76	60	6.2	10.6
	MEAN	1.2	10.1	22.1	3.9	7.4	82.4	64.4	6.9	11.1
	F prob	*0.011*	*n.s*	*n.s*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*n.s.*
	lsd	*1.1*	*-*	*-*	*1*	*3.7*	*11*	*10*	*1.1*	*-*
	%CV	*52.9*	*30.7*	*11.5*	*9.5*	*30.2*	*7.6*	*8.9*	*9.3*	*14.1*

Local and introduced varieties differed strikingly and significantly, the local 'Titboa' and 'Aisnata' being much taller (up to a meter tall, i.e. about 40% taller than the introduced varieties). This however did not result in more lodging. Local varieties also had slightly longer ears, but not necessarily more seeds per ear. Additionally, the local wheat awns were very short.

Significant correlations were only found in the Maubisse barley trials (Figure 42). Within the dry season trial, the yields proved to be correlated to both the number of tillers per hill and to the ear length. In the wet season trial, yields were correlated to the number of seeds per ear and to the plant height. Interestingly, yield and seed weight were correlated in both trials though in opposite directions. In the wet season trial, the varieties which performed the least well also had the lightest seeds (about 3g/100 seeds, against averages of 4-6 g/100), probably reflecting the difficulties for the grain to fill during the overcast conditions of the trial. The dry season trial showed an opposite trend, which might have been caused by the haying off, a phenomenon particular to cereals referring to their property of generating numerous grains if initial conditions are favourable (as they were in this trial), grains which might not be filled later.



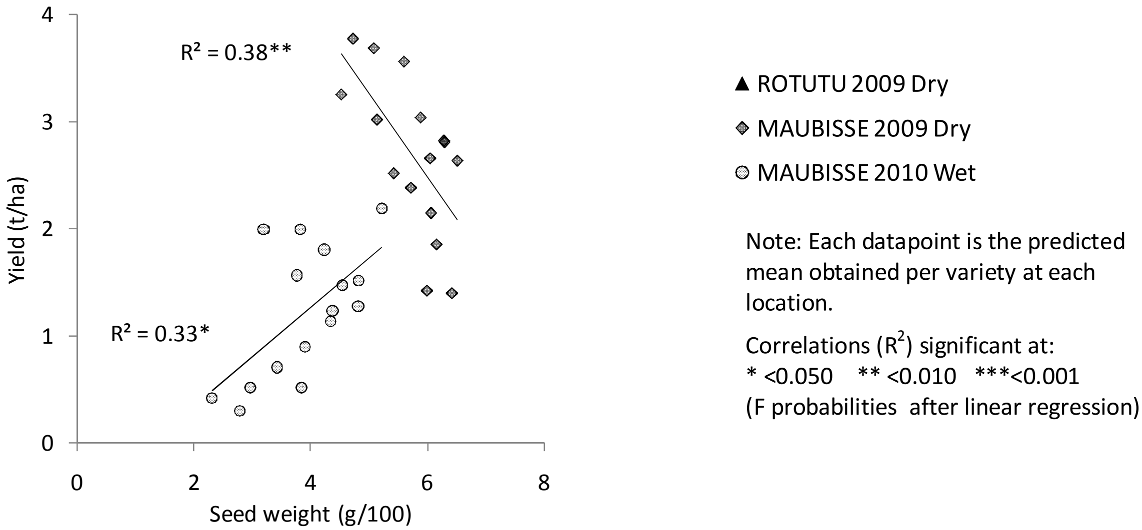


Figure 42. Correlations between yields and yield components, barley 2009 and 2009/10

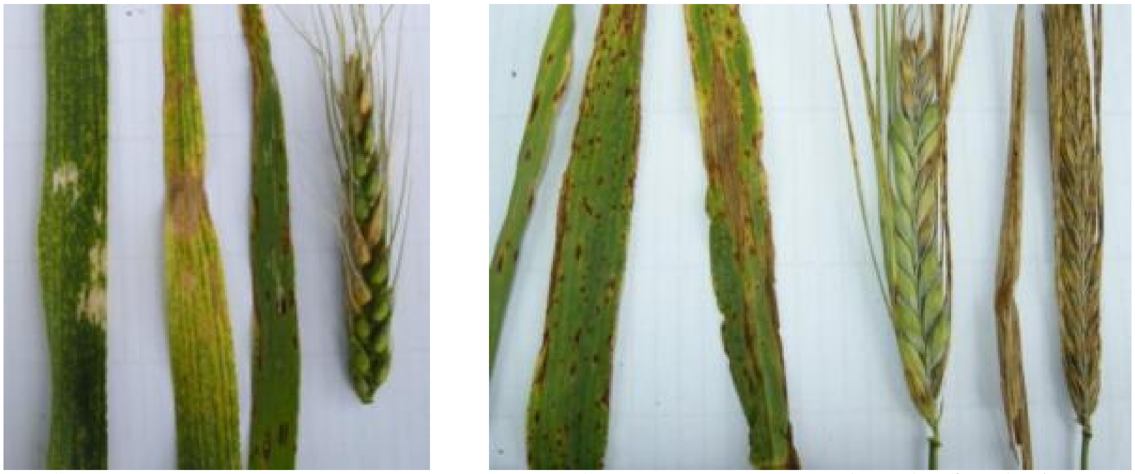
Maturity and disease impact

Additional parameters were recorded during the Maubisse wet season trials (Table 109). The germination rate of the barley varieties proved to be significantly different and to significantly impact yield (R^2=0.25, F pr.=0.030). The variety Shepherd, in particular, which did best in the dry season trials, had very poor plant stands in the wet season trial.

Table 109. Wheat and barley parameters, replicated trials 2009 and 2010

Site & season	*Wheat varieties*	*Germi-nation rate at 2 weeks (%)*	*Disease impact (min-max: 0-4)*	*No. of days to maturity*	*Barley varieties*	*Germi-nation rate at 2 weeks (%)*	*Disease impact (min-max: 0-4)*	*No. of days to maturity*
MAUBISSE 2010 Wet	Barham	72	1.3	95	Shepherd	37	3.2	93
	Young	72	0	95	2ND 25316	62	2.3	98
	Yitpi	65	1.3	95	*Loc. Aisnata*	*67*	*1.7*	*93*
	Derrimut	58	1.0	93	ND 24519-1	53	2.3	96
	Gladius	62	1.0	94	Fitzroy	35	1.7	95
	Loc. Titboa	*82*	*1.3*	*93*	Grout	63	2.7	88
	Correll	65	1.7	93	ND 24175	68	1.8	97
	Livingston	78	2.7	94	2ND 25473	43	2.7	97
	H46	72	0.5	94	ND 23074	47	3.0	97
	Janz	63	1.0	94	2ND 25454	55	2.2	96
	Chara	68	2.3	94	2ND 25610	72	2.7	93
	Yenda	62	4.0	93	Naked barley	50	3.7	95
					Bichy 2000	77	2.0	98
					ND 19119-5-3	40	1.5	100
					Canela	80	3.3	89
					ND 22942	*72*	*3.0*	*88*
	MEAN	68	1.5	94	MEAN	58	2.5	95
	F prob	*n.s.*	*<0.001*	*0.019*	*F prob*	*<0.001*	*0.003*	*0.001*
	lsd	*-*	*0.8*	*2*	*lsd*	*21*	*1.0*	*6*
	%CV	*17.1*	*32.7*	*1.0*	*%CV*	*21.9*	*25.0*	*3.5*

Disease symptoms were recorded at 10 weeks. Obvious differences were noticeable among varieties. Two symptoms were mostly visible. These were brown-black leaf spots and degenerated grains sometimes leading to the darkening and drying up of the whole ear. The latter particularly impacted the barley trial (Figure 43).



Wheat Barley 02/03/2010 (2.5 months after planting)

Figure 43. Disease symptoms on wheat and barley, Maubisse 2010 (wet season)

Preliminary observations led to the identification of fusarium head blight in the wheat (*Fusarium graminearum*) and possibly powdery mildew 0n the barley (*Blumeria graminis f.sp. hordei)*. No rust was observed. Even though general trends could be observed between disease impact and yields, particularly in wheat, no significant correlation was detected. The varieties which were the least impacted were Young and H46 in wheat and ND 19119-5-3, Fitzroy and the local check in barley.

Late maturing varieties with extended exposure to rain between flowering and maturing were more susceptible to damage. However, no significant statistical trend could be detected between the yields and the number of days to maturity.

Farmers' preferences

While visiting the trials, farmers showed a strong interest and enthusiasm to try new varieties. When asked what varieties they preferred and why, farmers immediately indicated the size of the ear as an important parameter for good results. Two other important criteria were resistance to disease and weathering tolerance. According to farmers, germination of the grain on the ear seems to be a relatively important issue and the main reason why farmers avoid planting cereals during the wet season. They mentioned that fast maturing varieties could reduce the problem.

Local varieties of cereals are more than a meter tall, which suggests a sensitivity to wind. However, farmers said that plant height was unimportant. Field observation confirmed that there was no particularly heavier lodging among local material. Compared to imported varieties, local wheat also had smaller or almost non existent awns. However, farmers said that longer awns were not an issue. Moreover, long awns may lead to less bird damage if the field can not be planted near a farmers house.

When asked what characteristics they value the most in cereals, farmers mentioned first the yield. Even tough eating qualities were said to be important too, no particular preference of a species taste over the other was expressed. Wheat was said to be more appreciated than barley rather because it is quicker to prepare as the husk does not remain attached to the grain. Nevertheless, farmers specified that they were equally willing to plant both species.

Conclusion

The first replicated trials of wheat and barley confirmed the potential for introduced varieties to increase the yield of temperate cereals in Timor-Leste highlands. However, of the two dozen new varieties, only a handful yielded more than the local checks, indicating the need for additional varieties to be imported and tested. A source of tropical barley would be an interesting lead. For wheat, the best performing varieties were Barham, Young and Yitpi with overall +20-15% yield advantages over the local check.

Farmers expressed their strong interest in new varieties to be trialled. Until 2010 there has been no suggestion of eating preference between the two species. The potential difference between varieties needs to be evaluated in the future, along with the time required for threshing, another important criterion.

Disease screening will be continued in the research as introduced varieties show obvious tolerance differences. Maturity speed should also be recorded as there is potential for the cultivation of fast maturing varieties, both for the wet season and for reducing weathering risks.

2.8 Potato

European potatoes (*Solanum tuberosum* L.) are often grown by farmers in cool environments in higher altitudes of Timor-Leste. Potatoes are a high value crop and have been a source of cash income for highland farmers for many years. They are often found for sale in local markets, or as chips in restaurant dishes. The crop does have production problems. For example, potato late blight (*Phytophthora infestans*), the same disease which caused the Irish famine around 1850, badly infected crops throughout East Timor between 2003 and 2005 and considerably reduced national production. The disease was a disaster for potato farmers because East Timor appeared to be free of this otherwise widespread disease until then.

During the wet season of 2009/10, a second preliminary trial on potatoes was conducted. The objectives were to a) select the most promising varieties, b) disease screening and c) planting material maintenance.

2.8.1 Potato observation trial, 2009/10

Material and methods

An observation trial (one replicate) of a range of potato varieties was implemented in Maubisse (Ainaro) during the 2009/10 wet season. Thirteen varieties were trialled. Two varieties were sourced from a local supermarket and eleven were from the CIP office in Bogor, Indonesia. Two of the varieties from Bogor (Tenggo and Berolina) had been extensively trialled in several locations in Indonesia and proved to be resistant to *Phytophthora*. The Tenggo variety was previously sourced from CIP and planted in Maubisse. This variety (Tenggo 1) was included as a control and kept separate from the newly sourced material (Tenggo 2).

Each variety was planted with 40 cm spacing between and within rows (a plant density of 6.25 plants/m²) in one or two rows depending on the quantities of available planting material. The number of hills per variety ranged from 5 to 63. Yields were calculated from the resulting plot areas (1 to 10 m^2). Planting and harvesting details are detailed in Table 110.

Table 110. Planting and harvest details of the potato observation trial, 2010

Trial location and altitude	*No. of entries*	*No. of reps*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)*
Maubisse (Ainaro) 1 660 m	14*	1	16 Dec 2009	31 March 2010	100	1 045

*13 varieties with two Tenggo generations kept apart. No adequate local tubers could be found at planting time.

Disease impact was evaluated by recording the number of plants badly infected (wilted and spotted leaves) or dead from disease at 2 weeks after planting, at 2.5 months and at harvest. At harvest tuber numbers and weight were also recorded, with distinction between edible and damaged tubers. From those data, number of tubers per plant and the weight of 10 tubers were then calculated.

GenStat Discovery 3 was used to determine correlations (Simple Linear Regression).

Results

The two varieties sourced from a local supermarket germinated well. They died prematurely from disease after a few weeks with no yield at all but in doing so acted as disease spreaders to ensure and even infection across the trial. They were discarded from teh analysis. The average yield for the 12 other entries was 7.3 t/ha (6.7 t/ha in 2009). Yields ranged again from 2 to 15 t/ha (Table 111), also similar to 2009. Germination was improved over the previous year (80% on average) and despite the high impact of disease, 90% of the plants gave tubers, more than 90% of which were edible.

Table 111. Potato varietal observation trial, Maubisse, wet season 2010

Variety	*Code*	*Number of planted hills*	*Plant density at harvest, per m²*	*Number of tubers / plant*	*Weight of 10 tubers (kg)*	*Yield* (t/ha)*
Berolina	EB	12	4.7	6.9	0.5	14.7
Tenggo 1	ET1	33	6.1	4.9	0.4	11.5
393371.6	E05	23	3.5	5.3	0.5	9.6
396034.1	E02	43	4.5	5.8	0.3	8.9
395195.7	E03	29	5.2	4.6	0.3	7.8
390043.4	E07	63	5.3	4.2	0.4	7.7
39184.5	E01	46	3.0	6.4	0.4	7.5
391004.2	E08	23	5.2	3.8	0.3	6.3
39602.13	E14	5	5.0	2.8	0.4	5.3
Tenggo 2	ET2	23	4.9	3.5	0.2	3.5
393280.6	E10	7	2.7	2.3	0.4	2.7
391058.2	E09	10	4.4	2.4	0.2	2.0
	Averages	26	4.5	4.4	0.4	7.3
	S.E.	18	1.0	1.5	0.1	3.7

* including damaged tubers inedible but fit for animals consumption (10% of the total yield on average)

The best performing varieties were Berolina and Tenggo 1. Berolina was less affected by disease, with plants appearing significantly healthier than all other varieties.

No correlation between plant stand and production was identified. However, strong and significant correlations were found between the yield and the yield components, particularly with the number of tubers per plant as shown in Figure 44.

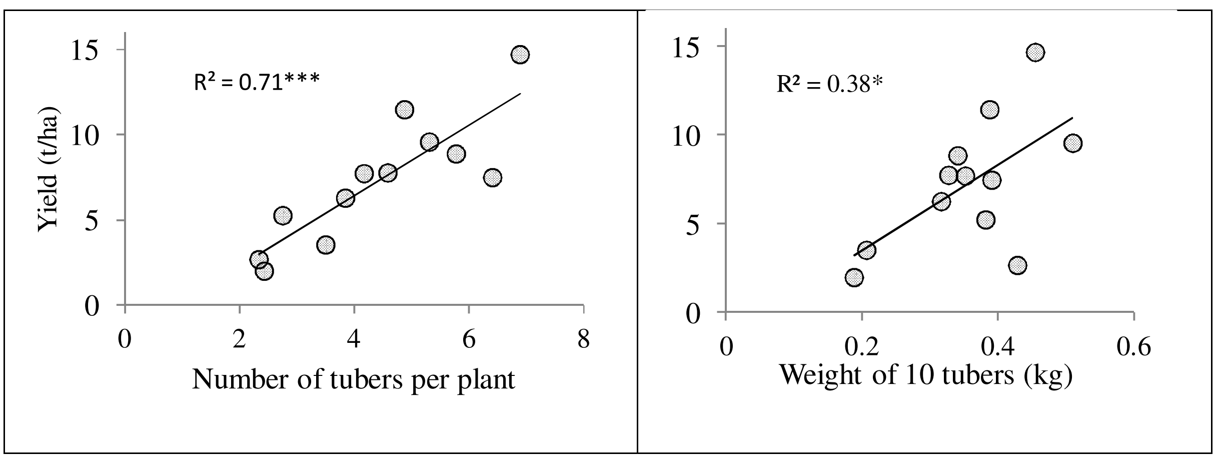


Figure 44. Correlation between yield and yield components, 2009/10

Diseases incidence was recorded at 10 weeks. Obvious differences in disease inpact were noticeable among varieties. Two symptoms were mostly visible in a similar manner to 2009. These were wilted and yellowing-spotted leaves (Figure 45). Preliminary observations led to believe those symptoms were due to potato late blight (*Phytophthora infestans*) and bacterial wilt (*Ralstonia solanacearum*). Both are serious diseases of potato.

Yellowing leaves with brown spots
(2.5 months after planting)

Wilted leaves and dying plant

Figure 45. Disease symptoms on potato, Maubisse 2010

No correlation was found between the percentage of diseased plants and production nor with plant stand at harvest. Nevertheless, differences in infection timing and scope where noticeable between varieties (Figure 46). The highest yielding varieties, Berolina, Tenggo 1 and E02, were impacted relatively late by disease as opposed to Tenggo 2, which was damaged very early and yielded poorly.

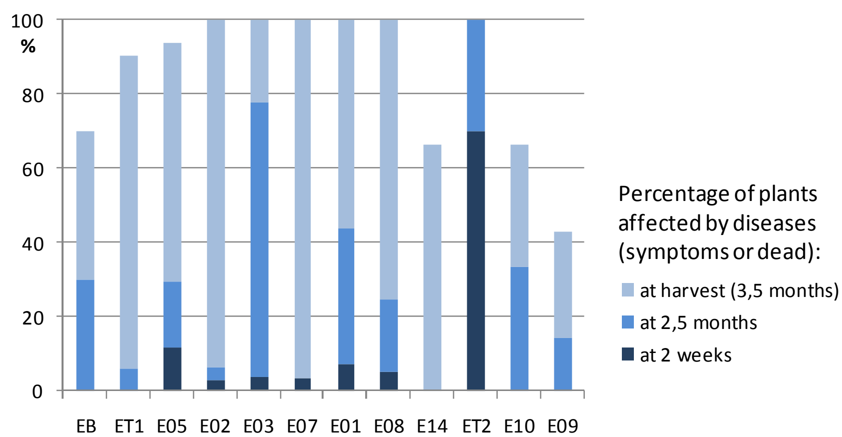


Figure 46. Timing and % of diseased potato plants 2009/10

Conclusions

This second preliminary trial provided additional information and experience with the test varieties. In future, the trials will be closely monitored to ensure there are consistent plant populations. Differences in disease tolerance will also be recorded as this characteristic is strongly valued by farmers.

At the end of the 2009/10 wet season, sufficient seed material was available for replicated trials. A concern with European potato is the difficulty of conserving the planting material as tubers tend to rot easily even in cool and ventilated areas. Damage from rats is also frequent in Timor-Leste. As a consequence, the best way to conserve germplasm material is to plant it. Trials will therefore be implemented continuously.

2.8.2 Potato observation trials, multi-years, 2009 and 2010

Two observation trials (one replicate) of a range of potato varieties were implemented in Maubisse (Ainaro) in the dry season of 2009 and during the wet one of 2009/10. The overall results are presented in Table 112:

Table 112. Potato varietal observation trials results, Maubisse 2009 and 2009/10

Variety	*Code*	*Yields (t/ha)*		*Averages*			*Yield advantages (%) over mean site*	
		2009 Dry	*2010 Wet*	*St. dev.*	*Yield (t/ha)*	*Yield adv. (%)*	*2009 Dry*	*2010 Wet*
390043.37	E07	14.1	7.7	4.5	10.9	60	110	6
396034.13	E02	12.9	8.9	2.9	10.9	60	93	22
39184.5	E01	12.3	7.5	3.4	9.9	45	83	3
Tenggo 1	ET1	7.1	11.5	3.1	9.3	36	5	58
Berolina	EB	3.5	14.7	7.9	9.1	33	-48	102
393371.58	E05	7.3	9.6	1.6	8.4	24	9	32
395195.7	E03	5.8	7.8	1.4	6.8	0	-13	7
391004.18	E08	5.1	6.3	0.9	5.7	-17	-24	-14
Tenggo 2	ET2	5.7	3.5	1.5	4.6	-33	-16	-51
396031.108	E14	3.4	5.3	1.3	4.3	-37	-49	-28
391058.173	E09	6.3	2.0	3.0	4.1	-40	-7	-73
393077.159	E04	2.8		-	2.8	-59	-58	
393280.64	E10	1.1	2.7	1.1	1.9	-72	-84	-63
	Mean site	6.7	7.3	2.0	6.8			

The most promising varieties appear to be E07, E02, E01, E05, Tenggo1 and Berolina. Those two varieties performed particularly well in the second trial, where the results are more reliable due to the fact that more hills were planted and plant stands were significantly better than in the first trial.

Varieties which performed poorly in consecutive trials were discarded from further trials.

Conclusions

The two potato observational trials conducted in Maubisse allowed the multiplication of enough planting material to implement replicated trials. These will include a comparison with local varieties. The trials also provided sufficient information to discard some varieties in order to focus on the more promising entries. The top 7 varieties yielded about +60% to +25 % more than an average of the entries.

3. Seed production and distribution

Introduction

The supply of quality seed of superior food crop varieties is a key determining factor for a successful agriculture sector. This chapter describes the seed production activities in the Seeds of Life program as follow up to the release of nine superior crop varieties. Seven of these varieties (two maize, three sweet potato, one rice and one peanut) were released in 2007 and two cassava varieties in 2009. The seed production and distribution program in SoL was established to ensure that the seed industry operates efficiently and effectively resulting in quality seed being delivered to the farmers.

For the past two years, SoL has produced increasing amounts of quality seed for distribution to farmers through structured distribution channels established by a) MAF, b) NGOs and other organizations, c) the establishment of On-Farm Demonstration and Trials (OFDT) and d) by directly assisting progressive farmers. These activities can be considered as initial implementation of a seed program in Timor-Leste.

Development of human resources conversant with seed technology and the provision of basic seed processing facilities are basic prerequisites to the development of a viable seed industry. In the year from Sept 2009–August 2010, the program conducted training on basic seed skills for seeds officers, policy makers and seed growers. These skills will assist the nation to produce quality seed based on rules stated by the International Seed Testing Association (ISTA).

Capacity building for seed production

The seed production program has seven seed officers working in 6 districts (Aileu, Baucau, Bobonaro, Liquica, Manufahi, and Viqueque) to produce commercial seed. The seed officers are supported by one seed researcher based at Betano research station who maintains higher seed classes such as nucleus, breeder, and foundation seed.

Basic seed production training during 2009-2010 inlcuded a) basic rice seed production, b) basic seed handling and storage, c) basic seed processing, and d) basic maize and peanut seed production. In 2009/2010, the seed officers implemented the basic rules of seed production they learned from this training and attended further similar, but more advanced courses to supplement their knowledge. In addition the seed officer acted as trainers for coursed provided to seed growers. Four hundred and ten person training days were provided during the year.

Seed production of rice, maize, and peanut seed

Seed was produced in the six districts (Aileu, Baucau, Bobonaro, Manufahi, Liquica and Viqueque) where the seed officers were based.

Seed officers started their activities by selecting seed growers in their district. In general, there were several aspects to be considered during selection of seed production areas and seed growers. Ideally, a seed grower should be either a progressive farmer or be within a progressive farmer group. The seed production area should at least 3-5ha in fields located close to important infrastructure (main roads, irrigation, drying floor, warehouse, etc). Seed officers commenced the selection of seed growers and seed production fields 1–2 months before the start of the season.

Approximately 49 ha of rice fields, 45 ha of maize fields and 30 ha of peanut fields were identified for seed production during 2009-2010 (Table 113). Not all of the contracted fields were able to produce seed during the season. Failures were attributed to poor cultivation resulting in excessive of weeds, natural disasters such as drought or pest and disease attacks. Seed officers also often rejected crops because they may have possessed a) a high percentage of off types in the field, b) there was too high a percentage of other varieties in the seed lot, c) the germination rates of the seed lots were too low, d) there was a high percentage of diseased seed or e) there were other reasons to believe that the seed lot would perform poorly.

Table 113. Seed production area and seed grower number, 2009/2010

	Contracted area (ha)/variety			*No of contracted seed growers**		
District	*Nakroma*	*Sele*	*Utamua*	*Nakroma*	*Sele*	*Utamua*
Aileu	5.0	5.2	0.0	4	4	0
Baucau B	6.5	5.0	8.0	3	1	5
Baucau O	9.0	1.0	6.7	1	1	4
Bobonaro	5.0	10.0	4.0	3	4	4
Liquica	10.4	3.2	5.5	8	8	19
Manufahi	8.0	11.3	4.0	4	6	5
Viqueque	5.0	9.0	1.8	5	4	4
Total	*48.9*	*44.7*	*30.0*	*28*	*28*	*41*

Note: * contracted seed grower can be an individual farmer or a group

Seed produced during the year amounted to approximately 55.7 tons of Nakroma, 38.8 tons of Sele and 22 tons of Utamua. (Table 114)

Table 114. Seed production of Nakroma, Sele and Utamua (2009/2010)

District	*Rice-Nakroma (kg)*	*Maize-Sele (kg)*	*Peanut-Utamua (kg)*
Aileu	5012	3347	0.0
Baucau	28095	2970	14595
Bobonaro	8564	5820	5034
Liquica	0	1399	643
Manufahi	8473	18827	1865
Viqueque	5526	6434	274
Total	*55670*	*38797*	*22411*

Seed distribution

Seed harvested during 2008/2009 was distributed to support SoL research, OFDTs and seed production, MAF activities and to support NGOs. About 53 t of Nakroma, 16 t of Utamua and 15 ton of Sele seed were distributed the Sept 09–August 2010 period (Table 115).

Table 115. Summary of seed distribution (2009-2010)

Commodity/variety	*NGO (ton)*	*MAF* (ton)*	*Total (ton)*
Rice/Nakroma seed	4.6 (8.8%)	48.1 (91.2%)	52.7
Peanut/ Utamua seed	5.2 (32.5%)	10.8 (67.5%)	16.0
Maize/Sele seed	5.0 (33.2%)	10.1 (66.8)	15.1
Total distributed seed	*17.8 (21.2%)*	*69.0 (82.3%)*	*83.8*

Note: *MAF inclusive MAF-SoL

The National Directorate of Agriculture and Horticulture (DNAH) approved all seed disbursals. Requests for seed were directed to by letter to DNAH director with a copy to SoL team leader. Once approved, an “approved seed request” (ASR form) was issued by MAF-DNAH. The seed applicant was then able to collect seed from seed warehouses mentioned in the ASR form. Seed was only issued to persons who had the ASR form in-hand. The variety name, seed class, seed quantity, seed warehouse where the seed should be collected, and contact person/seed officer name were clearly mentioned in the ASR form.

After seed delivery, a receipt (delivery order form/DO form) indicating variety, quantity, delivery date, and seed condition at delivery time was issued by the seed officer. The DO form was in triplicate, the original went to the consumer, and the others archived.

Seed distribution needs special effort and attention. The right amount of correct quality seed should be delivered to the correct farmer at the right time and seed channeling is one of the critical paths in all seed programs. With SoL, most of the maize, peanut and rice seed (82.3%) was channeled through MAF (including MAF-SoL and FAO) and 21.2 % was channeled through NGOs (Table 115). A list of the main SoL seed recipients is presented in Table 116.

Table 116. Recipient institutions of distributed seed (2009-2010).

Institution	Purpose
NGO Cailalo-Baucau	Farmers
NGO Care International	Farmers at Bobonaro and Suai
NGO World Vision	Farmers at Baucau and Bobonaro
NGO Child Fund	Farmers at Manatuto
NGO Susu Been	Farmers
FAO	Farmers
Cooperation de Portuguese at Liquica	Farmers
GTZ	Farmers
UNTL	Students
NGO CTID Madre Canossa Baucau	Farmer
NGO OXFARM	Farmer
NGO Charli, Viqueque	Farmer

Production and distribution of sweet potato and cassava stem cuttings.

Sweet potato

Three sweet potato varieties, Hohrae 1, Hohrae2, and Hohrae 3, released in 2007 were multiplied in the districts of Manufahi, Aileu, Viqueque, Liquica, Bobonaro and Baucau during 2009/2010. Approximately 0.8 ha of sweet potato seed bed was under production (Table 117) during this period.

Sweetpotato is propagated vegetatively. Therefore, once the farmer has planting material he is able to multiply it true to type each year. Most Timor-Leste farmers cultivate sweet potato on a small scale for their own purposes. Some farmers with good access to markets grow larger areas for sale and it is reported that one farmer in Baucau, has been planting Hohrae sweetpotato varieties in a large scale farm (>1ha) for commercial purposes. The success of commercial sweet potato farmers has been reported elsewhere (SoL, 2010).

The program was designed to produce about 512,000 sweet potato cuttings which are enough to cover 12.8 ha of farmers fields (about 0.35% of Timor-Leste sweetpotato fields). Unfortunately, only about 43,500 cuttings were distributed from Sept 09 – Aug 2010. This is enough for one ha of sweetpotato field (Table 117). Cuttings were distributed through MAF (60%) and NGOs (40%). Logistical problems limited its distribution.

Table 117. Sweet potato and cassava seed cutting production, 2009-2010

District	Sweetpotato Area (m^2)	Sweetpotato No. distributed stem cuttings	Cassava Area (ha)	Cassava No. distributed stem cuttings
Aileu	200	0	0	0
Baucau	200	32025	0	0
Bobonaro	200	5250	1	0
Liquica	100	1200	1	0
Manufahi	100	4960	1*	29798*
Viqueque	0	0	0	0
TOTAL	*8000*	*43435*	*3*	*29798*

Note: * = From Betano research station

Cassava

In August 2009, the MAF released Ca 15 and Ca 26 as two new cassava varieties named Ai Luka 2 and Ai Luka 4. Both varieties were introduced by CIAT to Timor-Leste in 2001. Fields for stem cutting production of Ailuka were established in 3 districts (Betano, Liquica and Bobonaro) each of 1 ha. Multiplication fields were established on August 09, December 09 and December 2008 at Loes (Liquica), Corluli (Bobonaro), and Betano (Manufahi) respectively. About 480,000 cassava stem cuttings will be available from these fields for the 2010/2011 planting season. Until these crops become available, only small amounts of cassava stem cuttings can be distributed. In 2009/2010, SoL distributed about 29,798 cassava stem cutting (Table 117). Most of them were allocated for the MAF-SoL program (93%) and some for NGOs (7%).

Percentage of distributed SoL variety seed to the national seed requirement

Assuming seed rates of rice at 25 kg/ha, maize at 20 kg/ha, and peanut at 200 kg/ha, the amount of seed distributed in 2009/2010 was sufficient to cover about 2,108 ha of rice paddy, 755 ha of maize field, and 80 ha of peanut field. Given that the total planted area of rice, corn, and peanut in Timor-Leste is 37,297 ha, 77,613 ha and 1,213 ha respectively (MAF Crop division, 2008) more than 5 % of the national rice and peanut seed requirements could be supplied by the 2009/2010 SoL program (Table 118). Detailed percentages of distributed seed 2009/2010 to the national seed requirement is presented in Table 118.

Table 118. Distributed SoL seed as % of national seed requirement (2009-2010)

Crop/variety	*Est. current planted area (ha)*	*Seed rates (/ha)*	*National seed requirement*	*Distributed seed 2009/2010*	*% of national requirement*
Rice/Nakroma	37,297	25 kg	932 t	52.7 t	5.6
Maize/Sele	77,613	20 kg	1552 t	15.1 t	1.0
Peanut/Utamua	1,213	200 kg	242 t	16.0 t	6.6
Sweetpotato/Hohrae 1, 2 and 3	3,615	40,000	145 mill	43,435 cuttings	0.02
Cassava/ Ailuka 2 and 4	10,043	10,000	100 mill	29,798 cuttings	0.03

*= stem cutting

Seed processing and storage facilities

The establishment of efficient seed processing and storage facilities plays an important role in the operation of a viable seed program. Effective processing facilities can ensure an output of a high percentage of pure live seed by reducing the number of seed impurities, cracked, empty, and diseased seed. With high quality storage there is an opportunity to produce high volumes of seed and for its viability to be maintained for longer periods. In 2010, not all districts in Timor-Leste had adequate seed processing and warehouse facilities. Serviceable warehouse facilities were available in Manufahi, Baucau, and Maliana. Those at Manufahi and Baucau were equipped with Batch driers (3 ton capacity) and air screen cleaners (capacity of cleaning 300 - 400 kg seed/hour). To improve seed processing efficiency, seed growers were encouraged to dry and clean their harvested seed before sending it to the seed centre. In 2009-2010, five additional 2000 l silos were allocated to Betano and five 1000 l of silos for the Aileu warehouse. Two additional plastic sealers were allocated to Liquica and Viqueque (each one plastic sealer). Three corn and rice threshers were allocated each to Bobonaro, Liquica and Viqueque. Details of the storage and processing equipments available in each seed warehouse district are presented in Table 120.

Table 119. Seed storage and seed processing facilities in the six districts, 2010

District	*Warehouse*	*200 l silo*	*1000 l silo*	*ASC*	*Batch dryer*	*Thresher*	*Plastic sealer*	*Seed moisture meter*	*Germinator*	*Seed divider*
Aileu	Not available	0	5	0	0	0	0	1	0	0
Baucau	Triloka R/S	28	3	1	1	1	1	2	0	0
Bobonaro	Not available	13	2	0	0	1	0	1	0	0
Liquica	Not available	1	8	0	0	1	1	1	0	0
Manufahi	Betano RS	8 + 5	6	2	1	0	1	2	2	1
Viqueque	MAF warehouse	10	0	0	0	1	1		0	0
Total	*2*	*65*	*19*	*3*	*1*	*4*	*4*	*7*	*2*	*1*

ASC Air Screen Cleaner; RS Research Station

SoL seed production over three years (2008 to 2010).

Rice seed production in 2008, 2009, and 2010 was 8.9t, 62.8t, and 54.t respectively (Table 120). The long rainy season in 2010 reduced drying time, resulting in poor quality seed being offered by a number of farmers. As an example, all of one seed growers production of 7t was rejected due to low germination rates because the harvest could not be dried fast enough. The installation of more batch dryers in seed warehouses may reduce this problem in the future.

Table 120. Seed production over time

	Seed production (t)		
Commodity	2008	2009	2010
Rice (Nakroma)	8.9	62.8	55.7
Maize (mainly Sele)	14.8	26.0	38.8
Peanuts (Utamua)	4.8	17.7	22.4

Both SoL maize and peanut seed production has increased each year since the commencement of the program in 2008. Increasing the number of trained seed officers, intensive guidance and an improvement in the seed processing-storage facilities are the key to the success of the program. In 2008 only one seed officer was assigned to the program and this number was increased in 2009. In 2010 there were seven seed officers assigned to work six districts and one seed researcher assigned in Betano research station. Two new seed storage facilities have also been installed since 2008. The number and quality of facilities plus the number of seed officers is projected to increase in the future to cater for an increase in demand for SoL seed.

4. Farming systems research

4.1 Agricultural calendars for the districts of Timor-Leste

Introduction

Calendars describing the agricultural practices in the districts of Timor-Leste were first prepared by the SoL team in 2006-2007. These calendars were part of a larger study aimed to provide baseline information on farmers' practices. The calendars were published by the MAF and SoL in 2010 as a tool for the extension of SoL/MAF varieties and for general dissemination of agricultural information.

This chapter gives a summary of the methodology used to collect the data used to produce the agricultural calendars, a few examples of which, for SoL research sites, are presented thereafter. Additional information can be found in the original 2007 report titled "Farmers' practices in East-Timor: a socio-economic study".

Methodology

Data were gathered between April 2006 and March 2007 in seventeen villages across eight sub-districts (four districts). Respondents in each district were identified to represent the varied elevation, soil types, slope, orientation and the consequent broad range of cultivation practices.

Respondents comprised OFDT participating farmers who were prominent 'figures' in their own communities. For example, they were village or hamlet head, catechist, teacher, or elder presiding over ritual activities and customary law. Local figures were chosen as respondents with the rationale that their community activities would provide wider knowledge of local patterns of cultivation and production constraints. Many interviews were not 'one on one', but included the respondent, adult members of their own household, extended family members living in households nearby, and neighbours. Interviews often resembled a focus group discussion with participants disputing, elaborating and clarifying each other's responses. On average, nine visits were made to each farmer household with interviews between 1.5 and 3 hours in length (representing approximately a total of 150 visits).

The data represented in the agricultural calendars format had been intended as a planning tool for SoL researchers, MAF field staff, and NGOs involved in agricultural extension work in Timor-Leste. The posters allow users to immediately determine cultivation activities (for both first and second season planting), and associated weather patterns, for any sites at any time during the calendar year. While the arrival and end of the wet season can only be represented as static in a calendar format, data on planting signals have been incorporated into the calendar for each commodity in each place. Rather than being attached to calendar time, these signs are attached to dynamic weather events. For example, a signal for planting peanuts could be: 'plant after heavy rain has fallen for three days and soaked the ground well' rather than 'the first week of November'.

Results

Two calendar sets have been produced. The first calendar set is a classic agriculture calendar showing the timing of all major cultivation activities (SoL commodities and other cash crops such as coffee or mung beans), and non-cultivation agricultural activities such as building fences, garden shelters, and mats for drying food, as well as timing of religious rituals associated with cultivation, for each of the 17 villages where research was conducted. The village is the ‘axis’ of this first type of calendar. The following pages present the calendars for the closest villages from SoL research sites, as detailed in Table 121:

Table 121. Agricultural calendars corresponding to SoL research stations/sites

District, Sub-District	*Research station/site*	*Village calendar*	*Figure*	*AEZ*	*Elevation (masl)*
Liquiça, Maubara	Loes	Guguleur	Figure 48	1	80
Baucau, Baucau-Villa	Fatumaka	Gariwai	Figure 49	1	680
Aileu, Aileu-Villa	Aileu, Q.Portugal	Sarin	Figure 50	3	935
Ainaro, Maubisse	Hohrae Ki’ik	Maubisse	Figure 51	4	1400
Manufahi, Betano	Betano	Betano	Figure 52	6	5

The axis of the second calendar set is the commodity. The second calendar set is comparative and shows cultivation activities for a single commodity against time/weather for each village. For example, the maize calendar for Baucau district shows cultivation activity times for maize in the five villages where research was carried out.

A total of 32 village-based calendars and 26 commodity-based (per district) calendars were compiled.

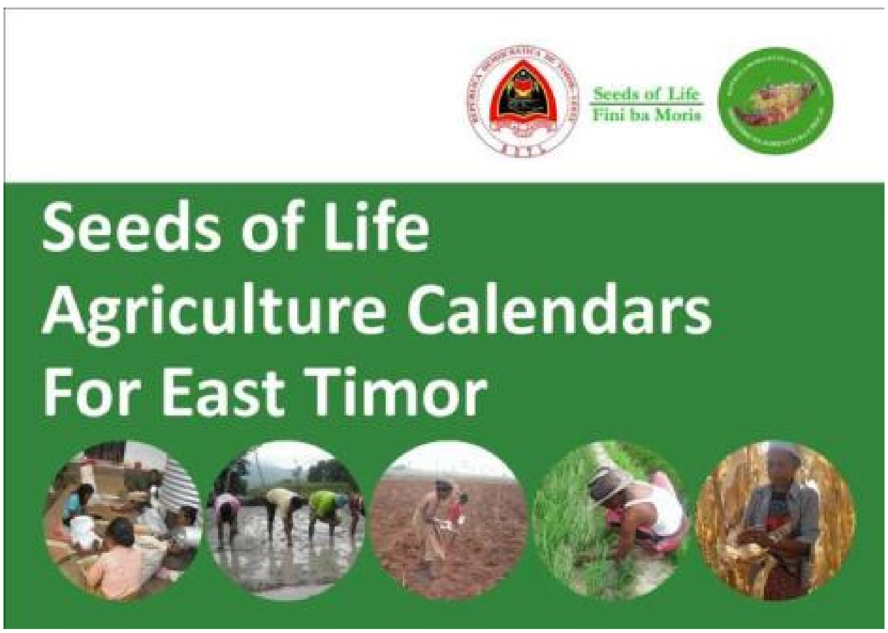


Figure 47. Front cover of the agricultural calendars compilation (MAF/SoL 2010)

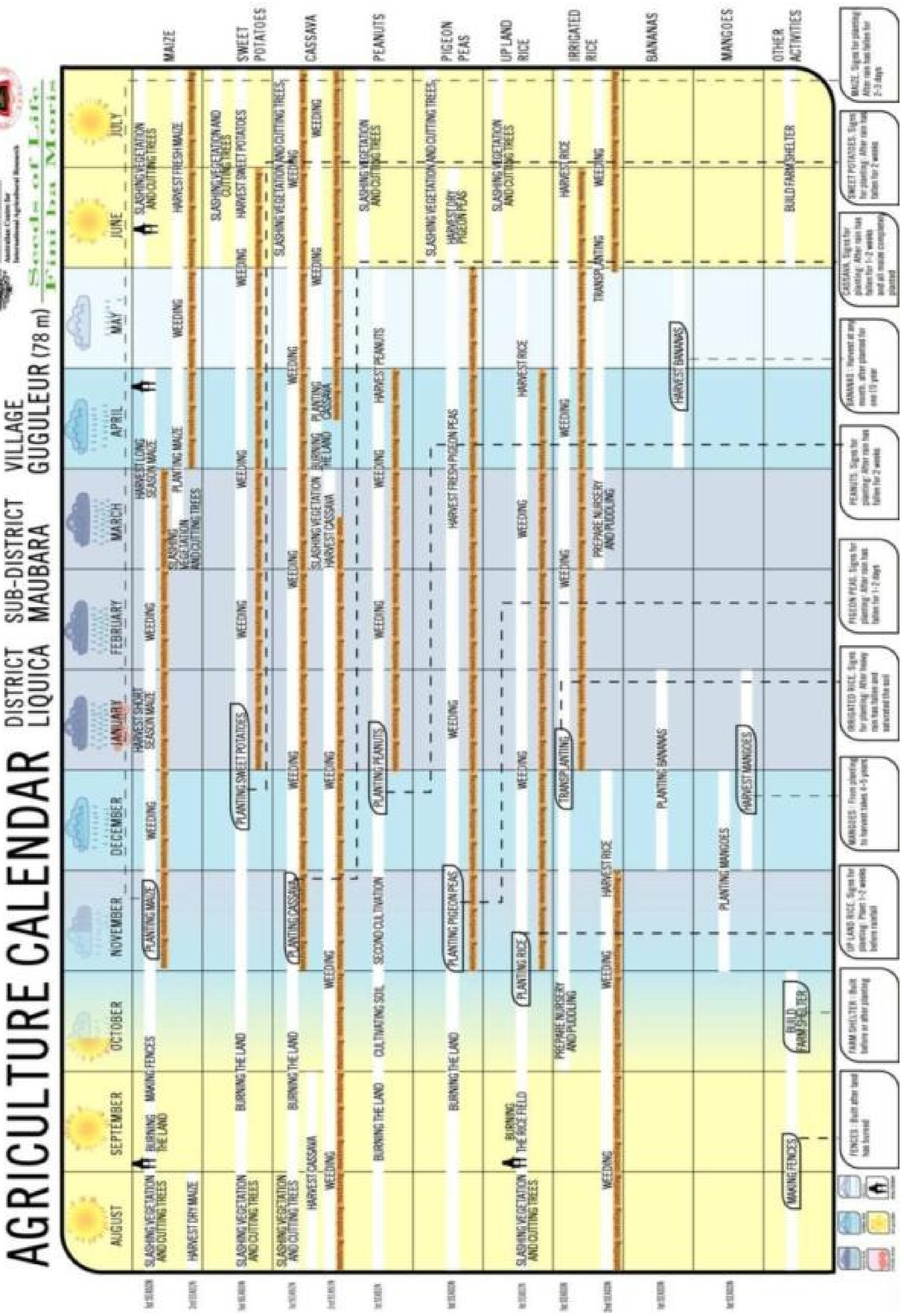


Figure 48. Guguleur agricultural calendar, nearby Loes station (Liquiça)

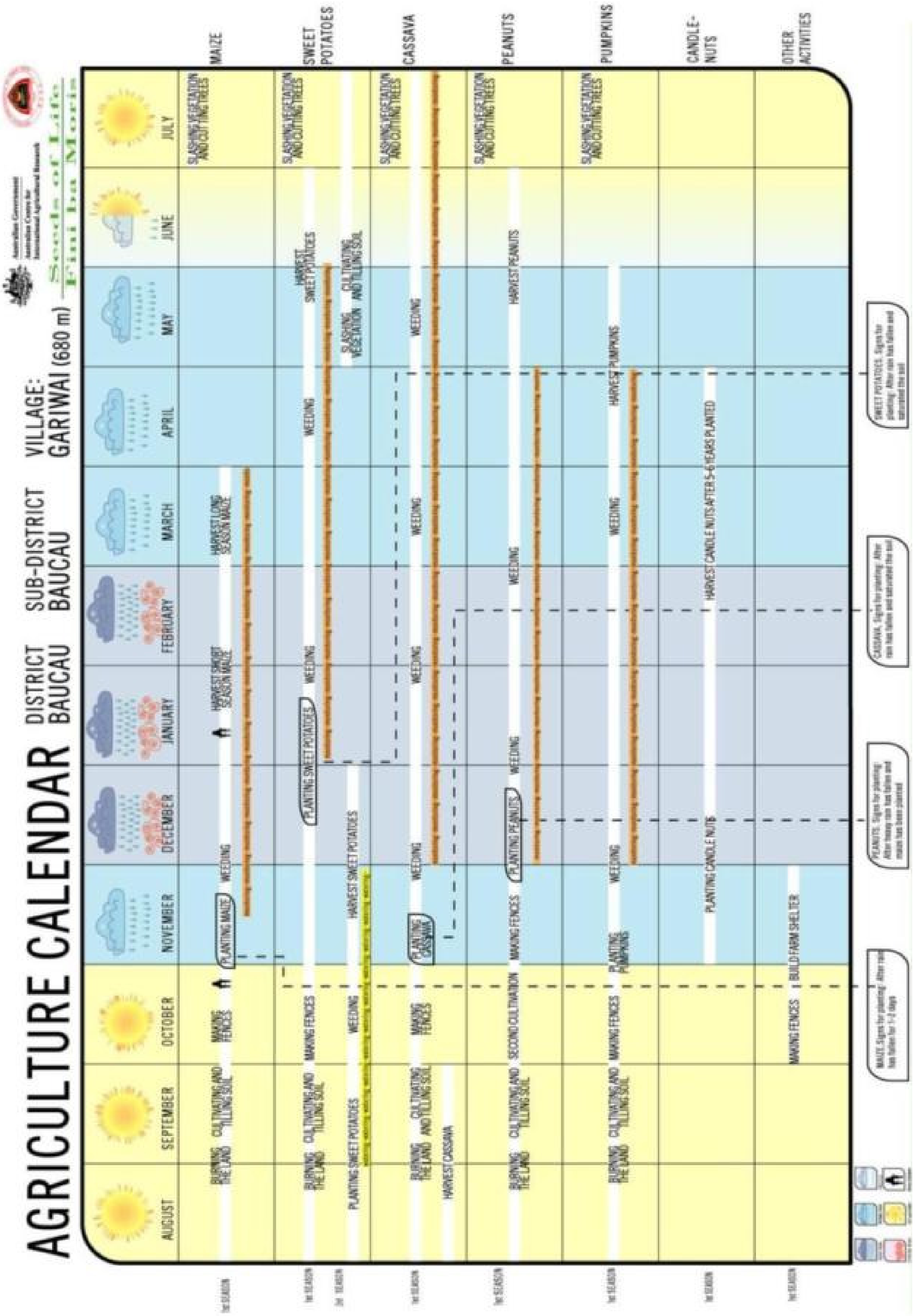


Figure 49. Gariwai agricultural calendar, nearby Fatumaka station (Baucau)

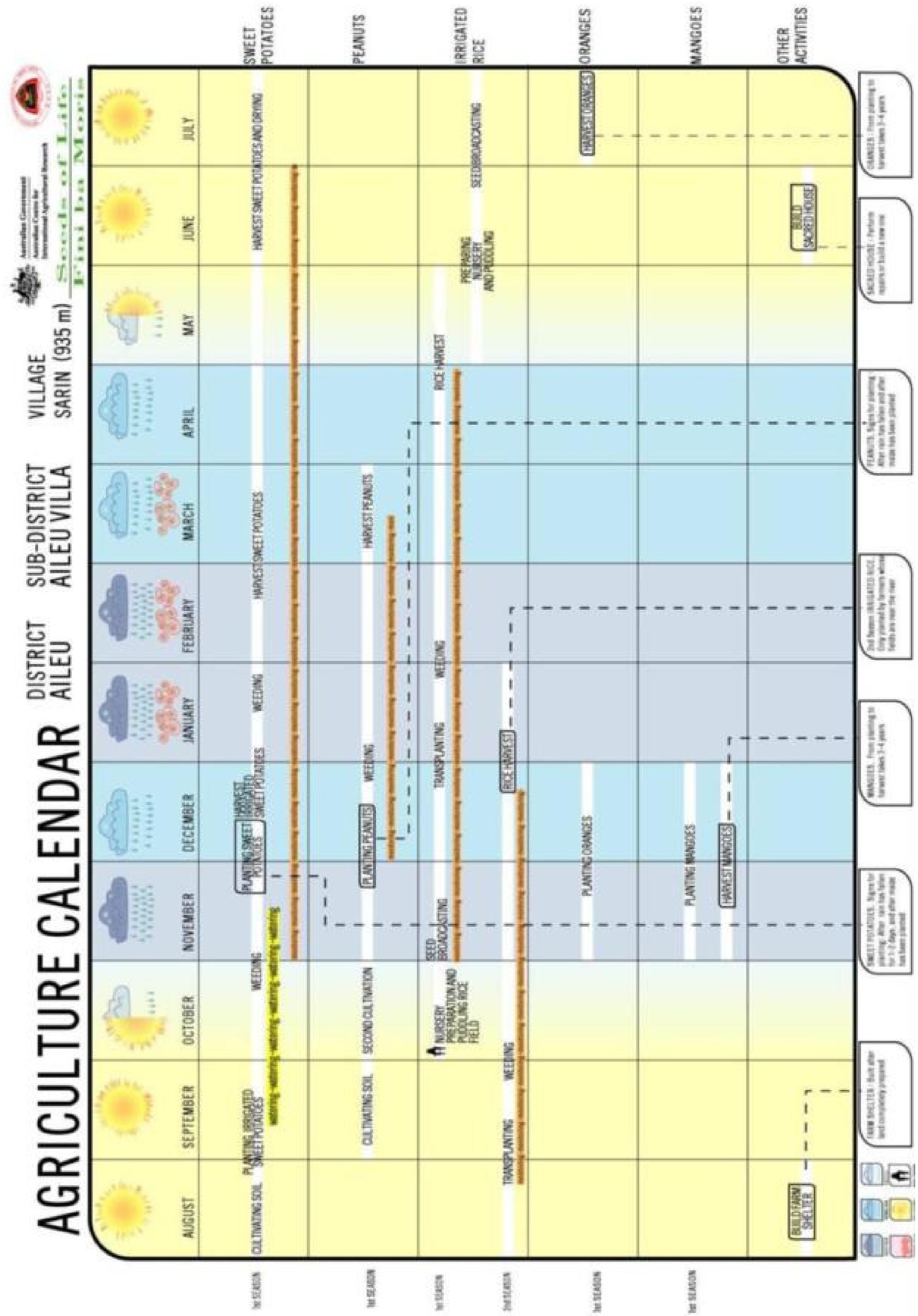


Figure 50. Sarin agricultural calendar, nearby Quintal Portugal station (Aileu)

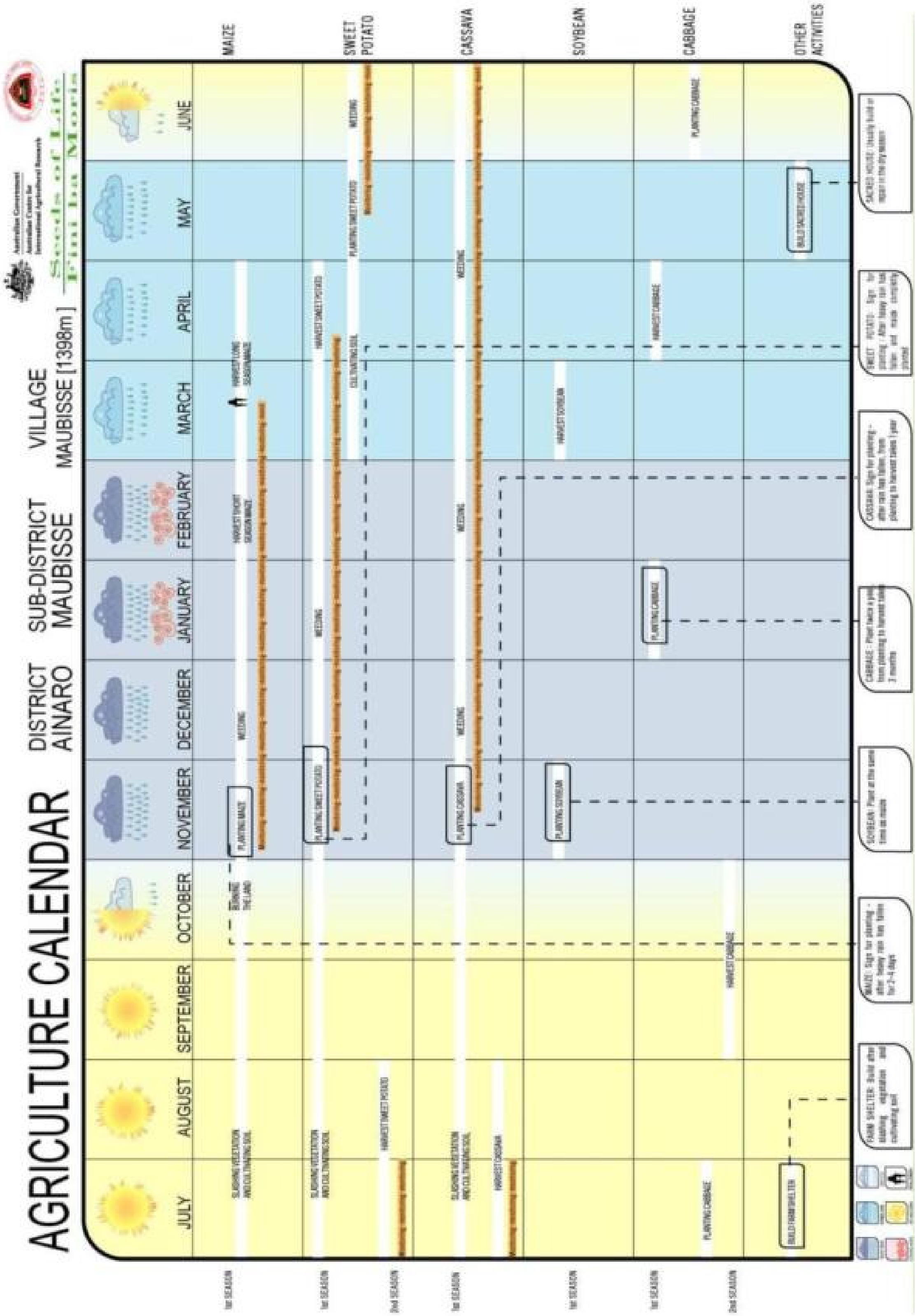


Figure 51. Maubisse agricultural calendar, nearby Hohrae Ki'ik site (Ainaro)

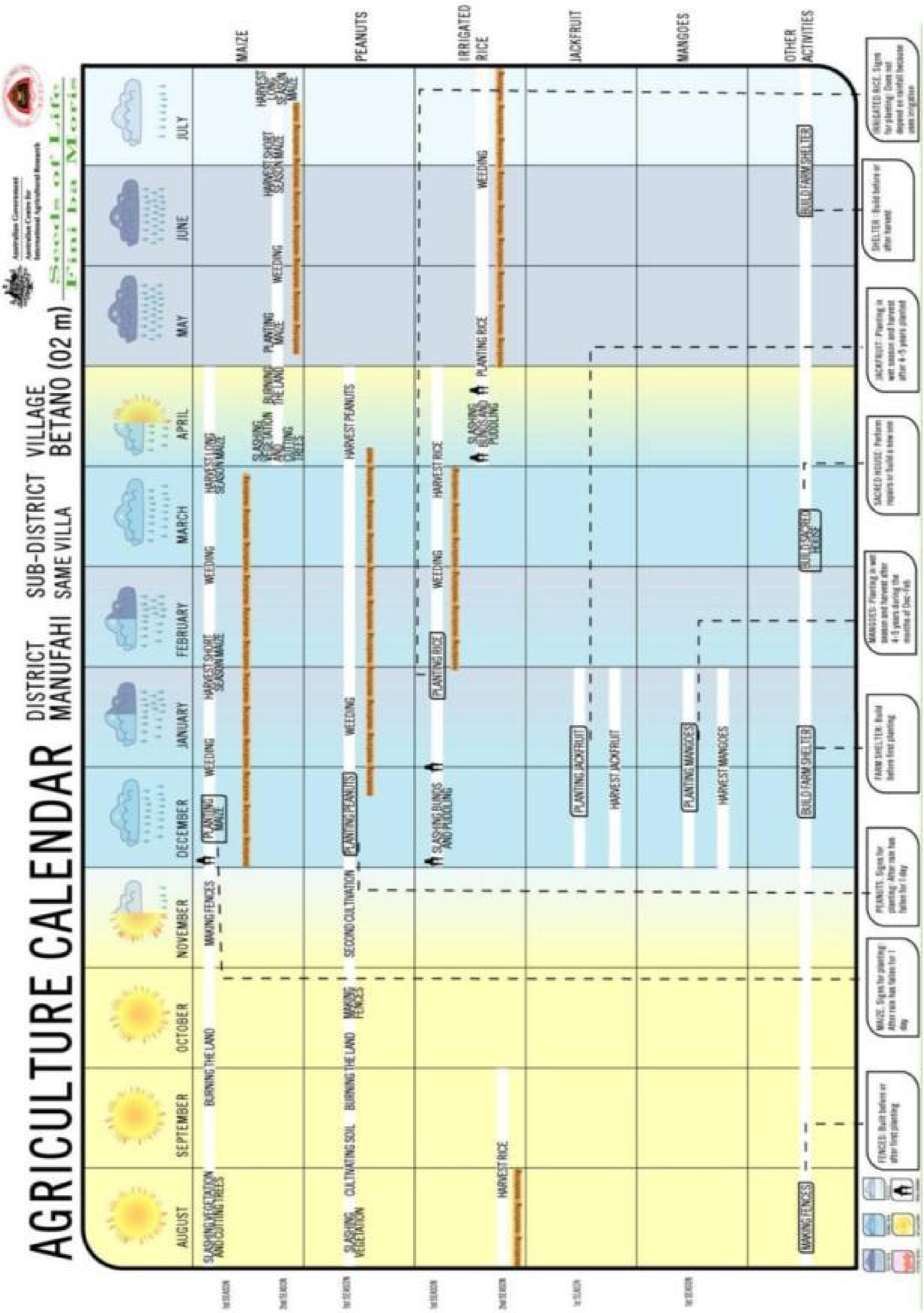


Figure 52. Betano agricultural calendar, nearby Betano station (Manufahi)

4.2 The effect of applied nitrogen on rice yield, Aileu

Introduction

Aileu has about 776 ha of rice fields (District data). Chlorosis is a common symptom in the rice crops of this district and yields appear to be constrained by nutrient deficiency. Much of the district is at higher altitudes and is cooler than the coastal areas where most of Timor-Leste rice is cultivated. Crop maturation generally takes longer under cooler conditions and there is potential for the crop to respond significantly to the application of fertilizer. This trial was implemented to evaluate the effectiveness of applying nitrogen to rice.

Methods and materials

The trial was conducted in a farmer's field (elevation 1080masl) at Selou kraik, a sub district of Aileu. A nursery of Nakroma rice was established on 15 July 2010. Three week old rice seedlings were then transplanted into the paddy field with two seedlings/hill at a planting distance of 25 cm x 25 cm. The trial plot size was 2m x 2m.

The trial was laid out in randomized complete block design with three replications. Three different treatments were applied. These were a) 0 kg N/ha, b) 34.5 kg N/ha (equal to 75 kg/ha of Urea) broadcast over the plot at transplanting, and c) 34.5 kg N/ha side dressed between the hills down the rows at transplanting.

Variables observed were: number of tillers, number of seeds/panicle, plant height (cm), and grain yield at harvest time. Gen-stat was used to analyze the collected data by analysis of variance followed with a LSD test if the ANOVA indicated a significant difference between the treatments.

Results and discussion

The trial area was well watered during the trial period and the crop was unaffected by diseases and insect pests.

Effect of nitrogen on yield and yield components

The application of nitrogen significantly and strikingly improved the health of the rice crop. (Table 122). Statistical-analysis of the data revealed that plant height, number of tillers/plant, number of seeds/panicle and grain yield were significantly (P 0.01) increased by the application of urea. Plant height increased from 25cm to over 70cm; tiller number increased from 23.3 to 73.6 per hill. Similarly, the number of seeds per panicle ranged from 17.3 to 102. The higher tiller density, number of seeds per panicle and higher percentage of viable seed resulted in higher grain yields. The application of urea did lengthen the time to maturity and there were more green (immature) grains on each panicle than for the control.

Banding the fertilizer increased grain yield compared with broadcasting (5.4t/ha compared with 4.6t/ha) and indicates a way to reduce the use of fertilizer over the short term. The long term benefits of this practice in Selou kraik may warrant further investigation.

Table 122. The effect of nitrogen on rice and yield components

Nitrogen application rate (kg/ha)	*Plant height (cm)*	*No. of tillers*	*No. seeds /panicle*	*No. green seeds/panicle*	*No. empty seeds/panicle*	*Yield (t/ha)*
Control (0)	25.0	23.3	17.3	1.7	8.3	1.2
34.5 kg broadcast	67.3	64.7	58.7	9.3	2.7	4.6
34.5 kg side dressed	70.3	73.7	102.0	9.7	2.3	5.4
LSD (P<0.5)	*3.7*	*4.9*	*10.0*	*4.4*	*2.0*	*0.5*

The significant response to the application of nitrogen on rice observed in this trial reflects similar responses in exploited soils in other parts of the world. A trial conducted in Seisal Baucau during 2008 reported that application of 90 kg N/ha increased the yield of Nakroma by 60%. The larger response at Selui kraik-Aileu indicates that nitrogen deficiency in Selui Krak could be more severe than at Seisal-Baucau. Farmers in this area report that they have not applied urea to their fields for more than ten years.

The trial reported here was a preliminary investigation into the response of rice to applied fertilizer and is the precurser to more intensive research in the future.

4.3 The effect of weeding on peanut yield

Introduction

Peanut is the most widely cultivated legume crop in Timor-Leste. Its seed is high in protein (20–50%), fat (40–50%) and carbohydrate (10–20%). Peanut seeds also contain vitamins and minerals such as Vit.E, zinc, iron, calcium, thiamine, etc. Apart from being consumed as a food (roasted and boiled) it can be manufactured as an industrial raw material, processed for cooking oil, etc. Peanut is a self-pollinated crop and after flowering above ground, the plant "pegs" the fertilized seed under ground where it matures (hence it is often called ground nut)

Peanuts are cultivated in Timor-Leste with very low inputs. Little, if any organic or inorganic fertilizer is applied and no pesticides. Weeds are a serious problem, and unless hand weeded, they can reduce pod yields by 20 to 80 %. This trial aimed to evaluate the benefit of weeding to peanut productivity.

Methods and materials

The trial was conducted in a farmer's field in Darasula, Guariwai, Baucau district. It was located in a field where seed production was in progress but the plots were managed by SoL staff.

The trial was laid out in randomized complete block design having 3 replications. The treatments applied in the trial were a) no weeding, b) weeding one time at 1 month after planting (MAP), and c) weeding twice - once at one MAP and the second time at two MAP. The trial plot size was 5m x 5m. Planting was on 4 January 2010 and harvesting four months later on 4 May 2010. No fertilizer was applied during the trial periods and other agronomic practices were kept constant for all the treatments.

At harvest, all plants in the plot were dug, dried and weighed. In addition, 5 sample plants were harvested separately, and the pods of these plants were used to measure yield components. Variables observed were: wet pod yield, sun dried pod yield, number of pods/5 plants, weight of empty pod/5 plants, number of good seed/5 plants, weight of good seed/5 plants and 1000 seed weight. Gen-stat was used to analyze collected data by analysis of variance followed with LSD test if ANOVA indicated a significant difference between the treatments.

Results and discussion

No significant attack of pest or disease was noted in the trial. In general, all plants grew well as reflected by the trial's high average yield of sun-dried pods (2.5 ton/ha).

Fresh pod weights increased from 4.5t/ha to 5.5t/ha with two weedings (Table 123). However, this was not statistically different. Dry pod yield responses to weeding were also non significant because of the high variability. There appeared to be less empty pods when the plots were weeded and this showed up statistically in the dry seed weight per five plants. Thus the dry seed yield per plot and total seed yield per hectare would also be significantly higher. The dry seed yield in the twice weeded treatment was almost double the unweeded treatment.

Table 123. Effect of weeding on peanut pod yield and yield components.

Treatment	*Fresh pod yield (t/ha)*	*Sun-dried pod yield (t/ha)*	*Number of pods/5 plants*	*Weight of empty pods/ 5 plants (g)*	*Dry seed weight/5 plants (g)*	*Number of good seed/ 5 plants*	*1000 seed weight (g)*
No weeding	4.5	2.2	185	58	126	134	95
Weeding 1x	5.0	2.5	205	28	213	217	102
Weeding 2x	5.5	2.7	195	18	234	233	106
LSD ($P<0.05$)	ns*	ns	ns	ns	4.7	19.0	ns

*ns = not significant

The first six weeks after planting has been reported by some authors as the critical period during which peanuts suffer from weed competition. In this trial, the farmer had plowed the field three times by tractor before planting. This may have kept the crop reasonably clean early, resulting in high pod yields but weeding certainly appeared to reduce competition at later stages of crop growth and increased the number of pods possessing viable nuts. This resulted in an improved seed yield.

4.4 Maize and velvet bean systems

Introduction

Integrating leguminous crops into maize-based cropping systems is a common answer to improving soil fertility and controlling weeds in countries where fertilizers are unavailable and labour is either expensive or scarce. In Timor, where a negligible percentage of the maize farmers use external inputs and where labour shortages are significant during the growing season, the benefits of using legumes are highly relevant.

Velvet bean performances and benefits

The choice of velvet bean (*Mucuna pruriens* L.) as a cover crop is justified by its exceptional vigor. It consistently shows superior agronomic performance compared to other annual legumes, having green forage yields of up to 15 t/ha per season and seed production ranging from 200 to 2000 kg/ha. Its abundant biomass production contributes to make velvet bean one of the most suitable crops for reclaiming land infested with weeds, including those dominated by *Imperata* (Gilbert, 2000; Wulijarni-Soetjipto & al., 2003). In Malawi, experiments studying the response of maize in rotation with diverse legumes showed that the maize-mucuna rotation produced the highest yield increase (over 100% in maize grain yields) and was the most beneficial for improving soil fertility (Kamanga, 2002). Cameroun, Hauser & al. (2006) also demonstrated in a 7-year experiment that maize relay cropping with velvet bean fallow led to higher maize production than with natural fallow. However, differences in soil chemical properties (total N, C:N ratio, P concentrations) and in the way the fields were managed by the farmers greatly influenced the results. For instance, retaining biomass as a mulch insures more N intake in the long term than burning (Hauser, 2006), while leaving the mulch to dry above the ground instead may increase stored nitrogen loss by as much as 50% (Wulijarni-Soetjipto & al., 2003).

Other perceived benefits of using velvet bean as a cover crop include better rainfall infiltration (increase in soil porosity), reduced evaporation from the soil and increased protection of the soil resource from erosion and soil temperature extremes. In addition, an increase of the rotation diversity could have benefits for pest and disease control.

A thick velvet bean ground cover leads to much higher biodiversity. The soil microbiological activity should theoretically increase and field observations confirmed that the number of species in the canopy does. This means potentially more pests (caterpillars, grubs) but also more biological control and overall resilience of the crops, in particular if insects favour the tender velvet bean leaves over maize.

Velvet bean grows in an annual rainfall ranging from 400-3000mm. However, it has a shallow root system and is only moderately resistant to drought. Velvet bean grows best at an average annual temperature of 19-27°C and prefers well-drained sandy and clay soils with a pH of 5-6.5, but it can also grow vigorously on acidic sandy soils (Wulijarni-Soetjipto & al., 2003). Despite its fast growth rate, velvet bean presents low risks of becoming invasive in East Timor as its leaves are highly palatable for feral and domestic animals, particularly goats.

Velvet bean in Timor-Leste, an indigenous technology

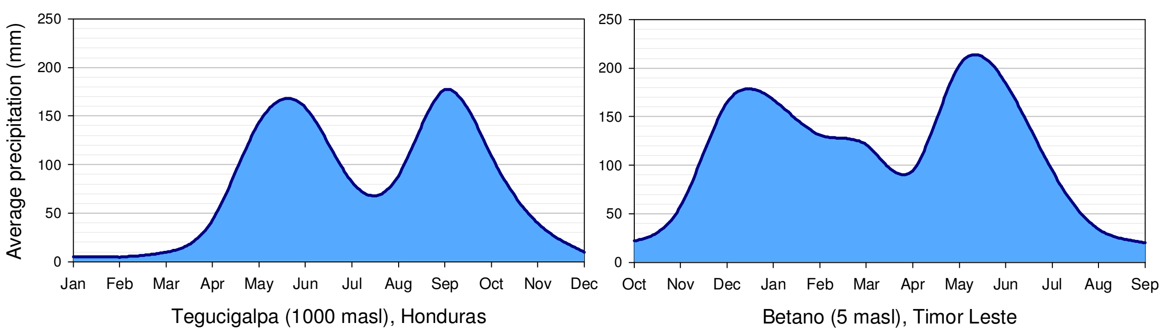
In Timor-Leste, velvet bean is known by the local name "Lehe", while the wild form presenting irritating pods is called "Karlele". A study from UNTL/Oxfam started in 2003 provided evidence that velvet bean was used in Timor-Leste as a weed control and soil fertilizer as well as a food crop. However, its cultivation virtually vanished as a result of turmoil and social dislocation and has only returned relatively recently (Williams, 2005).

Velvet bean-maize system in Honduras

It has been reported (Buckles *et al.*, 1998) that farmers in Honduras have been using sustainable maize-velvet bean cropping systems for over 20 years on hillside environments very similar to those in Timor. The practice involves sowing a twining legume such as velvet bean into maize after it is established (after about 30 days) and allow it to grow profusely after the maize is harvested. The velvet bean is slashed once it starts to seed, and the maize is planted again in the decaying mulch. The velvet bean then regrows spontaneously from the seed bank thus created, and the cropping cycle is generally repeated without the need for continued reseeding of velvet bean. The study by Buckles *et al.* (1998) suggested that the velvet bean supplies on average about 100 kg of new N/ha/year with very little leaching or other losses. Soil organic matter remained stable despite many years of continual cropping. Yields of maize were found to be almost double that in check plots in which velvet bean was not grown. Because of its ability to suppress weeds, velvet bean also significantly reduced the amount of labour required. One report (H. Heyler, *pers. comm.*) indicated that it took approximately 1 man-day/ha to plant the cover crop and this was enough to insure effective control of grassy weeds.

Possible misfits and barriers to adoption

Despite its direct and indirect benefits, the use of velvet bean may not be suitable for all Timor-Leste environments. The Hondurian system will only be suited in Timorese regions with long rainy seasons, i.e. in the south coast lowlands (Figure 53). Yet, local rainfall patterns could still differ enough from those in the central American hillsides to impact negatively the cropping cycle.



Source: World Meteorological Organization (WMO) 1961-1990, © 2008 Climate-Charts.com

Sources: TimorAgri 1962-1974 & MAF-SoL 2006-2009

Figure 53. Bimodal rainfall patterns of Honduras hillsides and Betano station

Vigorous and early growth of the velvet bean may compete with the main maize crop in some environments, particularly if water is limiting. The dense, leafy ground cover will improve soil characteristics and help retain soil moisture but its evapotranspiration could also be higher than from a bare or grassy ground, resulting in less overall moisture available in the soil for the main crop.

The accumulated increase in soil N, organic content and reduction of erosion is usually a long term process taking several years. Yield advantages seem to occur earlier probably because of the fast mineralisation occurring in hot and wet environments. Yet, stable and long term improvement of other soil parameters requires the association to be maintained. In shifting farming systems, the association may therefore be of little interest other than for fallowing. Even in a fixed farming system, the extra labour cost of implementing an additional crop which doesn't result in immediate economical benefits would be a strong limitation for farmers' adoption.

Human consumption of the beans is an economic benefit. It is however strongly limited by the time and fuel consuming process of repeatedly boiling the beans in water (up to ten times), necessary to remove its toxic content and to make the beans edible. The ground cover biomass is a very palatable feed for animals. Yet, the system relies on keeping the velvet bean as a mulch (Hauser and al., 2006).

The decaying lower layers of velvet bean host a range of microorganisms, insects and other animals which could potentially improve the soil properties as well as the overall crop resilience and hence production. Unfortunately, rats also favour that environment and could, in some cases, add a significant predation burden on the maize.

Another disadvantage of growing velvet bean is that during weeding, maize plants can be damaged by abrasion through uncontrolled movement of the rigid cover crop mulch material. Farmers generally cannot afford the time to remove and replace mulch in order to weed more carefully. Other barriers to the adoption of velvet bean, as for other legume associations, are seed availability, damage by animals, and labour shortages (Kamanga, 2002).

The validity of the velvet bean/maize system in Timor-Leste is being trialled by SoL in several locations, focusing on the effect of the association on maize yields. Other factors are also being investigated such as the number and time of weeding, variety or cropping systems effects. Quantification of the association benefits in labour efficiency and economics is also to be started.

4.4.1 Summary of results, maize/velvet bean 2004-2008

For more details, please refer to SoL, 2006, SoL, 2007 and SoL 2008.

2004-2005: Investigating the use of velvet bean in Timor-Leste

In 2004/05, an UNTL/Oxfam project funded by USAID conducted a study investigating the use of velvet bean in Timor-Leste. Local farmers in Hataz, Bobonaro district had very interesting responses to seeing velvet bean seeds. One farmer immediately recognized the seed, described the plant and how it was necessary to boil and wash the seed ten times prior to eating. He also described the plant's growth habit and its cultivation. For instance, when grown as a food crop, the seeds were planted at the base of a tree or along a fence, allowing the plant to climb and produce seeds out of reach of animals. He also explained how he and other farmers would also plant the seeds by throwing them in areas with weed problems or low soil fertility. Farmers in Bobonaro district included velvet bean as an integral part of cropping systems prior to the Indonesian invasion of 1974.

After 1975, velvet bean completely disappeared from the farming systems of the Hataz, Bobonaro area because, for 2-3 years after the invasion, farmers from there were displaced from their farms. When the population did return, all velvet seed had either rotted or been eaten by animals. Farmers were unable to source seed for the following 30 year period until the arrival of the UNTL in December 2004. The farmers in Hataz were very pleased to receive seeds of velvet bean again, as well as working with sword bean as an alternative. After one year, more than 100 farming households of the same area were again using velvet bean to smother weeds, fertilise the ground and provide an additional protein food source to their families.

In Manatuto district, the UNTL project also spoke to a number of farmers from the village of Seurtulan (Lacliubar area) who were willing to assist in the velvet bean project. Among them, Sr. Martinho describe how he had grown velvet bean for many years, both in order to control weeds and to fertilise the soil prior to burning the fallen leaves before planting crops. In this area, velvet bean seeds were kept until today.

Other anecdotal evidence indicates that velvet bean was a regular part of some Timor-Leste upland cropping systems, ranging from the eastern locations (Viqueque) to the west (Bobobaro).

2005-2006: Confirming with farmers the benefits of velvet bean

The UNTL project tested velvet bean with farmers in a range of Sucos in Maliana and Liquiça. On-farm trials in Atabae and Balibo were conducted by UNTL and two NGOs with the support of SoL in 2005-2006. Evidence from those trials indicated that planting velvet bean one to two months after the maize resulted in a very slow growth of the velvet bean, while planting at the same time as maize gave a faster early growth and soil cover. In both cases, most of the weeds were shaded out enough to reduce the need to manually remove them. Seventy five percent of the 120 participating farmers reported that the velvet bean reduced their weeding by half to two thirds (one weeding instead of 2-3 times), a strong incentive for labour-limited farmers. The plant from one velvet bean seed could potentially control weeds in an area of up to 10m². However, the research did not indicate whether maize yields were improved or depressed because of heavy growth of the green manure. The average velvet bean seed production was found to be of 0.3 t/ha.

Those results encouraged SoL to further investigate on-station research on the potential advantages of velvet bean. All studies are done using local germplasm.

2006-2007: First replicated trials

A preliminary study conducted at UNTL and focusing on maize yields tested the best green manure species and the optimum planting time. When planted simultaneously with maize, the vigorous growth of the velvet bean significantly reduced the maize yield compared to the control (no green manure associated with the maize) and compared to the use of sword bean (*Canavalia gladiata*) or jack bean (*C. ensiformis*). Planting any of the three green manures significantly increased maize yields when planted at three weeks, and was the highest with velvet bean. This effect became less significant when planting occurred at five weeks. The trial thus showed the benefits on maize yields of planting green manure as well as emphasizing how crucial the planting time was.

The Betano research station climate allowed implementing two trials during 2006-2007. The results of the first season trials did not detect any significant effect on the yields nor any effect of the interaction between the variety of maize and the velvet bean association (tested on a local variety and the introduced Harare 5, which yielded significantly differently from each other). However, the incidence of weeds was significantly reduced when maize was intercropped with velvet bean, irrespective of the number of weedings (1 to 3). At least one wedding in combination with velvet bean resulted in the complete absence of weeds at harvest, confirming farmers' observations. Besides reducing the weed burden, the weed seed bank in the soil would also be reduced.

There was a non significant but positive response of maize yield in the second season crop, planted directly after the harvest of the first season one. Maize yields in the treatment that had velvet beans planted in the first and second season were higher than those that had no velvet bean. In addition, the cob weight and the shelling percentage were higher after one or two velvet bean plantings than without. This might indicate that extra N from velvet bean became rapidly available.

The two trials also gave evidence that planting too early would encourage velvet bean dominance to the detriment of maize yield and planting too late will result in unsatisfactory velvet bean cover with regards to weed suppression. Based on those observations, it appears that velvet bean should be planted into maize at a later stage in the main season (a month to six weeks after maize) and earlier in the second season (possibly 3 weeks after maize).

2007-2008: Continuing replicated trials

A trial to further evaluate the effects on maize yields of the velvet bean association along with maize varieties and number of weeding was implemented in Fatumaka, Baucau research station in 2007-2008. However, no significant effect of individual factors nor of their interaction was found.

At the Corluli, Bobonaro site, the same conclusions were reached from a similar trial. However, the time of planting the velvet bean was also tested and proved to significantly diminish the maize yield if planted at the same time as the maize. This competitor effect disappeared if the velvet bean was planted 2 or 4 weeks after the maize. Further experiments were transferred from Corluli to the newly opened Loes research station.

At Betano, Manufahi, research station, a new research block was opened to start a long term trial. The 2007-2008 main cropping season was dedicated to a uniform planting of maize to limit site variation. The top soil level was also measured in order to allow later comparisons on soil movements due to runoff.

4.4.2 Maize/velvet bean replicated trials 2008-2010

Fatumaka: velvet bean, maize varieties and weeding regime, 2008/09

A replicated velvet bean associated with maize trial was implemented in Fatumaka research station in 2008. The trial included three replicates and tested the effect of three factors: velvet bean (or not), maize variety (Sele or Harare 5) and weeding regime (1, 2 or 3 weedings).

The maize was planted mid-November 2008 and harvested mid-March 2009. The velvet bean was planted a month after the maize with a density of 1 plant per m². Collected data included plant emergence, plant size, yields, yield components and cob damage as well as the biomass of suppressed weeds and velvet bean parameters (plant emergence and vigour).

However, low rainfall prevented the growth of maize and no significant data was recorded. The growth of velvet bean was also poor with overall poor plant survival being 40% or less.

Velvet bean had never reach the point of canopy closure in Fatumaka where any vigorous growth might be limited by some specific site characteristics. Whether this is linked to temperature, rain or soil characteristics (Fatumaka soils have, for instance, very low iron and zinc but high manganese contents and marginally acidic pH) is yet to be determined. Further experiments will be transferred from Fatumaka to the Darasula research station in 2011.

Betano: velvet bean and cropping systems, 2008-2010

The 2008-2010 period marked the first years of a long term trial at Betano research station designed to test the effect of the association of velvet bean with maize. One goal was to test the common belief that using tractors to till the soil is the best way of preparing the land. The use of Round-Up (a selective herbicide) was also included in the trial to compare with labour costs and to determine whether it allowed an earlier start to the season.

Methods

The first trial in the series at Betano was planted in December, 2008 and harvested in March 2009. The second trial was conducted between December 2009 and April 2010. A trial was to be implemented in the dry season of 2009 but a lack of rain prevented its installation. The trials were laid out in a randomized complete block design with 40 m x 20 m plots. Five treatments, as described in Table 124 were applied in three replicates to compare mechanical ploughing as opposed to the farmers' practice of no tillage, with or without Round-Up and velvet bean.

Table 124. Velvet bean/maize cropping systems trials, Betano, 2008/09 and 2009/2010

No.	*Treatment/Factor*			*Effect tested*
	Tractor	*Round-Up*	*Velvet bean*	
1.	X			Tillage (mechanical)
2.			X	Velvet bean system
3.	X		X	Combination Tillage / Velvet bean
4.		X		Round-Up
5.		X	X	Combination Velvet Bean / Round Up

Note: In all cases, sowing was done by placing seeds in holes made with a planting stick (standard farmers' practice)

At planting time, weeds and if need be, residual velvet bean, were slashed manually (as a tractor would have crushed the velvet bean pods) when not sprayed with Round-Up. Prior to planting, the soil was tilled with a tractor or not, depending on the treatment. Maize was planted with two seeds per hill at a planting distance of 75×25 cm (i.e. 5.3 plants/m^2). Velvet bean was planted approximately a month later with a 1 plant/m^2 density (one seed per hill). The plots without velvet bean were weeded twice, as farmers commonly do. The weight of wet and dry weed or velvet bean biomass was measured through 5 samples (quadrats of 1m^2) prior to planting and prior to harvest. At harvest, the number of maize plants were counted as well as the number of cobs per plot. The production per plot was weighed, prior to and after drying, as well as the weight of 100 seeds.

The 2008/2009 and 2009/2010 trials received about 500 mm and 400 mm of rainfall respectively, which was lower than the long term average (c. 500 mm on average for the months of December-January-February alone in 1957-1974 according to AgriTimor data).

As no spatial effect was detected, the results were analysed in GenStat Discovery 3 using ANOVAs (Unbalanced ANOVA for the factors analysis and ANOVA One-Way in Complete Randomized Block for the overall cropping system treatment).

Results

Data collection from the 2008/2009 trial was prevented by the growth of the velvet bean over the maize which was planted too late due to the lack of early rain. However, the long term implementation of maize and velvet bean successions was overall maintained as well as the tillage regimes.

The results of the 2009/2010 season trials are presented in Table 125:

Table 125. Maize-velvet bean replicated trial results, Betano 2009/2010

Treatment	*Dry biomass (weeds) prior to planting (t/ha)*	*Dry biomass at harvest (t/ha)*		*Maize yield (t/ha)*	*Plant density at harvest (plant /m²)*	*No cobs /plant*	*Cob weight (g) (seeds only)*	*Seed weight (g/100)*
		Weeds	*V.bean*					
Tillage (mechanical)	1.4	4.8	0	0.3	0.4	1.1	82.5	29.3
Velvet bean system	1.2	0	8.2	0.5	0.8	1.1	73.3	27.0
Tillage & Velvet bean	1.9	0	9.5	0.4	0.7	1.1	83.9	27.3
Round-Up	3.4	5.1	0	0.3	0.5	1.1	102.3	27.3
Velvet Bean & R-Up	2.6	0	9.3	0.6	1.5	1.0	71.0	26.0
F prob	*0.146*	*0.026*		*0.188*	*0.015*	*0.527*	*0.928*	*0.380*
LSD (P<0.05)	*n.s.*	*3.3*		*n.s.*	*0.6*	*n.s.*	*n.s.*	*3.6*
%CV	*48*	*24*		*43*	*40*	*3*	*57*	*7*

No significant yield differences between overall treatments were found, probably because plant density at harvest and subsequent production were low. However, when performing an ANOVA using ‘Tillage’, ‘Round-Up’ and ‘Velvet bean’ as (unbalanced) factors, the only factor with a significant effect on yield was ‘Velvet bean’ ($p = 0.043$, LSD = 0.20) with overall yields of 0.5 t/ha with velvet bean and 0.26 t/ha without, i.e. +83% yield advantage.

The most important result of the trial was the total absence of weeds in the plots cultivated with velvet bean which smothered all weed development.

Significant differences in biomass (other than maize) could be found in the plots with/without velvet bean where the manual control of weeds was supplemented by mechanical tillage (treatment 1) and chemical control (treatment 4.), a 5 t/ha gramineous weed cover had developed alongside the maize crop. Where velvet bean was planted, it developed into a 9 t/ha broad leaf cover, the lower layers of which decayed into mulch.

Conclusions

In the 2009/2010 trial, a +80% yield advantage was found in plots where the maize crop had been associated with velvet bean. Additionaly, the velvet bean developed well and completely replaced the usual graminaceous weeds while significantly reducing the weed burden. At harvest the velvet bean dry biomass was nearly two times higher than the gramineous weed cover.

No significant yield differences could otherwise be identified among the cropping system treatments. Further trials will help provide more information by measuring the long-term effects of additional cropping cycles. Labour requirements will also be recorded in order to provide economic data.

Loes: maize and legume variety trial, 2009/10

A trial to investigate the association of maize with climbing legumes was implemented at Loes research station during the 2009-2010 cropping season,. The trial tested the combinations of two maize varieties with three locally sourced legumes, two of them being velvet bean.

Methods

The trial was planted in early December 2009 and harvested mid-April 2010. It was laid out in a randomized complete block design with 5 m x 5 m plots in three replicates. Six different treatments were applied as combinations of two maize varieties and three legumes, as shown in Table 126:

Table 126. Variety factors in Loes maize-legume replicated trial, 2009/2010

No.	*Factors combination*	
	Maize	*Legume*
1.	Sele	'Asukuas'
2.	Sele	Velvet bean 'Makerek'
3.	Sele	Velvet bean 'Mutin'
4.	Local	'Asukuas'
5.	Local	Velvet bean 'Makerek'
6.	Local	Velvet bean 'Mutin'

Notes: - 'Asukua': local climbing legume particularly used in Maliana.
- 'Makerek' means 'multi-coloured'. 'Mutin' means 'white'.

The maize crop was planted with one seed per hill at a planting distance of 75×25 cm (i.e. 5.3 plants/m^2). The legumes were planted a month and a half after the maize (mid-January) with a 2.7 plant/m^2 density (one seed per hole). At harvest, the number of maize plants was counted as well as the number of cobs per plot. The production per plot was weighted, prior to and after drying, as well as the weight of 100 dry seeds. The trial received about 450 mm of rainfall.

A strong column effect was detected in the trial. The results were therefore analysed in GenStat Discovery 2 using REML with an AR1 model and a linear trend on columns. The effect of each factor (maize variety and legume type) was analysed as well as their interaction.

Results

The results were as presented in Table 127 and Table 128:

Table 127. Maize-legume replicated trial results Loes 2009/1010

Factor (number of modalities)	*Maize yield (t/ha)*	*Plant density at harvest (plant /m^2)*	*No. of cobs /plant*	*Cob weight (g) (seeds only)*	*Seeds weight (g/100)*
Factor 1: Maize (2)	***	***	***	***	n.s.
Factor 2: Legume (3)	n.s.	n.s.	n.s.	n.s.	n.s.
Interaction (6)	***	n.s.	*	*	n.s.

Effects significant at: * <0.050 ** <0.010 ***<0.001 (χ^2 probabilities after REML)

Table 128. Maize-legume replicated trials results, yields (t/ha), Loes 2009/10

Legume / *Maize*	*Asukuas*	*Velvet b. 'Makerek'*	*Velvet b. 'Mutin'*	*Mean*
Local	1.3	0.7	1.5	1.2
Sele	2.1	2.6	1.9	2.2
Mean	1.7	1.7	1.7	1.7

l.s.d (p<0.050): Maize: 0.4 ; Legume: n.s. ; Interaction: 0.8

The high difference in yield between the local maize variety and the released Sele (respectively 1.2 t/ha and 2.2 t/ha on average for this trial) led to significant effect of the maize factor for all the tested components, with the exception of seed weight. Conversely, no effect could be detected from the three types of legumes tested in association with maize.

The interaction between the two factors proved to be significant for the yield, and to some extent, for the number of cobs per plant and the weight of cobs. The best association was Sele with the 'makerek' velvet bean with 2.6 t/ha. On the other hand, the association of the local maize with this same velvet bean variety let to the poorest yield of the trial (0.7 t/ha).

Conclusions

This trial investigating the combination of different varieties of maize and climbing legumes led to interesting results. However, no clear trend could be indentified in terms of impact of the different legume tested. Further trials are planned.

4.4.3 Maize-velvet bean research conclusions

Several trials investigating the benefits of intercropping velvet bean with maize were implemented over the five year period from 2006 to 2010. A number of these trials failed to produce results, often due to the lack of rain, or because of other research site characteristics. Nevertheless, a few points have largely been demonstrated. These are summarized as follows:

- The use of intercropped velvet bean significantly reduced the weed burden during the first season it was planted. The combination of velvet bean and at least one weeding resulted in the absence of weeds at harvest, confirming farmers' observations.

- The planting time of the velvet bean is critical. If planted too early, velvet bean competes with the maize and can significantly reduce its yields. If planted too late, the velvet bean doesn't grow vigorously enough to reduce the weed burdon. The ideal timing appears to be one month after planting the maize. However, local and annual variations in rainfall patterns need to be taken into account.

- The benefits of using velvet bean to increase maize yields appear to accrue quickly. Significant effects have been recorded after only one of two velvet bean cycles. These long term effects need to be measured more precisely with the implementation of long term trials on the same plots. Effects are expected to be particularly strong on soils low in nitrogen and where water is not a limiting factor.

- The effect of different velvet bean varieties and other vigorous climbing legumes deserves to be investigated further, particularly species and varieties with easy-cooking beans. Trials of this nature will continue at Betano and Loes in 2011.

4.5 The effect of agronomic practices on maize yield

Introduction

Maize is one of the major crops in East Timor and a particularly important staple food in rural areas. It is usually planted at the beginning of the wet season to take advantage of an abundance of soil moisture and a relatively low weed burden. Timorese farmers also believe that late planted maize crops (i.e. 6 weeks after the start of wet session) fail to produce. Recent research in Baucau has confirmed that late crops of maize do not develop properly even when weeds are controlled. It is hypothesized that mite and insect burden (i.e. white grubs or stem borers) increases after the start of the wet season, putting increased pressure on late-sown crops, resulting in poor growth and no yield.

This experiment was designed to see if the systemic insecticide Furadan could reduce the symptoms of poor growth in late sown maize in Baucau.

Methodology

Maize was planted at the Baucau research station at three different times, a) on first rains, b) 3 weeks after first rains and c) 6 weeks after first rains with and without the application of Furadan (Carbofuran), a broad spectrum systemic pesticide. Furadan was either not used, or applied at 10g, 15g, or 20g per $25m^2$ plot. Each of the twelve treatments was replicated three times in randomized blocks. Growth was monitored throughout the season and various measurements recorded.

At harvest the inner 5 rows of each plot were recorded for yield. The number of plants and cobs as well as the weight of produce from each was noted. Data were later transferred from the field book to an MS Excel spreadsheet. The data was later transferred to GenStat Discovery Edition 3 and a two-way ANOVA used to investigate the effects of time of planting and Furadan application. The interaction between time of planting and level of Furadan application was also investigated.

Results and discussion

The plants planted six weeks after the opening rains failed to develop and such plots failed to produce any harvestable cobs. The plants reached a height of only 10-30 cm before dying. From soon after germination, the leaves had a wilted appearance, and plants lacked vigor.

Many of the other plots also had poor productivity. The highest yield was in the treatments planted immediately after rain without a Furadan pesticide application (Table 129). Planting immediately after rain produced higher yields than planting three weeks after. Furadan application of 10g/plot provided the lowest yields. The two higher levels of Furadan application resulted in higher (but not statistically significantly) maize grain yields.

Table 129. Maize yield (t/ha) with Furadan applications

No. of weeks after rain when planted	*Furadan application (g/25m² plot)*				
	0	*10*	*15*	*20*	*Mean*
0	0.88	0.15	0.40	0.52	0.49
3	0.13	0.07	0.22	0.45	0.22
LSD ($p<0.05$) Interaction		0.58			
6	0	0	0	0	0

Conclusion

Maize planted after early rains gave the highest yields. Applications of Furadan did not improve yields. The poor response to Furadan applications suggest that common maize insects (stem borer and white grubs) were not causing poor plant growth. However, Furadan has poor control against mites and it is possible that mite damage may be the cause of poor growth and development of late sown maize.

4.6 The effect of variety and soil preparation on sweet potato yield

Introduction

The introduction of SoL/MAF sweet potato (*Ipomoea batatas* (L.) Lam) varieties has resulted in very high yield advantages above locals. They are recommended for wide-spread planting by East Timorese farmers through the Seeds of Life program. With the large yield advantage resulting from larger tubers, it is possible that farmers may need to alter their agronomy to ensure that tubers of this size have adequate soil depth in which to grow.

Sweet potatoes store well in the soil when there is sufficient soil cover. In East Timor they are sequentially harvested to meet requirements leaving room for more roots to develop. Farmers use soil surface cracks to identify the location of large tubers, and dig these tubers when the soil cracks first appear. Once the soil is cracked, risk of pest attack is dramatically increased, particularly, from sweet potato weevil (*Cylas formicarius*). This trial investigated whether the larger roots from the new varieties might require an alteration in land preparation.

Methodology

The trial conducted at Betano research station used three methods of soil preparation and the three recommended varieties of sweet potato (Hohra 1, 2 and 3) planted in a randomized complete block design.

The soil preparation treatments were: a) cuttings were planted into a level tilled area with no further soil movement around the cutting until harvest; b) cuttings were planted with the same soil preparation but soil was concentrated around the roots once as they developed and c) cuttings were planted into soil ridges 50cm in width as usually the case with potatoes. Each of the soil treatments was sub divided with three replicates of each of the three recommended varieties.

Plot size was 5m x 5m with cuttings planted in rows. The distance between plants in rows was 30cm and the distance between rows (or ridges) was 50cm. Planting was on 7th January with plots harvested on 6th July, 2010. No fertilizer was used but the plots were irrigated on four occasions.

A two-way ANOVA was conducted using GenStat Discovery Edition 3 to test for the effects of variety, and soil preparation on productivity. The interaction of variety and method of soil preparation on productivity was also investigated.

Results and discussion

Sweet potato cuttings planted on ridges established a good ground cover much quicker than with the other treatments. Ridges also had the greatest number of viable plants. At harvest there was a significant difference in plant stand based on agronomic practice but non-significant varietal differences (Table 130).

Table 130. Yield of SoL sweet potatoes under different agronomic practices

Agronomy	*Variety*	*Plants / m^2*	*Roots / plant*	*Root weight (g)*	*Yield (t/ha)*	*Soil treatment mean (t/ha)*
	Hohrae 1	0.9	1.1	117	1.0	
Planting into flat area only	Hohrae 2	0.9	1.1	195	2.4	
	Hohrae 3	0.8	5.9	181	5.0	2.8
	Hohrae 1	1.3	0.9	129	1.4	
Planting into ridges of soil	Hohrae 2	1.1	1.3	229	3.5	
	Hohrae 3	1.6	4.8	166	12.8	5.9
Planting into flat area and	Hohrae 1	0.8	0.2	155	0.3	
subsequent hilling of soil	Hohrae 2	0.7	1.9	110	1.9	
around developing roots	Hohrae 3	1.0	8.4	132	10.5	5.0
LSD interaction (P<0.05)		*0.42*	*1.64*	*n.s.*	*2.6*	

Variety, type of soil preparation and their interaction significantly affected yield. There were consistent significant yield differences of F Pr. <0.001 between varieties with Hohrae 3 yielding most highest across all soil treatments (Table 130). Soil preparation type also recorded significant yield differences of F Pr. 0.002. However this was not consistent across varieties with an interaction of variety and soil preparation method (F Pr. = 0.003). The use of ridges produced the highest yields for all varieties. Surprisingly, planting into a flat seed bed with subsequent hilling of soil around the roots produced better yields than without subsequent hilling of soil for Hohrae 3 only. Lower yields were recorded for Hohrae 1 and 2 using this method. The latter result suggests that higher yielding varieties could benefit from a further covering of soil as the roots enlarge.

There were no significant differences recorded between mean weight per root across varieties or soil practices (Table 130). However there was a large amount of variation in the number of roots per m^2. In line with overall yield, Hohrae 3 had significantly more roots than the other varieties across all environments. Unlike yield however, it did not have the greatest number of roots per plant when planted in ridges. This was in contrast with the other varieties ensuring that on this variable, planting in ridges still produced the highest number of roots overall. An interaction of root number and agronomy was strong at F Pr. <0.001.

Hohrae 3 also had the greatest secondary root production (both weight and number) in all environments. Differences across the various varieties and environments for these variables did not display a clear pattern. Planting in ridges did tend to have lower secondary root production with Hohrae 2 and Hohrae 3 but not to a significant extent.

Conclusions

Seeds of Life sweet potato varietal evaluation trials record a number of variables. These include the number or weight of root tubers growing directly under the cuttings as well as secondary growth from the trailing vine. Higher yielding root tubers may trigger limitations caused by agronomic practice in both cases.

Higher yields were recorded for all varieties when ridging was used. However the number of root tubers per plant was slightly less for the highest yielding variety, Hohrae 3, when ridging compared to planting in the flat and subsequent hilling of soil around the tubers was used. While overall secondary root yield was greatest in ridged plots this did not hold true for Hohrae 3 which had fewer and lower yields of secondary roots compared with when soil was subsequently pooled around the roots.

The results presented in Table 130 suggest that, while ridges produce the greatest overall yield benefits, high yielding varieties might be limited in their lateral growth when planted in ridges. The ridges in question were 50cm in width leaving 25cm on each side of the cutting for lateral growth. Subsequent hilling of soil on top of the developing tubers of a high yielding crop also appeared to improve productivity although affects of this practice with the lower yielding varieties showed mixed results.

Planting on ridges achieved greater yields through enabling improved plant stand establishment. Although this tended to result in a lower number of roots per plant, the roots that were produced were more viable resulting in higher yields overall.

The research work conducted by Seeds of Life on sweet potato differs in one important respect to a frequent practice conducted on Timorese farmers' fields. Farmers periodically harvest the biggest root tubers from their fields replacing the soil and vines over the remaining tubers. This has proved very effective in gaining a number of harvests from the same crop in one season. It also has the added benefit that space is created for the smaller tubers to continue their development. This in itself may mitigate against the potential of a crowding out effect with higher yielding varieties.

4.7 Maize weevil tolerance

East Timorese farmers use maize weevil tolerance as a key selection criterion when choosing new maize varieties. This is acknowledged in the farmer field days conducted by Seeds of Life where farmers are asked to give their opinion on how effective the cob sheath will be in keeping weevils outside the cob. Storage losses due to weevil damage can be up to 30% of the crop. Local varieties with small cobs and tight sheaths tend to provide a good barrier against weevil infestation while those promoted during Indonesian times such as Arjuna remain poorly adopted when not stored in an airtight container. Weevil tolerance is measured in maize variety evaluation to assess the usefulness of the introduced maize populations for subsistence farmers, particularly when cobs are stored in the sheath.

Methods

Weevil (*Sitophilus zeamais*) damage and sheath tightness of 19 maize populations was measured at four locations in 2010, nine months after the 2008-2009 season's harvest. These included 3 local maize populations, 8 populations from the Philippines, 2 approved varieties from Thailand and India, 2 from Zimbabwe, 1 from Indonesia, and 1 Indonesian x Thai cross. More detailed information on these varieties is contained in the 2009 Annual Research Report.

Cobs for weevil tolerance testing of the 19 populations were sourced from the SoL maize variety trials. The maize populations were grown and stored at the Aileu, Baucau, Betano and Loes research locations. These locations represent different agro-ecological zones. Yields at these locations are detailed in the Seeds of Life Annual Research Report 2009.

At each location, the test populations were grown in a randomized complete block field design in 5m x 5m plots with three replicates. Cobs were taken from the outer two guard rows of each plot and stored for nine months as whole cobs in the sheath placed inside nylon bags in a rat-proof environment. Storage areas included hanging from a secured shipping container and a crop storage tree house where the bags were stored in a thatched house on top of a large wooden pole with a length of tin place around the circumference of the pole to prevent animals from climbing up it.

After nine months, cobs were separated into loose and tight sheaths at the end of the cobs. Cobs were then opened and the percentage of grains with evident weevil damage was assessed as 0, 10, 50 or 90%. This was inputted into an MS Excel spreadsheet to calculate the overall percentage damage for each plot and each site before being transferred for further analysis to GenStat Discovery Edition 3.

Results

There were significant differences between varieties and between locations. No variety x location interaction was observed however when tested using linear mixed models analysis.

Local maize varieties (M45, M47 and M49) had an overall lower level of weevil damage of 18–35% compared with 27-58% recorded for introduced populations (Table 131). The released varieties of Sele and Suwan 5 both ranked similar in the bottom half of the table. This is at odds with previous experience which showed Sele to be much more resilient to weevil damage than Suwan 5.

A promising line from recent on farm evaluation, P07 ranked in the top half regarding its resilience to weevil damage. This concurs with the opinions of farmers that have tested P07. HAR05 and HAR12 that have also been tested on farmers' fields were among the better performers.

The Indonesian Arjuna variety (M 24) which is still widely used in East Timor was consistently among the most weevil susceptible across sites.

Table 131. Weevil damage (%) 2010.

	Weevil score (% damage)					
Variety	*Aileu*	*Betano*	*Loes*	*Baucau*	*Average*	*St. dev.*
M 47	*38*	*26*	*23*	*12*	*25*	*11*
P 08	30	60	4	12	27	25
M 51	30	31	26	31	30	2
M 45	-	*23*	*12*	-	*18*	*8*
HAR 05	22	56	23	32	33	16
P 01	40	40	27	29	34	7
M 49	*53*	*35*	*23*	*30*	*35*	*13*
P 13	45	51	24	20	35	15
P 03	17	60	25	40	36	19
HAR 12	24	55	36	33	37	13
P 07	69	-	37	21	42	24
M 50	35	57	36	42	43	10
P 02	43	56	43	32	44	10
P 11	31	70	48	35	46	18
P 06	68	70	24	25	47	26
Suwan 5	44	64	42	38	47	12
Sele	55	62	50	26	48	16
M 24	46	54	56	54	53	4
P 09	69	72	46	44	58	15
F Prob	0.028	0.012	0.039	n.s.		
l.s.d.	31	27	28			
% cv	45	32	52			
Average	42	52	32	31	39	10
Local average	46	28	19	21	28	12

Overall weevil damage across locations is presented in Table 132 alongside a number of related measures. All measures were significant at the F Pr. <0.05 apart from the percentage weevil damage in cobs with loose sheaths. These measures are further explored in the following correlation graphs.

Table 132. Weevil damage of maize stored on four research stations

Variety	*Weevil damage (% grains damaged)*	*Percent of sheaths tight (%)*	*Weevil damage in cobs with tight sheaths (%)*	*Weevil damage in cobs with loose sheaths (%)*	*Percent clean cobs (%)*	*Cob weight (g)*	*Average yield (t/ha)*
M 47	*24*	*75*	*15*	*50*	*64*	*37*	*1.3*
P 08	26	66	17	46	62	57	1.2
M 45	*27*	*89*	*8*	*30*	*74*	*35*	*0.8*
M 51	29	69	20	52	61	49	1.3
HAR 05	33	69	21	56	53	57	1.6
P 01	34	63	19	59	45	51	1.6
M 49	*35*	*69*	*18*	*63*	*48*	*38*	*1.0*
P 13	35	54	22	53	36	50	1.2
P 03	35	62	18	50	46	57	1.4
HAR 12	37	60	20	63	49	51	1.7
P 07	42	48	39	61	32	73	1.0
M 50	42	63	26	72	45	51	1.7
P 02	43	50	21	63	42	53	1.6
P11	46	55	28	66	38	63	1.7
P 06	44	52	28	57	34	56	1.2
Suwan 5	47	54	33	69	39	56	2.0
Sele	48	61	31	66	34	57	2.0
M 24	52	51	35	75	31	53	1.5
P 09	57	44	36	74	26	50	1.7
LSD (P<0.05)	16	16	16	n.s.	17		

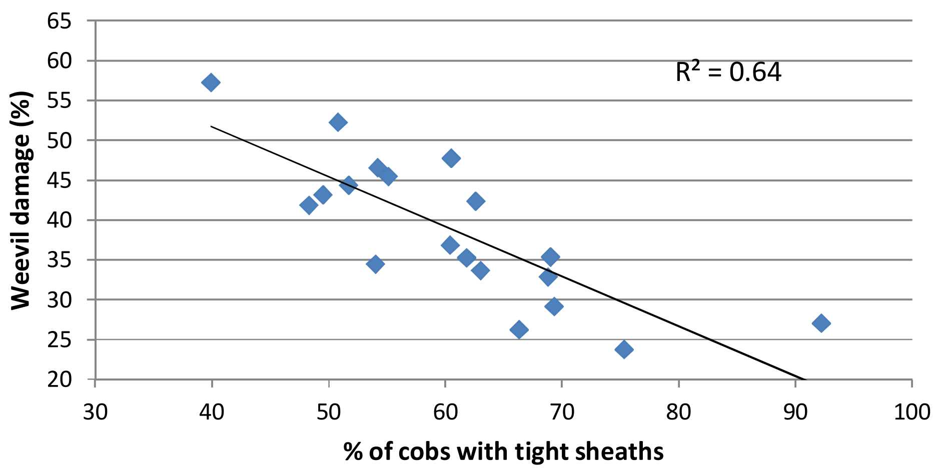


Figure 54. Correlation between weevil damage and tight sheath cover

Figure 54 displays the inverse correlation between the weevil damage within the cobs and the proportion of tight sheaths recorded for that variety. As expected Table 131 and Figure 54 show that varieties with a high proportion of cobs with tight sheaths are much less susceptible to weevil damage than those with more exposed cobs. All points are close to the line of best fit. A total of 64% of the differences in weevil damage were accounted for by how tightly closed the cob sheaths were. Further emphasising the importance of this protective barrier was a much better correlation of overall weevil damage to the damage scores of the cobs with loose sheaths compared to those with tight sheaths (Figure 55).

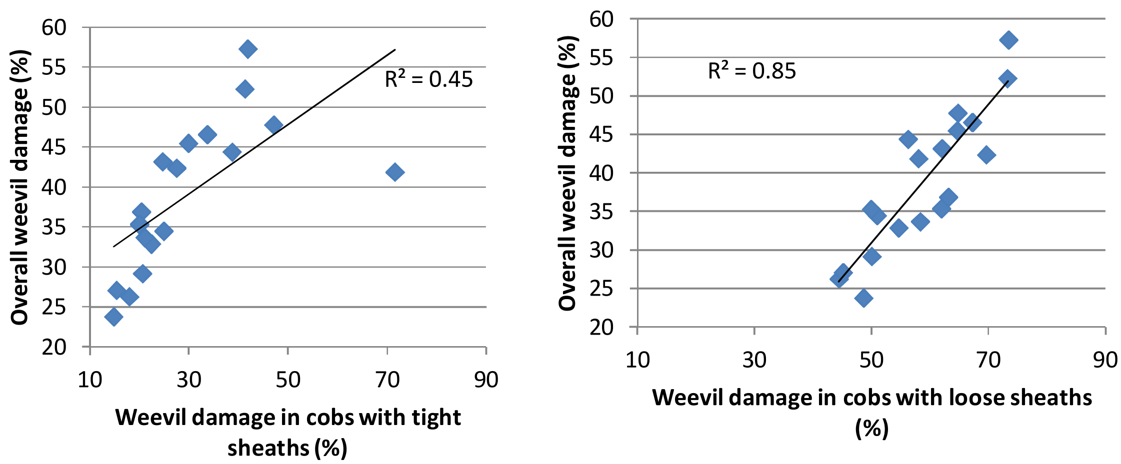


Figure 55. Weevil damage correlations between tight and loose sheath cobs

The correlation between cob size and weevil damage was much lower (Figure 56). Similarly the percentage of clean cobs when compared to cob weight gave a low R^2 value. The overall yield did tend towards a better correlation with susceptibility to weevil damage although this was still relatively weak (Figure 57).

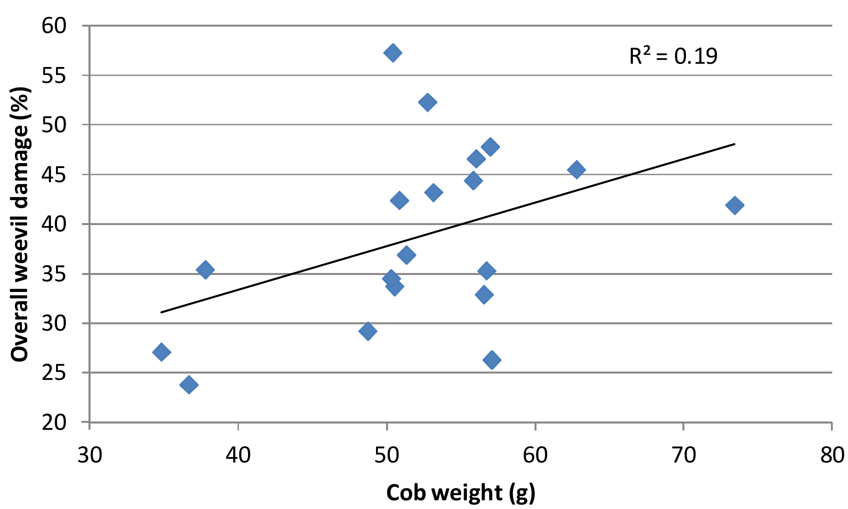


Figure 56. Correlation between weevil damage and cob weight

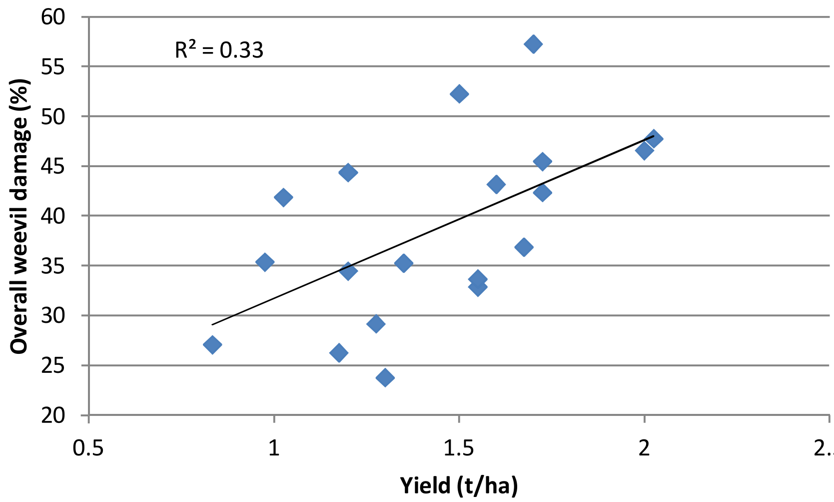


Figure 57. Correlation between weevil damage and yield

Conclusion

Grain spoilage due to weevil damage is estimated to be 30-40% when stored in the open in Timor-Leste. With with such a high rate it is vital for many Timorese farmers to mitigate against such damage by choosing varieties which have sheaths that completely cover the cob and remain in place over the storage period. Local varieties are well adapted in this respect with a sheath length which usually enables the farmer to tie the end in a knot thereby ensuring that the sheath covering remains firmly in place. However as seen in Table 132, local varieties (shown in italics) recorded much lower cob weights. Table 6 from the 2009/10 replicated maize results shows the importance of cob weights to overall crop yield. It can also be seen from Table 132 that the greater protection afforded by local varieties against weevils was at the expense of yield.

The larger cobs of maize varieties associated with greater yield are not necessarily associated with longer sheaths. Some cobs may have sheaths shorter than the cobs. There was not a significant overall correlation found between cob weight and weevil levels in the above data (Figure 56). However the divergence in these traits apparent when the local and new varieties are compared suggests that the size of cobs may well be inversely related to their weevil resistance.

There are now a number of organizations working in East Timor promoting the storage of maize kernels in airtight drums. For farmers with access to these drums, issues of weevil infestation in their stored maize becomes far less problematic. As weevils multiply in such conditions, the increased carbon dioxide they produce in respiration rises to critical levels resulting in their death. An extra benefit of improved storage would be the confidence it would give farmers to increase production of maize.

While the use of these drums will reduce the need to select for weevil tolerance, traditional storage of tied bundles remains the standard practive throughout the country. It is therefore critical that, for now that varieties continue to be chosen that have a reasonable level of tolerance.

5. Germplasm and weed collections

5.1 Germplasm collection

The MAF germplasm collection conserves plant genetic resources from rural areas in Timor-Leste. It was completed after the collection, conservation and monitoring of samples as well as the identification and characterization of the material. Germplasm (or 'plasma nutfah' in Tetun) is an asset for farmers, scientists and researchers because it is considered to be the biological basis for future plant breeding programs. In addition, the SoL/MAF program is conscious of the increasing popularity of a small number or improved varieties and that traditionally used germplasm should be conserved.

The SoL/MAF germplasm program was established in 2008 with the appointment and training in Australia of a full-time germplasm curator. The establishment of this program was a response to concerns expressed by international and national NGOs regarding the risk of losing local material. The germplasm program allows collecting and maintaining varieties of various crops in order to defend the sovereignty of local material.

Many varieties were imported to Timor-Leste during Portuguese and Indonesian regimes and even more after the country became independent. Maintaining both introduced and local varieties which are well adapted to the territory climate is a challenge.

The objectives of germplasm collection are:

- Exploring and gathering crop varieties from Timor-Leste
- Maintaining and managing new and local germplasm for the future
- Preparing information for further research

Methodology

Locations of collection: The current germplasm collection sites are at Betano, Loes, Aileu, Fatumaca and Maubisse

The largest collections are maintained at Betano and Loes research stations where the major food crop collections are maintained.

Aileu and Fatumaca are smaller research sites which are used as additional locations for germplasm collection.

Maubisse is a cool place which represents the temperate areas of Timor-Leste. The site is used to test and conserve varieties which are adapted to higher elevations.

Collection system: Activities involved are:

- Collection of material at the time of harvest
- Development of passport data for each sample
- Labelling
- Planting, observation and evaluation
- Conservation and documentation
- Identification and characterization
- Duplication or backup germplasm
- Seed bank management and storage

Germplasm data

A description of the germplasm collections are presented in Table 133, Table 134 and Table 135.

Table 133. Germplasm collection data, 2010

Crop category	*Tetum*	*English/Latin*	*Local*	*Introduced*	*Total germplasm*
Cereals	Hare Natar	Rice (Irrigated) (*Oryza sativa L.)*	3	17	20
	Batar	Maize (*Zea mays L.)*	3	12	15
	Terigu	Wheat (*Triticum aestivum L.)*	1	12	13
	Barley	Barley (*Hordeum vulgare L.*)	1	12	13
Tubers	Ai fariña	Cassava (*Manihot esculenta Cranz*))	5	30	83
	Fehuk midar	Sweet potato *(Ipomea batatus L.*)	3	27	30
			3		
Legumes	Fehuk ropa	Potato (*Solanum tubersosum L.*)	1	7	8
	Koto nani	Climbing bean (*Phaseolus vulgaris L.)*	3	17	20
	Fore-rai	Peanut (*Arachis hypogaea L.*)	3	17	20
	Foretali	Cowpea (*Vigna unguiculata L)*	3	0	3
	Lehe	Velvet bean (*Mucuna puriens L*)	3	0	3
	Koto moruk	Lima bean (*Phaseolus lunatus L.)*		1	1
	Foremunggu	Mung bean (*Vigna radiata*)	8	4	12
Total Germplasm			86	154	241

Table 134. Germplasm collection at the 6 research centres/sites, 2010

Crop	*Total No. of varieties*	*Number of varieties in each site*					
		Betano	*Loes*	*Aileu*	*Fatumaca*	*Corluli*	*Maubisse*
Maize	15	15	15	15	15	-	-
Sweet potato	30	30		7	10	-	-
Cassava	83	83	-	-	-	14	-
Velvet/Lima beans	13	13	4	-	4	-	-
Rice	20	13	-	-	-	-	-
Peanuts	25	20	-	-	-	-	-
Climbing bean	20	25	-	-	-	-	20
Mung bean	12	-	12	-	-	-	-
Wheat	13	12	-	-	-	-	13
Barley	13	-	-	-	-	-	13
Potato	8	-	-	-	-	-	8

Table 135. Details of local germplasm, 2010

Category	*Crop*	*Code*	*Name*	*Stock (Kg)*
Cereal	Irrigated rice	01	President	4 kg
		16	Membramo	4 kg
		17	Nona portu	4 kg
	Maize	M 45	Fatulurik	3 kg
		M 47	Kakatua	3 kg
		M 49	Viqueque	3 kg
	Wheat	W 12	Titboa	< 1 kg
	Barley	B L1	Aisnata	< 1 kg
Tubers	Sweet potato	C 01	Mutin	9 m^2
		C 02	Mean	9 m^2
		C 03	Atabae	9 m^2
	Potato	F 01	Maubisse	9 m^2
Legume	String bean	F M 1	Foretali makerek	< 1 kg
		A M	Asu kuas mean	1 kg
		A K	Asu kuas kinur	< 1 kg
	Climbing bean	K 20	Koto Maubisse	< 1 kg
		K 22	Koto Turiscai mutin	< 1 kg
		K 24	Koto Same Vila mutin	< 1 kg
	Velvet bean	LM 01	Lehe mutin	6 kg
		LM 02	Lehe metan	8 kg
		LM 03	Lehe makerek	< 1 kg
	Mung bean	Su	Suai	1 kg
		Be	Besikama	1 kg
		B	Balibo	2 kg
		F M	Foremungu metan	2 kg
	Peanuts	PT 21	Lokál Bo'ot	2 kg
		PT 22	Lokál Mean	2 kg
		PT 23	Lokál Bo'ot Loes	2 kg

The cassava collection at Betano has been collected over eight years, originating from the CIAT cassava evaluations conducted between 2003 and 2006. Details of the cassava collection are presented in Table 136 and Table 137.

Table 136. Introduced accessions in the cassava germplasm collection, Betano, 2010

Original district	*Code*	*Name*	*Original district*	*Code*	*Name*
Indonesia	Ca 01	CMM 96-27-76	Indonesia	Ca 36	CMM 97-02-36
Indonesia	Ca 02	SM 2361-1	Indonesia	Ca 25	Gempol
Indonesia	Ca 03	CM 96-08-19	Indonesia	Ca 37	CMM 97-11-157
Indonesia	Ca 04	CMM 96-08-44	Indonesia	Ca 15	Ai luka 2
Indonesia	Ca 05	CMM 96-36-255	Indonesia	Ca 42	CMM 97-02-181
Indonesia	Ca 06	CMM 96-37-275	Indonesia	Ca 26	Ai luka 4
Indonesia	Ca 07	CMM 90-36-224	Thailand	Ca 101	Hanate
Indonesia	Ca 08	OMM 96-02-133	Thailand	Ca 102	Rayong 1
Indonesia	Ca 09	CMM 96-36-	Thailand	Ca 103	Rayong 2
Indonesia	Ca 010	OMM 96-01-69	Thailand	Ca 104	Rayong 3
Indonesia	Ca 31	CMM 97-04-87	Thailand	Ca 105	Rayong 5
Indonesia	Ca 20	Daeng mere	Thailand	Ca 106	Rayong 60
Indonesia	Ca 33	CMM 97-02-183	Thailand	Ca 107	Rayong 72
Indonesia	Ca 34	CMM 97-11-155	Thailand	Ca 108	Rayong 90
Indonesia	Ca 35	CMM 97-11-155	Thailand	Ca 109	Kaset sart 50

Table 137. Local accessions in the cassava germplasm collection, Betano, 2010

Original district	*Code*	*Local name*	*Original district*	*Code*	*Local name*
Aileu	L 1	Mantega	Lautem	L 37	Ai fariña mutin
Aileu	L 3	Marungi	Lautem	L 38	Ai fariña mutin
Aileu	L 4	Mantega	Lautem	L 39	Kasarubi
Aileu	L 5	Silva	Lautem	L 40	Ai fariña mutin
Aileu	L 7	Nona metan	Lautem	L 42	Mantega
Ainaro	L 9	Tolon toka	Lautem	L 49	Mat com
Manufahi	L 13	Ai fariña mutin	Bobonaro	L 43	Mantega
Manufahi	L 14	Lesu	Bobonaro	L 44	Lesu
Manufahi	L 16	Mantega	Bobonaro	L 45	Senora
Manufahi	L 06	Au tahan	Bobonaro	L 46	Ai fariña mutin
Manatuto	L 17	Ai fariña ai funan	Bobonaro	L 47	Ai fariña mutin
Manatuto	L 41	Luru mean	Bobonaro	L 48	Mantega
Viqueque	L 18	Mantega	Bobonaro	L 50	Ai fariña Fuik
Viqueque	L 19	Caimalac	Bobonaro	L 53	Nona metan
Viqueque	L 23	Atisia butilai	Bobonaro	L 54	Ai fariña mutin
Viqueque	L 74	Boxnovi	Bobonaro	L 55	Nona metan
Baucau	L 24	Dara atisia	Bobonaro	L 56	Nona metan
Baucau	L 25	Atematu asarinik	Bobonaro	L 57	Mantega
Baucau	L 26	Olokai	Bobonaro	L 59	Nona metan
Baucau	L 28	Kasarubi	Liquiça	L 61	Mantega
Baucau	L 29	Mantega	Liquiça	L 63	Etu hare
Baucau	L 30	Dara atisia	Liquiça	L 64	Mantega
Baucau	L 32	Kulu atisia	Liquiça	L 70	Mantega
Baucau	L 34	Atisia lisibua	Liquiça	L 71	Ai fariña kangkung
Lautem	L 37	Ai fariña mutin	Liquiça	L 72	Nona metan
Lautem	L 38	Ai fariña mutin	Ermera	L 75	Ermera 35
Lautem	L 39	Kasarubi	Ermera	L 76	Ermera 36
Lautem	L 40	Ai fariña mutin			
Lautem	L 42	Mantega			
Lautem	L 49	Mat com			

Conclusion and recommendations

The SoL program to identify and release higher yielding improved varieties through the MAF is designed to supplement current cultivar useage rather than replace them. The introduction of new germplasm will increase genetic diversity in Timor-Leste. To ensure the diversity of germplasm remains available, the collection and conservation of local and imported germplasm should continue. If unique local varieties are identified they can be sent to international centres for maintenance under long-term storage. A large cool room will be purchased by the program for this purpose.

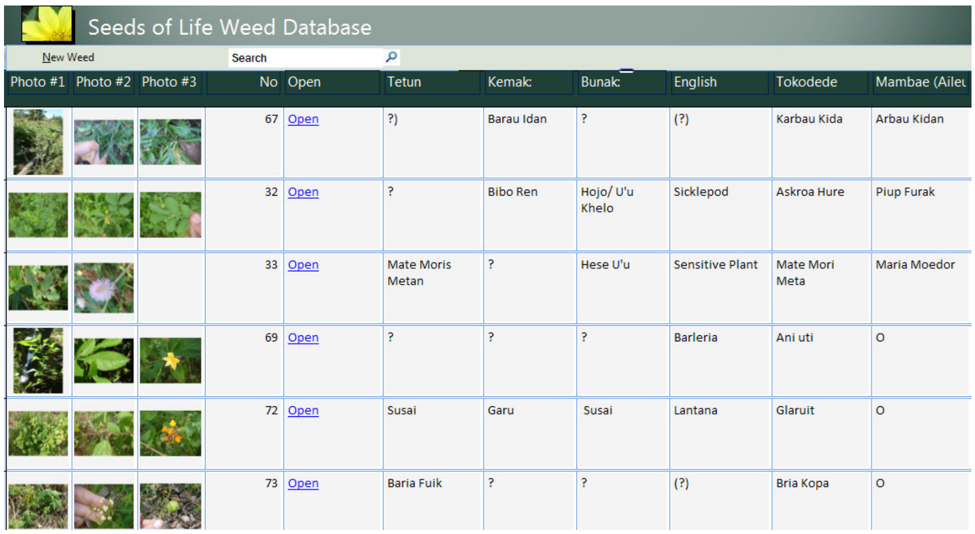
5.2 Weed collection & database

The SoL/MAF weed collection commenced in 2007 and at the end of 2010 a 121-entry weed collection and database, unique in Timor-Leste has been established .

Methodology

In March 2007, Jane Farrell provided training to SoL staff in pressing and drying of weed samples, which were subsequently stored at the SoL Dili office in MAF. An identity document was compiled including the plant description (with photos), collection location and up to ten different Timor-Leste language names as well as in Latin and English. In 2009, the information contained into those identification sheets were translated into an Excel database which is regularly updated.

In March 2010, additional training from the Australian Quarantine (AQIS) was provided about weed sampling and identification. In the meantime, Karen Myers converted the Excel spreadsheet into an Access database. The associated formula easily allows finding information and adding entries (Figure 58).


Seeds of Life Weed Database

New Weed Search

Photo #1	Photo #2	Photo #3	No	Open	Tetun	Kemak	Bunak	English	Tokodede	Mambae (Aileu
			67	Open	?)	Barau Idan	?	(?)	Karbau Kida	Arbau Kidan
			32	Open	?	Bibo Ren	Hojo/ U'u Khelo	Sicklepod	Askroa Hure	Piup Furak
			33	Open	Mate Moris Metan	?	Hese U'u	Sensitive Plant	Mate Mori Meta	Maria Moedor
			69	Open	?	?	?	Barleria	Ani uti	O
			72	Open	Susai	Garu	Susai	Lantana	Glaruit	O
			73	Open	Baria Fuik	?	?	(?)	Bria Kopa	O

Figure 58. An extract of the SoL Weed Database, 2010

Results

The weed database at the end of 2010 possessed 121 entries, most of which have corresponding dry samples stored in Dili (Table 138). This weed collection is the only one of its kind in Timor-Leste.

A total of 748 names have been recorded, 569 of them belonging to East Timorese local languages. This corresponds to an average of four or five local names recorded for each weed.

Table 138. Weed database characteristics, 2010

Total number of entries	*121*
Entries (%) with:	
4 names or less	36
5-8 names	36
at least 9 names	29
Monocot entries (%)	24
Dycot entries (%)	76

Language	*No. of entries with corresponding name recorded*
Latin (provisional)	91
English	88
Tetun Dili	46
Kemak	55
Bunak	46
Tokodede	72
Mambae (Aileu)	64
Mambae (Same)	65
Makasae	68
Midiki	38
Tetun Terik	79
Waimaa	36

6. Social science research

6.1 Baseline data survey (Buka Data Los)

A new set of farmers are interviewed each year to see if they are interested in participating in the OFDT program. Farmers who do accept the responsibility of installing 25 m^2 plots of different varieties for evaluation are then surveyed to determine their livelihood status. The program attempts to select representative farmers for the varietal evaluation program. Participating farmers are requested to complete a survey form to document their livelihood status and current farming practices. This survey is termed Buka Data Los (means 'looking for true or reliable data' in Tetun language) (BDL). The results of the survey then provide data to assist evaluate the results of the OFDT trials and for comparison across years. Any significant changes in the status of families, crops grown or serious issues with production can also be reviewed and evaluated for further action.

In 2009/2010 farmers were interviewed and data collected from the districts of Aileu, Ainaro, Baucau, Liquiça, Bobonaro and Viqueque. Data was collected from 480 farm households although a complete set of data was collected from only 354 households.

The results of the BDL survey provides information on the number of members in each household, whether the house is headed by a male or female, the type of crops grown, food security by household, reasons for crop failures or poor yields and a measurement of household wealth.

Farmer households and gender participation

Each farm household member in Timor-Leste plays a role in the farm operation. Young boys, for example, tend animals and older family members perform light duties such as milling grain. In 2009/2010 most farm households had between 5 and 9 members to distribute the workload (Table 139). A good proportion of these were children reflecting of the nation's high annual birth rate (2.7% in 2010). Larger households (greater than 10) accounted for approximately 11% of the population and most likely represents the inclusion of extended (grand parents) family members. Overall, comparing this year's figures with the 2009 survey, it would appear that the family size had increased by one person.

Table 139. Number of members of households by District

Members/household	*Aileu (%)*	*Ainaro (%)*	*Baucau (%)*	*Bobonaro (%)*	*Liquica (%)*	*Viqueque (%)*	*Average (%)*
1	0	0	0	9	2	14	4
2	8	0	4	7	4	2	5
3	4	12	5	4	5	7	6
4	4	6	5	13	4	5	6
5	13	12	18	19	19	14	16
6	42	35	21	12	14	10	22
7	0	0	13	7	19	19	7
8	13	6	11	10	18	14	12
9	13	6	5	12	9	5	8
10	4	18	12	4	2	3	7
11	0	0	2	0	4	3	2
12	0	0	3	0	0	3	1
13	0	0	0	0	0	2	1
14	0	0	1	0	2	0	1
15	0	6	0	0	0	0	1

Although farm households operate as production units, the head of household is considered to be the most senior person in house. Often this is a male but regularly females provide overall leadership in the house. During 2009/10 26% of the surveyed OFDT households were considered to be headed by women and 74% by men (Table 140). This compares with 30% and 70% respectively in the 2008/9 survey.

Table 140. Gender participation as heads of households, 2008/9

District	*Sub-District*	*Female (%)*	*Total Female*	*Male (%)*	*Total Male*
Aileu	Aileu	25	13	75	40
	Laulara	75	6	25	2
	Liquidoe	44	4	56	5
	Remexio	33	6	67	12
Ainaro	Hatudo	15	2	85	11
	Maubisse	18	3	82	14
Baucau	Baucau	33	22	67	45
	Vemasse	39	12	61	19
	Venilale	21	5	79	19
Bobonaro	Balibo	7	2	93	28
	Maliana	38	16	62	26
Liquica	Liquica	25	7	75	21
	Maubara	20	6	80	24
Viqueque	Ossu	24	9	76	29
	Viqueque Vila	11	4	89	34
Total		*26*	*117*	*74*	*329*

Cropping patterns

Farmers in Timor-Leste grow a wide range of crops to spread the risk of failure in one or more commodities. A list of food crops cultivated by farmers conducting OFDTs in 2009/10 is presented in Table 141. The risk of crop failure is also reduced though intercropping. The key food crops grown during the year were maize, sweet potato, cassava, rice and peanuts. Household consumption from harvest of these was supplemented with pumpkins, beans, taro and a wide range of other traditionally grown species. Approximately 19% of the OFDT farmers reported planting irrigated rice which is consistent with other surveys in Timor-Leste and reflects the greater emphasis on upland and dryland food cropping among the majority of Timorese farming households.

Surprisingly, only a small number of farmers reported growing bananas, papaya and mango. Most of the research was conducted at lower altitudes, and potato and bean farmers are not highly represented.

Table 141. Food crops planted in house gardens or bush gardens

Crops planted	*Total*	*% of total respondents*
Cassava (*Manihot esculenta Cranz*)	295	65
Long season maize (*Zea mays L.)*	272	60
Pumpkin (*Cucurbita spp*)	309	68
Sweet potato *(Ipomea batatas L.*)	264	58
Long bean (*Vigna unguiculata subsp.sesquipedalis*)	210	46
Short season maize (*Zea mays L.)*	247	54
Peanut (*Arachis hypogaea L.*)	231	51
Cucumber (*Cucumis sativus)*	197	43
Taro (*Colocasia esculenta)*	188	41
Arrowroot (*Maranta arundinacea)*	121	27
Kumbili (wild yam) (*Dioscorea spp.)*	144	32
Sinkumas tuber (yam bean) (*Pachyrhizus erosus)*	110	24
Irrigated rice (*Oryza sativa L.)*	86	19
Sorghum (*Sorghum bicolor*)	61	13
Maek (elephant foot's yam) (*Amorphophallus paeoniifolius)*	54	12
Red bean (*Phaseolus vulgaris)*	36	8
Bitter bean (*Phaseolus lunatus L.)*	51	11
Mung bean (*Vigna radiata*)	18	4
Upland rice (*Oryza sativa L.)*	16	4
Potato (*Solanum tubersosum L.*)	29	6
Banana (*Musa spp*)	8	2
Papaya (*Carica papaya)*	8	2

Tuber crops were prominent in the key staples (Table 142) of farmer households. Some of these (cassava and sweet potato for example) can be harvested over a period of time and provide valuable supplements to maize and/or rice and/or replace them during lean times. Tubers store well in the ground and are also harvested opportunistically as wild products from surrounding forests (see SoL, 2007). Although not mentioned in the tables, most farmers also grew additional spices, condiments and other vegetables in their gardens.

Table 142. Tubers cultivated

Tuber crop	*%*
Cassava	65
Sweet potato	58
Taro	41
Arrowroot	27
Kumbili (wild yam)	32
Singkumas (yam bean)	24
Maek (elephant foot's yam)	12
Potato	5

Food security

Data from the survey provided an indication of food production adequacy for domestic consumption among the participant farmers. (Table 143). Respondents were asked whether they considered their last harvest was insufficient to cover their annual needs, sufficient or they considered they had a surplus. This was a measure of production yields and was dependent to some extent on the availability of supplementary or alternative food supplies by particular households.

The percentage of farmers who considered that their harvests were particularly poor in 2008/2009 (to eat during the 2009/2010 growing season) were quite low compared to previous years (Table 144). This may be an anomaly for 2009/2010 but there does appear to be a trend of reducing numbers of food insecure farmers over the previous three years, despite the fact that the percentage of farmers with sufficient maize to sell remained low at 11%. Maize insufficiency was considered to be very serious in the districts of Ainaro and Liquica which recorded 94% and 25% insufficiency respectively. These results highlight the importance of crop diversification into tubers and other crops to spread the risk of a poor maize harvest.

Table 143. Respondent measures of food sufficiency (maize)

District	*Insufficient*	*%*	*Sufficient*	*%*	*Surplus*	*%*	*Total*
Aileu	6	12	31	62	13	26	50
Ainaro	16	94	1	6	0	0	17
Baucau	13	11	97	81	10	8	120
Bobonaro	9	13	45	66	14	21	68
Liquica	14	25	41	72	2	4	57
Viqueque	0	0	42	100	0	0	42
Total	58	16	257	73	39	11	354

Table 144. Respondent food security over years (maize)

Year	*Insufficient (%)*	*Sufficient (%)*	*Surplus (%)*	*No. respondents*
2006/2007	37	58	5	340
2007/2008	38	47	15	502
2008/2009	29	54	17	362
2009/2010	16	73	11	354

Although food sufficiency was much higher in 2009/2010, those farmers who were short of food had to cut back on consumption earlier during the year compared with the previous years (Figure 59). These figures suggest that maize supplies of 40% of poorest group were exhausted in June compared with 20% in 2008/2009. These farmers must have suffered a catastrophic reduction in maize yields in the previous year. Less than 5% of all respondents had run out of maize stores at this stage suggesting that an increased percentage of farmers were adopting yield increasing technologies as suggested in Table 144.

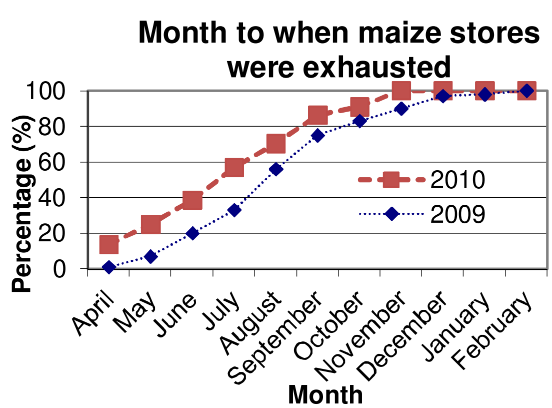


Figure 59. Maize sufficiency in farm households 2009 and 2010

A smaller number of farmers reported problems with their crops in 2009/2010 compared with the previous year. The lack of rain continued to be the main factor perceived to have reduced crop yields. Wind also appeared to be a problem (Table 145). Damage to maize crops from strong winds is particularly high in local varieties which tend to be taller. Farmers from areas where these winds occur may benefit from growing shorter statured varieties. Such varieties and those which display an advantage when cultivated under lower rainfall conditions will be investigated in the SoL varietal evaluation program.

Table 145. Farmer's perceptions of factors reducing harvest yields by district

District	*Lack of rain*	*Damage by livestock*	*Pests*	*Wind damage*
Aileu	0	0	0	0
Ainaro	9	0	0	6
Baucau	0	0	0	0
Bobonaro	2	1	1	4
Liquica	1	0	1	0
Viqueque	0	0	1	0
Total	*12*	*1*	*3*	*10*
Percentage	*46*	*4*	*12*	*38*

The most common practices of storage for maize and other crops are presented in Table 146. By far the most common practice was storing the maize above the fireplace or somewhere else in the house (88% of respondents). It is believed that the smoke and dry atmosphere above the fireplace reduces weevil damage. Other storage techniques included storage in a tree (to reduce rat and other animal damage) or in baskets. The use of improved storage techniques such as air tight silos, jerry cans and grainpro plastic bags remained infrequent. These improved storage techniques are designed to reduce oxygen levels in the containers to a level in which weevils cannot survive. It is interesting to note that the only farmers recorded using drums for storage were in Liquica and Bobonaro where the NGOs "Drums on Farms" and CARE's on-farm storage improvement program operate. The wider use of sealed drums and other improved storage techniques will reduce post harvest storage losses considerably.

Table 146. Storage methods for maize (and other crops)

Method	*Aileu %*	*Ainaro %*	*Baucau %*	*Bobonaro %*	*Liquica %*	*Viqueque %*	*Mean (%)*
Above the fireplace	92	100	82	79	79	0	72
Inside the house	0	0	1	0	0	97	16
Jerry can	2	0	2	10	16	0	5
Hang in a tree	2	0	11	4	0	3	3
Drum	0	0	0	6	4	0	2
Purchase in market	0	0	3	0	0	0	1
Sack	0	0	2	0	2	0	1
Along the wall	4	0	0	0	0	0	1
Total no. respondents	49	17	118	67	57	39	347

Economic status and strategies

The socio-economic standing of the farmers participating in the OFDTs was assessed to evaluate the range and average level to determine whether SoL was directing its varietal evaluation program correctly. The program aims to direct its activities towards an appropriate range of farmer families. Two levels of general household wealth were measured. These were the house type and household ownership of purchased consumer goods.

The standard residential housing among farmers participating in OFDTs is presented in Table 147. House style and quality are a widely used proxy for relative economic standing and tend to correlate well with household financial capacity. Roof type is a common indicator of household wealth with farmers opting for a waterproof galvanized iron covering if they can afford it. A majority (79%) of participating farmers did have iron or board roofs in 2010. A smaller number (69%) possessed solid roofs in 2009 (SoL, 2009). Walls were generally sago palm (bebak) (54%), half walls or full walls. In 2010, the percentage of farmers possessing cement floors was 34% compared with 22% in 2009.

Table 147. House types across the seven Districts

Description	Aileu	Ainaro	Baucau	Bobonaro	Liquica	Viqueque	Average
	%	%	%	%	%	%	%
Basic thatch roof	10	6	28	24	8	48	21
Tin/board roof	90	94	72	76	92	52	79
Tin walls	10	0	0	0	0	0	2
Sago tree walls	36	85	40	63	54	80	54
Half block wall	5	0	27	24	15	10	13
Full block wall	33	41	35	9	19	3	24
Non-cement floor	55	41	67	62	75	86	65
Cement/floor tiles	45	59	33	38	23	14	35

Ownership of vehicles and diesel generators was extremely low for farmers participating in the OFDTs (Table 148). However, ownership of mobile phones multiplied seven fold from 6% in 2009 to 43% in 2010 (Table 149). This is an indicator of improving wealth of OFDT farmers. Mobile phone ownership also facilitates the communication of improved technologies to farmers in the future.

Table 148. Wealth measures by key commodity ownership

Description	*Aileu*	*Ainaro*	*Baucau*	*Bobonaro*	*Liquica*	*Viqueque*	*Average*
	(%)	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*	*(%)*
Car	2	6	2	0	2	0	2
Motorbike	29	0	20	7	10	0	11
Mobile phone	45	47	64	58	19	24	43
Diesel generator	7	0	7	0	0	0	3

Table 149. Wealth measures across years

Description	2006/7	2007/8	2008/9	2009/10
	%	%	%	%
Car	2	3	1	2
Motorbike	5	5	3	11
Mobile Phone	3	10	6	43
Diesel Generator	3	3	2	3
Tin/board roof	na	76	69	79
Half block wall	na	22	20	13
Full block wall	na	19	17	24
Cement/floor tiles	na	34	22	35
Total number of respondents	340	502	362	354

Conclusion

The BDL survey presented above provided a good measurement of the farmer households participating in SoL OFDTs during 2009/2010. Most of the data indicate that OFDT farmers were subsistence farmers cultivating a wide range of crops to reduce the risk of food shortages. A small percentage of farmers did, however, start running out of stored maize early in the year. This loss of carbohydrate was most likely made up through the consumption of tubers, and in some cases, subsidized Government rice. The farm household food consumption survey described below commenced measuring some of these trends.

In 2010, there appeared to be signs of improvement in the wealth and wellbeing of OFDT farmers. Possible indicators include a smaller percentage of farmers facing food shortages, small improvements to the farm homes and a large increase in the number of telephones possessed by farmers. All of these indicators will be measured again in 2011 to see if these trends continue.

6.2 Farm household food consumption

A farm household consumption study conducted between 2007 and 2010 identified some indicators of food security levels as food availability ebbs and flows over the annual cultivation cycle. For the year from July, 2009 to June, 2010, measurements were taken in households in the districts of Aileu, Baucau, Liquiça and Manufahi. As with past studies, this study identified a number of issues. These were the change in consumption of staple during the year, the reliance on wild food when crops supply were reduced and the effect imported rice had on household food consumption patterns.

There was a notable shift from predominantly cereal consumption to consumption of tubers and roots as the supply of rice and corn thinned over the course of the year after being harvested in February - June. Compared to cereal crops, tubers such as sweet potato and cassava have the advantage of being able to be stored in the ground and harvested further into the dry season. This trend is illustrated in Table 150 showing daily consumption of rice, maize, sweet potato and cassava in a household in Lihuntutu, Maubisse, during 2009-2010. Small amounts of cassava were also consumed in this household. In Datulor, Manufahi (Table 151), where sweet potato is not as commonly grown, cassava was the substitute root crop during the same period.

Table 150. Daily carbohydrate consumption (kg), Lihuntutu, Maubisse 2009-2010

	Rice	*Maize*	*Sweet Potato*	*Cassava*
July	0.6	0	1.5	1.5
Aug	0.2	0	0	0
Sept	0.4	0	1.5	0
Oct	0.6	0	1	0
Nov	0.4	0	0	0.8
Dec	0.4	0	1.8	0
Jan	0.4	0	1.2	0
Feb	0.4	0	1.5	0
Mar	0.4	2	0	0
Apr	0.4	1	0	0
May	0	1	0	0
June	0	0	0	0

The surveys also indicate that there was increased consumption of wild foods over the year as the crop supply is reduced. A certain amount of foraging of wild foods was not necessarily an indicator of food insecurity but rather part of normal daily life as households appreciate the diversity that wild food brings to the diet. However, a larger amount of wild food foraging is an indicator of food shortages due to the fact that it is labour intensive to search for the food and cook it as extensive boiling is required to remove poisons and bitterness. Therefore as a main staple wild food is a food of last resort.

In more recent years, there have been notable increases in the amount of imported rice purchases towards the end of the cropping and start of the wet season as farmers' supply of food drops. Since 2004, the Government of Timor-Leste has imported rice and sold it at a subsidised price to the population. Over time the nation has become increasingly reliant on this imported staple which is discussed in more detail later in the paper under this year's research. Seven of the ten households surveyed in 2009 – 2010 relied on rice rather than the traditional maize crops.

Table 151. Daily carbohydrate consumption (kg), Datulor, Manufahi, 2009-2010

	Rice	*Maize*	*Sweet Potato*	*Cassava*
July	1.6	2.2	0	0
Aug	2.4	2	0	4.2
Sept	2.4	0	0	4.2
Oct	1.4	1	0	1
Nov	0.8	2	0	0
Dec	1.6	1	0	3
Jan	0.8	3.1	0	0
Feb	0	2	0	0
Mar	4	0	0	0
Apr	0	1	0	3
May	0	1	0	3
June	1	0	0	0

These findings have been useful in helping to guide the SoL program. For example, the identification of patterns of consumption has helped SoL to effectively target its variety development. The Consumption Study highlighted the importance of tubers for the Timorese diet and this has been recognised by the SoL program for which the sourcing and testing tuber varieties (cassava and sweet potato) has been a key pillar.

Second, the Consumption Study provides important information for the development of indicators for levels of food security. Such indicators can be useful for identifying both positive and negative changes. In relation to negative changes, one of the challenges for the Government and development partners is knowing when food security drops to a critical point and food assistance is required. The development of indicators of changes in food security can assist with this. In relation to positive changes, in the context of the SoL program it was hoped that the indicators could be developed that would reflect positive trends associated with the adoption of SoL varieties and their impact on food security. Such indicators might include:

- increases in levels of cereals consumed, particularly corn
- reduction in purchases of rice and/or a shift from consumption of imported rice to local rice
- increases in the amount of produce being bought and sold in the markets
- increased investment in assets such as livestock, consumer items or productive assets for on-farm or off-farm enterprises

6.3 Farming community focus group discussion

A Focus Group Discussion (FGD) Study was carried out in 2010 in four communities in the districts of Manufahi, Baucau and Ainaro to evaluate how communities from different ecological conditions effectively adapted their livelihood strategies. This included the different roles played by market and subsistence activities. Some attention was also given to assessing the challenges faced by communities both ecological and institutional and evaluating the priorities for communities, for SoL and for Government in improving their livelihood potential and food security.

The study was designed to highlight the diversity of the livelihood strategies employed by the different communities in terms of their crop management, seed systems, water management, livestock management and market interaction among other things.

Methodology

The FGD Study was carried out over the months of April to June 2010 in four locations which were selected to represent contrasting conditions such as upland and lowland, in-land and coastal, remote and accessible. The locations were selected in conjunction with OFDT staff to capture areas where the SoL program had been active. However, it was not a necessity that all participants had been part of the SoL program. In each location a group of approximately 10 participants was selected and research activity was conducted over one day. The locations of the Focus Group Discussions (FGD) are presented in Table 152:

Table 152. Sites for Focus Group Discussions

District	*Sub-district*	*Village*	*Hamlet*
Manufahi	Same	Selihasan	Selihasan
Baucau	Baucau	Liboroe	Liboroe
Ainaro	Maubisse	Lihuntutu	Lihuntutu
Baucau	Venilale	Fatulia	Ossowaki

A discussion was held in each location during which social science surveyors asked participants about their livelihood activities including growing, buying and selling activities, gifting and loaning, wild food consumption and land management. Questions were asked about challenges in carrying out these activities and farmers' main concerns. The survey team also asked questions about seed mapping including sourcing of seed and the nature and extent of circulation. Women and men both participated in the FGDs. Techniques were employed to ensure that input was captured from all participants including women. Following the group discussion, up to six of the farmers who participated in the FGD were surveyed in more detail. Both women and men were interviewed. Questions were asked about similar topics. The aim was to capture more specific detailed information about individuals' households' activities to complement the information garnered through the FGD. There were a number of limitations to the methodology in terms of its capacity to provide a representative picture of livelihood strategies and systems.

Results

The livelihood strategy of the Selihasan community, shaped by the ecological conditions and networks of market relations in which they were situated had both strengths and weaknesses. In terms of their ability to achieve food security through subsistence they were disadvantaged by poor rainfall and poor fertility of their lands. However, living relatively close to a major town and major market centre respondents had more cash earning opportunities such as wage earning. The wage earning sometimes prevented residents from preparing their land for planting and thus is a mixed blessing in terms of livelihoods.

Liboroe is a lowland rice growing area near the north coast in the district of Baucau. Residents in Liboroe are rice farmers. Due to the high labour intensity required to cultivate irrigated rice, farmers tend to specialise in rice farming, meaning they farm less land for corn and other crops compared with farmers in upland areas. They may also farm rice as a cash crop. Liboroe residents have difficulty affording costly inputs required to maintain their irrigation infrastructure.

Lihuntutu is an upland aldeia (hamlet) in the district of Ainaro with a temperate climate situated on the main road from Dili to the town of Same on the south coast. The livelihood strategy of Lihuntutu respondents is orientated around temperate crops, cash crop sales of coffee and red beans and a mix of growing and purchase of staple crops. Respondents do not grow any rice. Living next to a main road they have ready access to markets (transport is available) and potential customers. Moreover, while they do not have access to irrigation or experience two wet seasons, because of the high altitude (damp climate) and short dry season they often grow two red bean crops when they get good rains and can grow vegetables well into the dry season.

Ossowaki is located upland in Baucau district. Residents have a very subsistence orientated livelihood strategy. They live two hours walk from the local market which hampers their capacity to buy and sell produce but their subsistence capacity is strengthened by the fact that they can grow a wide range of crops. In addition to rice and corn, tubers and peanuts were all grown extensively by respondents in the last cultivation cycle as were a wide range of vegetables. The fact that both tubers and cereals grow well in the area increases the overall availability of food. Also, respondents in Ossowaki have ongoing access to all the SoL varieties which they had obtained through World Vision as well as SoL. A greater quantity of seed has been available through the NGO program. Food availability over the course of the annual food cycle, however, is marred by the fact that Ossowaki residents do not have access to irrigation.

Communities have varying strengths and weaknesses in relation to both these aspects that interact to form their livelihood context. While the study focused on the distinctiveness of the communities, a number of common themes and issues emerged which have implications for livelihood and food security programs.

A community’s ability to feed itself by growing food depends on the quantity and type of food grown and the availability of food throughout the year in the context of the calendars of cultivation for the crops grown. Germplasm for a wide range of species suited to particular locations should be tested.

Programs in integrated pest management and integrated rodent management are needed which make careful use of chemicals combined with other methodologies such as strategic intercropping, knowledge of and interception in the life cycle of pests and use of physical barriers to increase the availability of food for consumption. Distributing sealed storage containers is a simple, effective initiative that can also be considered “low hanging fruit” and a priority for funding.

Improving their access to water for agriculture is a major preoccupation for all groups. This preoccupation tended to overshadow perceived benefits from improved varieties. While water harvesting systems such as small-scale irrigation systems and farm dams may not be able to make available enough water to grow cereal crops the whole year around, such systems can sometimes enable farmers to grow a second crop, can help to tide farmers over when rainfall is inconsistent and also enable farmers grow vegetables for longer into the dry season. Support for water harvesting would be a good compliment to support for making available improved germplasm of staple crops due to the high level of priority of the water issue in community members minds in addition to the advantages for crop growing.

The study showed that seed systems are primarily subsistence based with farmers seeking, and the majority succeeding, to obtain seed to plant from their own harvest. This was not always possible, however, due to crop failure or damage to seed during storage. When farmers were deficient in seed to plant, farmers would access seed by requesting, buying or borrowing seed from their family members or neighbours or buying seed in the market. In regard to the purchase of seed in the market, farmers in different areas had different “rules” about which seed could be purchased.

The study indicated that farmers are keen to plant SoL varieties and indeed many would be prepared to pay for the seed depending on the appropriateness of the varieties for local conditions and preferences. Farmers still plant local varieties however, due to the fact that local varieties also have characteristics they like, for risk management and so the strains don't disappear.

Availability of SoL seed is still largely constricted to distribution through the SoL program and there has been limited integration of SoL varieties into local seed systems. It is notable that the area where there has been more integration of SoL seed into local seed systems (Ossowaki) is the area where there is an NGO program operating (World Vision).

In terms of achieving food security by obtaining cash to purchase food, issues which make a difference are proximity to markets and main roads, whether or not viable cash crops can be grown and availability of other sources of income such as wage labour.

For those communities which are very far from a main road consideration should be given as to whether it would be possible for regular transport (eg weekly) to be provided to a local market.

Continuing to develop germplasm for cash crops such as peanuts and red beans should be a priority. Developing the rice industry is also important for cash crop development.

Even with improvements to productivity, however, cash income earned from the sale of agricultural production is not a consistent source of food security as it is only obtained by the household at harvest time. Communities with some cash earning potential but lacking in a strong subsistence base are vulnerable to food insecurity. There is a need for ways to smooth out cash flow across the ebbs and flows of cultivation cycles.

Food availability

A community's ability to feed itself by growing food depends on the quantity and type of food grown and the availability of food throughout the year in the context of the calendars of cultivation for the crops grown. This study was not able to effectively assess issues relating to the quantity of food available due to the fact that, in talking with farmers, it is difficult to get a measurable account of land size and the amount of food planted or harvested. Nor has the study been able to look at differences in food availability at different times of the year. However, it was evident that there were differences in the variety of food grown between different areas and the impact of the level of variety on food security. Ossowaki was the only area where tubers, cereals, peanuts and vegetables all grew well and this contributed positively to food security. At this site, households were able to eat a more varied diet which stretched out food availability and had positive nutritional benefits. For example, respondents in Ossowaki ate tubers for breakfast and cereals for lunch and dinner whereas in other areas where tubers did not grow so well respondents ate cereals or wild foods for breakfast.

The study reconfirmed the well-known fact that pests and rats contribute to significant harvest losses both pre and post harvest. The study also revealed substantial losses post harvest and limited availability of sealed storage containers. Distributing sealed storage containers is a simple, effective initiative that can also be considered and a priority for funding.

Drought was also identified by respondents as a major factor contributing to reduced harvests, although it was less of an issue in 2010 which was wetter than previous years for most farmers. Improving farmers' access to water for agriculture was a major preoccupation for all groups. The two communities that did not have irrigation mentioned that they had submitted a proposal to the Government for piping water from the river. The two communities that had irrigation lamented the poor state of the infrastructure..

As mentioned above, seed systems are primarily subsistence based with most seed being saved from previous harvests. Where needed, some seed was gifted by friends and neighbours but generally in small amounts (e.g. 1kg). Larger amounts of seed (e.g. 5g) was generally bought or borrowed. Borrowing incurred high interest rates (often 100%) unless it was between family members in which case no interest is charged. In regard to the purchase of seed in the market, farmers in different areas had different "rules" about which seed was purchased. For example, in Maubisse, farmers were reluctant to purchase corn in the market due to concerns about quality. In Secial farmers would purchase corn but not rice.

Something that came through the study strongly was that each variety had its strengths and weaknesses. Availability of SoL seed was still largely restricted to distribution through the SoL program and there was limited integration of SoL varieties into local seed systems. It was notable that the area where there had been more integration of SoL seed (Ossowaki), an NGO program had operated for some time (World Vision). The World Vision program distributed larger amounts of seed over successive seasons than the OFDT program which was involved in on-farm testing rather than distribution. This constraint will be reduced in 2011 when the new SOL 3 program commences and seed production and distribution of released varieties will be ramped up.

The ability of communities to organise working groups was observed to be a key factor influencing livelihood success. Traditional systems of organisation existed, such as mutual labour exchange systems. Some communities had more developed systems of organisation (eg Ossowaki) than others (eg Selihasan). However, at the time of the study, traditional systems were not covering land management, seed production, IPM and IRM and infrastructure development for irrigated rice farming.

Access to markets and communication

The proximity of farmers to markets and main roads influences their ability to achieve food security by obtaining cash through product sales. Two of the studied communities (Selihasan, Lihuntutu) were located next to a main thoroughfare and two of the communities (Liboroe, Ossowaki) were approximately two hours walk from a main road or market. For the latter communities the provision of regular transport (eg weekly) would support the community

Two of the communities grew cash crops (in Maubisse they grew red beans and coffee and in Liboroe they grew rice). In Selihasan respondents had more access to wage labour than the other regions.. Continuing to develop germplasm for cash crops such as peanuts, rice and red beans will remain a research priority to improve access to cash. Access to off-farm work would also assist food security.

Cash income earned from the sale of agricultural production is not a consistent source of food security as it is only obtained by the household at harvest time. Communities with some cash earning potential but lacking in a strong subsistence base are vulnerable to food insecurity. There is a need for ways to smooth out cash flow across the ebbs and flows of cultivation cycles. The practice of borrowing provides this to some degree. In addition, households can invest in livestock which can be sold at a later time when cash is needed. The productivity of livestock as an investment base has been improved in rural communities in some countries through improving the diet and care of animals.

6.4 Seed mapping

Introduction

A number of reviews on ways to improve agricultural production in Timor-Leste have identified the need to better understand seed systems. These are systems of production, storage, use and distribution of seed operational within the community. The objective is to get to the point where improved seed is available within communities in a sustainable way, whether through systems of distribution involving the government, private sector or community systems or a mixture of all of them. Thus it is necessary to understand existing systems of distribution of seed. In this context, a seed mapping study was conducted to analyse systems of production, distribution and storage of seed for peanut and maize crops.

Methodology

Semi-structured interviews were conducted with 40 farmers who planted maize and peanut in the most recent season. The survey was carried out in December 2009.

The questionnaire covered topics related to household decisions about planting, land tenure, source of seed and quantity of seed planted, farmer strategies to access seed in the case of seed gifting of seed to other farmers, planting methods including the number of seeds planted per hill, rituals related to the planting activities.

Participant farmers in this survey were from 5 Districts where the Seeds of Life program operated including: Baucau, 13 participants (33%), Manufahi, 10 participants (25%), Liquiça, 9 participants (23%) participants, Aileu, 5 participants (12%) participants and Ainaro, 3 participants (7%) participants. Of the total participants, 60% were male and 40% were female.

Results

Of 40 participant farmers, 65% planted maize (local), 32.5% planted peanut (local), and 10% planted Utamua. No farmers planted any SoL maize varieties. All the farmers who planted Utamua also planted local varieties of peanut.

Reasons for growing varieties

Farmers grew the different varieties for a range of reasons as shown in Table 153. The majority of farmers (75%) said they grew the large seeded peanut Utamua to sell and 25% said they chose Utamua because of its high yields. Seventy five percent also said they grew Utamua because they wanted to try a new variety and 25% said they grew the new variety because they were dissatisfied with their local varieties. Of those farmers growing local peanuts, 31% said they did so to sell, 31% said they grew it for staple food and 31% said they grew it for its high yield. It is notable that Utamua was viewed more as a cash crop than the local variety of peanut.

Table 153. Farmers' reasons for growing varieties

Reason	Varieties		
	Utamua %	Peanut *(Local)%*	Maize *(Local)%*
Daily food	0	31	54
Familiar with that variety	0	7	38
High yield	25	31	0
Good taste	0	0	8
Sell	75	31	0
Want to try a new variety	75		
Dissatisfied with local variety	25		

In regard to local maize, 54% of farmers said they grew it because it was their daily food and 38% said they grew it because they were familiar with it and 8% said they grew it because of its good taste.

Decisions about seed selection

Associated studies (see this chapter) found that women have a dominant role in decisions about seed selection, planting, and storage. However this study showed a greater trend toward joint decision making and decision making by men as the table below shows.

Table 154. Decision making about planting

Decision maker	Varieties		
	Utamua %	Peanut *(Local)%*	Maize *(Local)%*
Men	0	38	0
Women	0	15	8
Both	100	47	92
Total	100	100	100

Sources of seed

Farmers have developed systems to ensure a sustained supply of seed. As subsistence farmers, farmers' intention is to save seed from their previous harvest. The majority of farmers (77%) participating in the study were successful in doing so as Table 155 demonstrates. For participant farmers in the most recent cultivation cycle, those who were unable to save their own seed purchased seed at the market (23%).

Table 155. Seeds sources in 2009/2010

Seeds sources	Varieties		
	Utamua %	Peanut *(Local)%*	Maize *(Local)%*
Own seed	0	77	77
Buying *(Market)*	0	23	23
SoL program	100	0	0
Total	100	100	100

Table 156 shows that of farmers who purchased local peanut and maize seed at the market, 100% did so because the supply of seed from their own harvest was insufficient due to poor harvest. Utamua was only obtained by farmers through the SoL program. This shows that the SoL variety peanut is not yet integrated into local seed systems.

Table 156. Reasons for purchasing seeds from market

Reason	Varieties		
	Utamua %	Peanut *(Local)%*	Maize *(Local)%*
Insufficient seed	0	100	100
Total	100	100	100

All farmers who sourced seed from the market also said they borrowed seed or received seed from relatives or neighbours as Table 157 shows. It is notable that there was a higher level of gifting of seed than borrowing/lending, and borrowing/lending only occurred in relation to distribution of maize seed and not of peanut seed. Information such as this helps to build up a picture of seed systems in different locations and in relation to different commodities.

Table 157. Farmers' strategies to source seeds if supply insufficient

Farmers' strategies	Varieties		
	Utamua %	Peanut *(Local)%*	Maize *(Local)%*
Buying *(Market)*	100	100	100
Loan	0	0	31
Obtain from Family/neighbours	75	54	35

Table 158 shows the ways in which farmers distributed seed if their own supply permitted. The majority of farmers did not share any of their maize seed. However, a larger proportion of farmers distributed their peanut seed, both local and SoL variety, by selling and gifting to neighbours and friends. In the exchange of commodities, the buyer did the differentiation between seed and food. Therefore the fact that participant farmers distributed a larger amount of peanut seed is reflective of the fact that a majority of peanut produce was sold.

Table 158. Methods of distribution of seed by farmers

Methods of sharing	*Varieties*		
	Utamua%	*Peanut (Local)%*	*Maize (Local)%*
Did not share	0	0	88
Sell *(Market)*	50	61	4
Loan	0	9	4
Gave to family/neighbours	50	30	4
Total	*100*	*100*	*100*

Another interesting point is that the high level of circulation of Utamua implies that its availability in the community should increase in the future. While for this seed mapping survey, Utamua was only sourced by farmers from the SoL program, the high level of distribution of the seed that occurred is likely to result in a greater level of availability in subsequent seasons and integration of the variety into local seed systems.

Table 159 shows planting methods used by farmers participating in the survey. It is notable that a small amount of row planting was done in growing local peanuts. Table 160 shows the number of seeds per hill.

Table 159. Planting methods

Planting methods	*Varieties*		
	Utamua %	*Peanut (Local)%*	*Maize (Local)%*
Random	100	85	100
Row	0	15	0
Total	*100*	*100*	*100*

Table 160. Seed numbers per hill

Seeds per hill	*Varieties*		
	Utamua%	*Peanut (Local)%*	*Maize (Local)%*
1	25	30	0
2	75	62	50
3	0	8	35
4	0	0	15
Total	*100*	*100*	*100*

The results presented in Table 161 shows that a small percentage of farmers undertook a ritual activity in association with planting. There was a slightly higher number for Utamua but given the small sample it is hard to draw definitive conclusions from this data. From the farmers who did the ritual ceremony at planting 100% reported that the objective was to protect the seeds from pest or damage as (Table 162).

Table 161. Ritual ceremony related to the planting

Do ritual ceremony	Varieties		
	Utamua%	Peanut *(Local)%*	Maize *(Local)%*
Yes	25	8	19
No	75	92	81
Total	100	100	100

Table 162. Objectives of ritual ceremonies

Objective	Varieties		
	Utamua%	Peanut *(Local)%*	Maize *(Local)%*
Protect seeds from pests	100	100	100
Total	100	100	100

Discussion

This study was an investigation of farmer behaviour relating to sourcing seed for two local crops (maize and peanut) and one new variety (Utamua peanut). The results indicate that the orientation of farmers in obtaining seed from one season to the next is primarily subsistence i.e. by saving seed from their previous harvest to plant in the next harvest. However this system fails in some cases and then there were other means to obtain seed which included purchase at the market or requesting, borrowing or buying it from friends or relatives. In relation to a question of what they had actually done, all farmers (23%) who had lost local peanut or maize seed said they purchased it in the market. However, when asked in general about strategies employed to access seed when lost (not in relation to any specific time scale) farmers said that they also borrowed or requested seed from family or neighbours.

The subsistence orientation of farmers in regard to seed makes it more challenging to link up the distribution of seed to existing seed systems. It shows that seed markets are underdeveloped compared to many countries where there are networks of seed traders. In this context a community based approach to developing sustainable systems of seed distribution for improved varieties may be more appropriate than a commercial approach.

Another point, which is supported by evidence presented in the FGD study is that seed systems are variable. This seed mapping study shows levels of maize distribution to be much lower than levels of peanut distribution. The FGD study shows there are different rules about the sourcing of seed for different locations. The development of systems for distribution of seed needs to be sensitive and responsive to these nuances.

6.5 District market study

A market survey in Manufahi and Baucau markets was carried out which involved monthly visits to the two markets over the period of September 2009-June 2010. This survey aimed to reveal which staple foods were sold by farmers each month in order to track the presence of varieties in the community and determine their impact on the economy.

Methodology

A surveyor identified which commodities were being sold, of which varieties, who was selling them (woman or man) and where they were from.

Results and Discussion

The number of sellers with each commodity for each month are presented in Table 163 for the Baucau market and in Table 164 for the Manufahi market. As these tables show, most farmers sold local maize, rice, peanut and cassava each month. Only a small amount of SoL varieties reached the market in 2009-2010 but some varieties were becoming popular for sale in Baucau. For example, Utamua peanut was available in the market every month except October. Ailuka cassava was unavailable overall but small amounts of Sele maize and Nakroma rice were being sold.

Table 163. Number of sellers of commodities by month, Baucau market

	2009		*2010*									
	Nov	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Sep*	*Oct*	*Tot.*	*%*
Local. maize	65	24	51	45	23	33	30	22	26	46	365	26
Sele maize	0	0	0	0	2	0	1	0	0	0	3	0.2
Local rice	15	16	10	5	1	6	25	2	16	7	103	7.5
MTCI rice	1	0	6	8	5	3	9	6	2	3	43	3.1
Nakroma rice	0	0	0	0	0	0	2	0	0	0	2	0.2
Local sweet potato	1	3	1	0	12	8	12	3	4	0	44	3.2
Hohrae sweet potato	2	0	1	0	7	6	15	4	0	0	35	2.6
Local peanut	8	17	18	46	38	12	28	20	17	4	208	15
Utamua peanut	1	1	3	0	1	0	7	2	5	0	20	1.5
Local cassava	1	15	2	2	7	7	10	2	15	5	66	4.8
Ai luka cassava	0	0	0	0	0	0	0	0	0	0	0	0.0

Note: MTCI rice is Ministry of Tourism Trade and Industry subsidized rice (mainly imported).

In the Manufahi market (Table 164), no Nakroma, Hohrae or Ai luka was sold during the survey period but small amounts of Sele and Utamua were available in May, 2010. It is expected that the availability of SoL varieties will become more prevalent onwards from 2010 as they become more widely adopted by farmers.

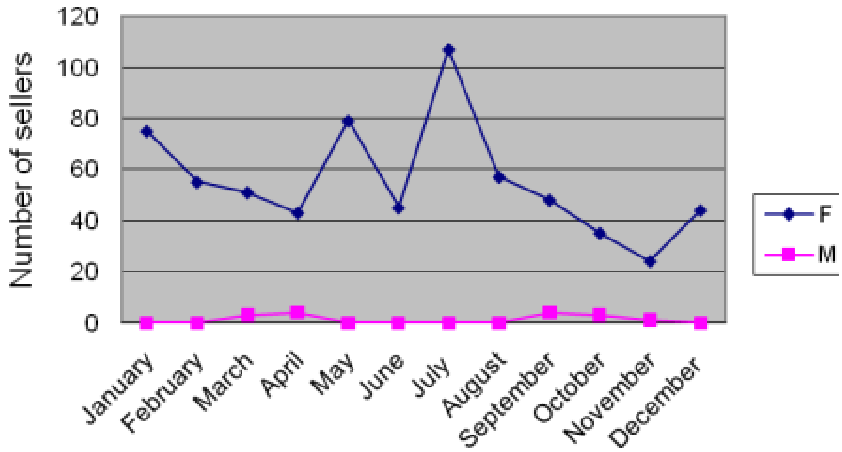
Imported rice, local maize and local peanut were available in the market every month in both districts. Imported rice was most available in January, February because in those months all crops were still in the field except for farmers who grew short season maize in order to secure food shortages in that month.

Table 164. Number of sellers of commodities, Manufahi market by month

	2009		*2010*									
	Nov	*Dec*	*Jan*	*Feb*	*Mar*	*Apr*	*Ma*	*Jun*	*Sep*	*Oct*	*Tot.*	*%*
Local. maize	12	16	18	15	15	18	28	15	16	9	162	32
Sele maize	0	0	0	0	0	0	1	0	0	0	1	0.2
Local rice	0	0	7	0	0	0	0	0	0	4	11	2.2
MTCI rice	12	19	48	27	14	5	12	14	25	18	194	38
Nakroma rice	0	0	0	0	0	0	0	0	0	0	0	0.0
Local. Sweet Potato	0	0	0	0	0	0	0	0	3	0	3	0.6
Hohrae SP	0	0	0	0	0	0	0	0	0	0	0	0.0
Local peanut	1	8	3	13	25	18	35	16	2	3	124	25
Utamua peanut	0	0	0	0	0	0	2	0	0	0	2	0.4
Local cassava	0	1	0	0	0	2	1	0	2	1	7	1.4
Ai luka cassava	0	0	0	0	0	0	0	0	0	0	0	0.0

Gender role in market activities

Farm work responsibilities are generally split along gender lines. The SoL survey conducted in 2006 demonstrated that men tend to do the heavy jobs such as land preparation, carrying, carting the harvest and threshing. Seed selection, planting, and harvest are generally the responsibility of women. Women also prepare the food for all household members and develop strategies to find food during food shortages. This market survey demonstrates that, as part of this strategy, women play the predominant role in selling the farm surplus in the market. In Baucau, 99% of the sellers were women and 1% men and in Manufahi 97% were women and 3% men. A typical pattern is presented in Figure 60.



F= Female M=Male

Figure 60. Number of men and women selling food in Baucau market. 2009-2010

Seeds of life variety availability and value

One objective of the market survey was to determine the availability and value of SoL varieties. According to this survey, most SoL varieties (except cassava released in 2009) were available for sale in either the Baucau or Manufahi markets. The product generally held the same price as the local except Hohrae and Utamua. Hohrae sold for $ 12.00/sack compared to $8 for the local in Baucau market where Utamua was $9.00/sack compared to the local at $5.00-7.00/sack.

Marketer origin and selling method

In both the Baucau and Manufahi markets, the crop product sellers originated from that district and often represented a village of a sub-district. This demonstrates how "local" the produce was.

Selling methods were the same in both markets. A sack was used to measure maize for large volumes and standard milk cans and cobs for smaller amounts. For peanut, a sack was also used in addition to the SGM milk can. Rice was generally measured by SGM milk can and for sweet potato, a sack or by weight (kg).

Discussion

The level of sales of SoL varieties was quite low in the survey. The most common SoL variety on sale was Hohrae (sweet potato). The two markets surveyed are major market centres where farmers from a range of areas congregate including those who have not been involved in the program. Many farmers who have received and grown seed are in remote locations (such as Ossowaki or Liboroe). They frequent local sub-district or village markets rather than large district markets. To better use the market survey as a tool for measuring adoption and impact it may be more effective to survey the local markets near areas where it is known that seed has circulated.

7. Climate change research

7.1 Introduction

Extreme weather events and high rainfall variability leading to erratic drought and flooding have historically caused significant yield losses of staple food crops such as maize and rice in Timor-Leste. According to Seeds of Life research in 2010, climate change is likely to increase temperature and rainfall averages towards 2050, while the consensus within the climate science community is that climate change will likely increase the frequency of extreme events. Together these increases will affect the ability of Timorese farmers to successfully cultivate crops and feed their households and may dictate changes to the cultivars, farming systems and locations required to produce enough food to meet food security targets.

Temperature changes are relatively predictable and are both spatially and temporally less erratic than rainfall predictions. Temperature increases however could present the most dramatic and chronic affects on agriculture in Timor. Planning for average temperature changes is though relatively straight forward in theory and can be performed through selective breeding and tolerant cultivar introductions, as well as appropriate site selection. It should be recognized that agriculture in Timor-Leste is already spread over a broad temperature gradient from sea level to >1,500 masl.

On the other hand, changes in rainfall averages which will also directly affect the largely subsistence agriculture systems of Timor-Leste, are much harder to mitigate. Increased rainfall (most likely) will increase the frequency and intensity of extreme events such as flash floods and landslides as well as adding to the chronic soil erosion problems present throughout much of Timor's interior. Increased rainfall can also impact farmers ability to clear land and plant crops. Reduced rainfall is associated with drought which can have serious implications for yields through interfering with emergence, pollination and grain filling life-stages of crops. Increased variability in rainfall (both monthly and annual variability) will exacerbate all of the above and may allow two or more of the deleterious conditions to appear in the same growing season. Rainfall variability is harder to prepare against through cultivar selection than increased temperature.

Together the predicted temperature and rainfall changes, combined with the steep topography and widespread soil erosion problems, and the need to increase food production in line with development targets and population increase dictate an urgent need for thorough climatic research and analysis in order to prepare Timor-Leste for the potentially adverse agricultural conditions ahead.

Timor-Leste's climate is extremely variable, but has been divided in to 6 different Agro-Ecological Zones spanning the Island from North to South. The zones are categorised by their elevation (0-100m. 100-500m and 500m+) and whether they are on the north or south side of the island's highland spine of mountainous peaks. Even so the climate is not easily categorized into general environmental types and ecosystems and there is large variability within these zones.

Agricultural Ecological Zones (AEZ)* can be used to group areas of different elevation, based on classification into one of six AEZ:

1. Northern Coast (0-100m altitude)
2. Northern Slopes (100-500m altitude)
3. Northern upland (>500m altitude)
4. Southern Upland (>500m altitude)
5. Southern Slopes (100-500m altitude)
6. Southern Coast (<100m altitude)

* From ARPAPET (1996)

The distinction between some zones, especially the upland areas that are identified by their Northern or Southern locations may however be arbitrary for agricultural purposes. Ecological and agricultural differences may be more related to whether the slopes are northerly or southerly facing, rather than located.

The variability of rainfall related weather patterns is highly conspicuous between and within different regions of Timor. The differences in rainfall between locations is likely due to the variability in the topography, the steep slopes and the overall high elevation impacting the weather conditions coming of the sea surrounding the island. Temporal variability between and within years, which is endemic across all sites (not just spatial between sites), can also be attributed to the island's susceptibility to regional meteorological forces stemming from oceanic interactions with the atmosphere. Seasonally the island of Timor is strongly influenced by the Inter-tropical Convergence Zone and during active years is strongly affected by the El Niño/La Niña Southern Oscillation. Both of these ocean-atmospheric events have meteorological implications that strongly influence the inter-annual rainfall variability in Timor-Leste, which in turn is an important factor influencing agricultural considerations.

In order to farm successfully, farmers need to have an intrinsic knowledge of the weather systems influencing their planting and harvesting cycles. In light of potential changes to climatic conditions and averages, Timorese farmers may need to adapt their farming practices towards more flexible systems that will cope with more unpredictable rainfall regimes from year to year. Research needs to be conducted to enable farmers to have access to timely information (such as El Niño warnings) that will assist their decision making in the short and long term. At the current time the available observed meteorological data is broken, spurious and insufficient (particularly during the 80s, 90s and early 00s) for accurately modelling variability into the future. Addressing these shortfalls is a priority task for improving our knowledge on agro-climatic issues.

Through accessing various public domain information sources from the internet, published by some of the world's leading institutions for climatic research, it has been possible to augment the scant observed data available for Timor-Leste with a multitude of calculated baseline data and predictions to 2080. This regional data for current and future climates can be downscaled to provide visualisations at a resolution of $5km^2$ (Figure 61).

7.2 Climate change theory

Climate change is widely attributed to an increase in atmospheric green house gasses (GHG), of which CO_2 is a major component. GHGs are known to increase the capacity of an atmosphere to store heat from the sun through its ability to absorb long-wave infrared energy which is reflected off the surface of the earth. The industrial revolution, the associated increase in energy requirements and the burning of fossil fuels to liberate the required energy instigated the release of unprecedented levels of anthropogenic CO_2 into the atmosphere. Since 1860 CO_2 levels have been rising, and it is unanimously accepted that this is due to human actions; CO_2 concentrations have not been as high as they are today (387ppm) for over 100,000 years. Temperature has also been rising, though global temperature's highly fluctuating nature make it more difficult to identify exactly when the current rising in temperature began. It is widely accepted that from around 1600 the movement has been generally upwards.

While it is almost beyond dispute that we are going through a warming phase, the extent of the importance of CO_2 in the process of global warming is often questioned and has been highly scrutinized. Our ability to understand and predict the extent of the influence of a vast array of positive and negative feedbacks associated with increasing CO_2 levels and temperature is also highly questionable and makes modeling climate change incredibly difficult and prone to a wide range of outcomes. However current conventional wisdom, the international community and the majority of scientists place anthropogenic emissions of CO_2 as the main driver behind global temperature increases of the last 150 years, and up to now there is no better or more substantial argument to explain the current global warming trend. With this in mind it wise to take a precautionary approach to the relative unknowns of climate science and make timely decisions to pre-empt, mitigate and adapt to the potential deleterious effects of a changing global climate.

Climate change not only implies the general warming and precipitation trends that can be seen from the prediction maps, but may also be associated with more radical occurrences of extreme events such as drought and heat-waves. Increases in cyclones are likely due to increased sea-surface temperatures and evaporation strengthening meteorological processes, and drought and heat-waves can be attributed to changes in El Niño and La Niña frequencies. Unfortunately, the reputable studies discussing these topics have failed to draw strong conclusions or consensus and as such we are again left advocating a precautionary approach until matters become clearer.

Preliminary studies and continued research on the likely elements and potential effects of climate change in Timor-Leste has and will continue to provide the GOTL with suggestions towards reducing the potential effects of climate change on the country's key food crops.

7.3 Climate change research, 2010

Methods and materials

To improve on and augment the data available for analysing Timor-Leste's climate, it was necessary to compile an exhaustive bank of historical and contemporary weather data relevant to Timor. This was achieved through an extensive search of the literature and through contact and cooperation with Timor-Leste's various weather associated departments and through sorting and compiling Seeds of Life's own data. The compiled data permits some degree of analysis, and can be used for some sites to draw broad conclusions and relationships between agriculture productivity and climate conditions. It does not however (due to its often poor quality and limited extent) allow for rigorous analysis of long term climate conditions and the generation of future climate predictions.

In order to assess future climate change, it was necessary to use proxy, calculated data, and hence it was necessary and proper to use external climate models based on global data.

The website WORLDCLIM.org was identified as an open source of information and data relevant to the task in hand. WORLDCLIM along with its accompanying visualisation programme DIVA, and associated international GCM development institutions; CSIRO, CCMA, HADLEY and CCM3, allows users to download the programmes and data necessary to generate climate baselines and projections.

Precipitation and temperature predictions for Timor-Leste can be visualised in map format using the DIVA-GIS program as a platform for inputting data and outputting visual representations. Predictions for the years 2020, 2050 and 2080 (CSIRO, CCCMA, HADLEY) and 2 x CO_2 (CCM3) atmospheric concentrations were produced. All the data was downloaded from the WORLDCLIM (public domain and free) and loaded into the DIVA program at SoL. Future climate prediction data was downloaded in monthly units, each of which had to be individually run through the system, saved and then aggregated to produce yearly average outputs. These outputs could then be compared with and subtracted from the baseline data to give a change to 2020, 2050 and 2080. The data could go on to be manipulated further or could be compared on a month by month basis to show changes in intra-annual patterns.

After the raw data (worldwide) had been processed, the rainfall and temperature outputs were further manipulated to show Timor-Leste specific images which are useful for predicting long term climatic changes that may affect agricultural production and food security within Timor. To create maps of Timor-Leste the map boundaries were then set using the layer function and specifying the co-ordinates. To ensure that Oecusse and Atauro were included in the selected block, the longitudinal and latitudinal boundaries were set at with minimal and maximal co-ordinates (Latitude 124.04 to 127.30 and Longitude -9.50 to -8.13).

Definitions:

WORLDCLIM—A global climate layer representing the baseline 'current' climate. We use this as a foundation for climate prediction models to build on to produce various climate outcomes under various climate scenarios.

GCMs (Global circulation models) are mathematical models used for simulating the atmosphere and oceans of the earth. The GCMs we used were created by CSIRO, CCCMA, HADLEY and CCM institutions. GCMs are used by the WORLDCLIM baseline climate layer, on top of which potential future climatic changes are calculated.

DIVA-GIS is a free computer program for mapping and geographic data analysis (a geographic information system (GIS). DIVA is used to visualize the output of the various GCMs in a common format. All the maps in the following pages were produced using the DIVA-GIS program.

CSIRO -The Commonwealth Scientific and Industrial Research Organization is an Australia based institution at the forefront of climate research and modeling in the Asia-Pacific region. The CSIRO GCM incorporates El Nino interactions and provides more accurate predictions for the south Pacific regions.

HADLEY– The Hadley Centre for Climate Prediction and Research is the UK's main body for climatic research. It aims to better understand the atmospheric processes that lead to climate change, with a view to simulating the last 100 years of climate change and predicting the next 100. Particular attention is paid to inter-annual and decadal variability.

CCCMA– The Canadian Centre for Climate Modelling and Analysis.

CCM3– From the US National Centre for Atmospheric research. Projections are based on a 2 x CO2 scenario

WorldClim climate data is sourced from Govindasamy, *et al*, 2003, while the database is documented the article of Hijams et at, 2005.

Results

Rainfall and temperature

Rainfall and temperature maps were produced to illustrate the historic rainfall and temperature patterns in Timor-Leste, predicted annual rainfall and temperature patterns and from these, predicted changes over time were mapped. The maps were compiled from data shaded in grey presented in Table 165**Error! Reference source not found.** and Table 166.

Table 165. Baseline temperature and rainfall data source

1950-2000	1950-2000	1950-2000
Max T	Min T	Rainfall
Jan	Jan	Jan
Feb	Feb	Feb
Mar	Mar	Mar
Apr	Apr	Apr
May	May	May
Jun	Jun	Jun
Jul	Jul	Jul
Aug	Aug	Aug
Sep	Sep	Sep
Oct	Oct	Oct
Nov	Nov	Nov
Dec	Dec	Dec
Annual	Annual	Annual

Source: (WORLDCLIM)

Table 166.Predicted temperature and rainfall data

2020	2020	2020	2050	2050	2050	2080	2080	2080
Max T	Min T	Rainfall	Max T	Min T	Rainfall	Max T	Min T	Rainfall
Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan	Jan
Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb	Feb
Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar	Mar
Apr	Apr	Apr	Apr	Apr	Apr	Apr	Apr	Apr
May	May	May	May	May	May	May	May	May
Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun	Jun
Jul	Jul	Jul	Jul	Jul	Jul	Jul	Jul	Jul
Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug	Aug
Sep	Sep	Sep	Sep	Sep	Sep	Sep	Sep	Sep
Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct	Oct
Nov	Nov	Nov	Nov	Nov	Nov	Nov	Nov	Nov
Dec	Dec	Dec	Dec	Dec	Dec	Dec	Dec	Dec
Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual	Annual
Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000	Change Vs 2000
			Change Vs 2020	Change Vs 2020	Change Vs 2020	Change Vs 2020	Change Vs 2020	Change Vs 2020
Change Vs 2050	Change Vs 2050	Change Vs 2050				Change Vs 2050	Change Vs 2050	Change Vs 2050
Change Vs 2080	Change Vs 2080	Change Vs 2080	Change Vs 2080	Change Vs 2080	Change Vs 2080			

Source CSIRO, CCCMA, CCM3, HADLEY

A total of 609 digital maps (4 models x (16 x 9) + 33 baseline) were generated during the study. The most important maps produced were the:

- annual baseline maps –Rainfall (Figure 61) and Mean Temperature (Figure 63)
- annual 2050 Rainfall and Mean Temperature (Figure 64 and Figure 65)
- change in annual rainfall between 2050 and baseline for Rainfall and Mean Temperature (Figure 66 and Figure 67)

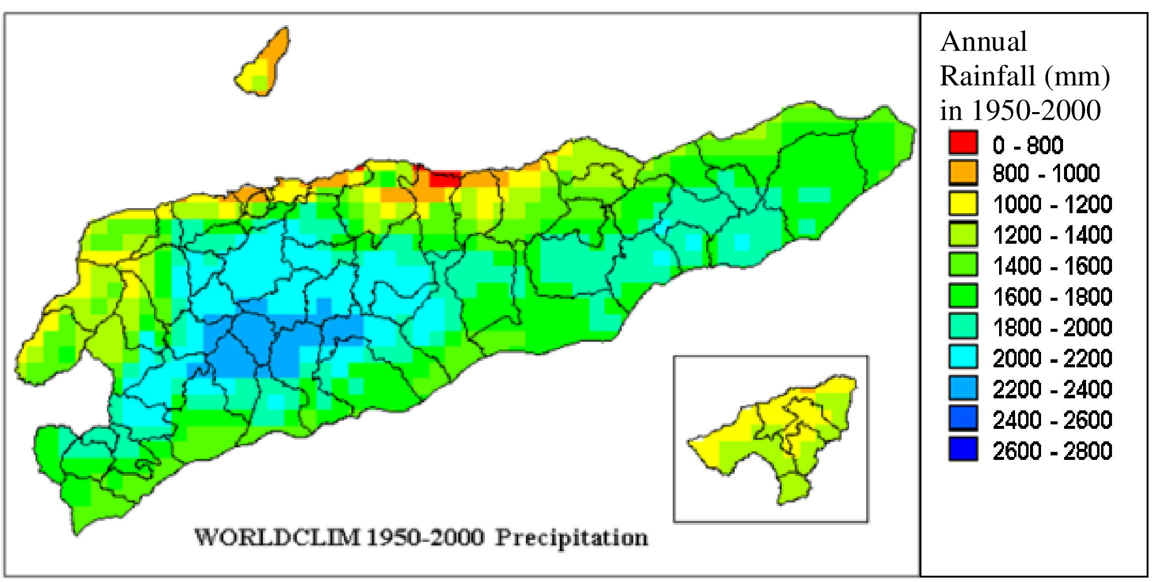


Figure 61. Baseline data of annual precipitation for Timor-Leste (1950 - 2000).

These visualizations are useful for allowing a wide ranging audience to quickly understand the current and future climate of Timor. They are also useful for displaying information across the whole of the country, not just at observation stations. All data shown in the map is however, calculated and not observational data. In order to calculate the rainfall and temperature for the many sites that do not have observed data, readings were interpolated based on their latitude, longitude and elevation.

To test whether the output data presented in the visualizations is accurate and useful, observed data from various stations around Timor was plotted against the interpolated data (Figure 62) shows how well the real, observed data matches the calculated data.

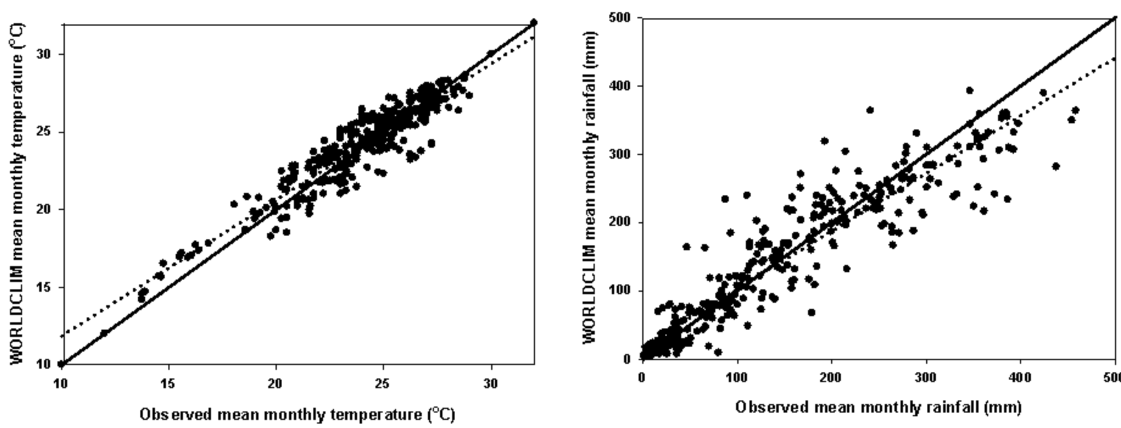


Figure 62. Temperature and rainfall plots of observed cvs calculated data points.

From the graphs we can see that for temperature, the calculations match the observations very well though at lower temperatures (normally high elevations) the calculated data was a little high (i.e. actual temperatures are lower than those calculated by the model). Rainfall calculations were less accurate, especially in areas of high monthly rainfall (normally high elevations) where rainfall quantity was consistently under-estimated by the calculations. This can be seen as above 300mm many of the plots fall under the 'perfect relationship' line of observed mean monthly rainfall. However the general relationship between observed and calculated data was correct for both graphs giving a high confidence level and usefulness to the visualizations, particularly for temperature. Some caution should be used with rainfall estimates and it may be wise to err on the side of a higher rainfall than is predicted by the visualizations. Together, all this information is used as a proxy for today's current climate and allows us to establish a baseline onto which we can build climate forecasts.

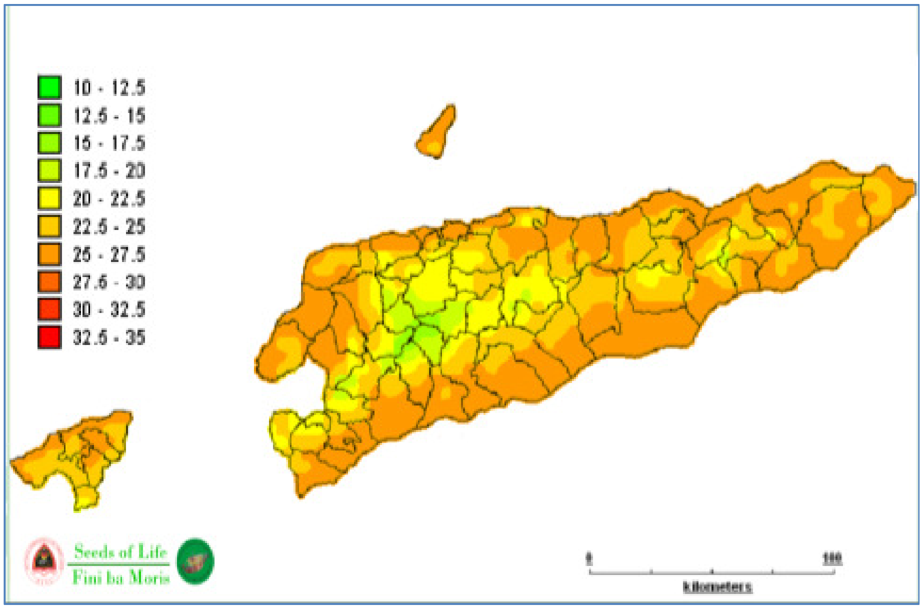


Figure 63. Current mean annual temperature

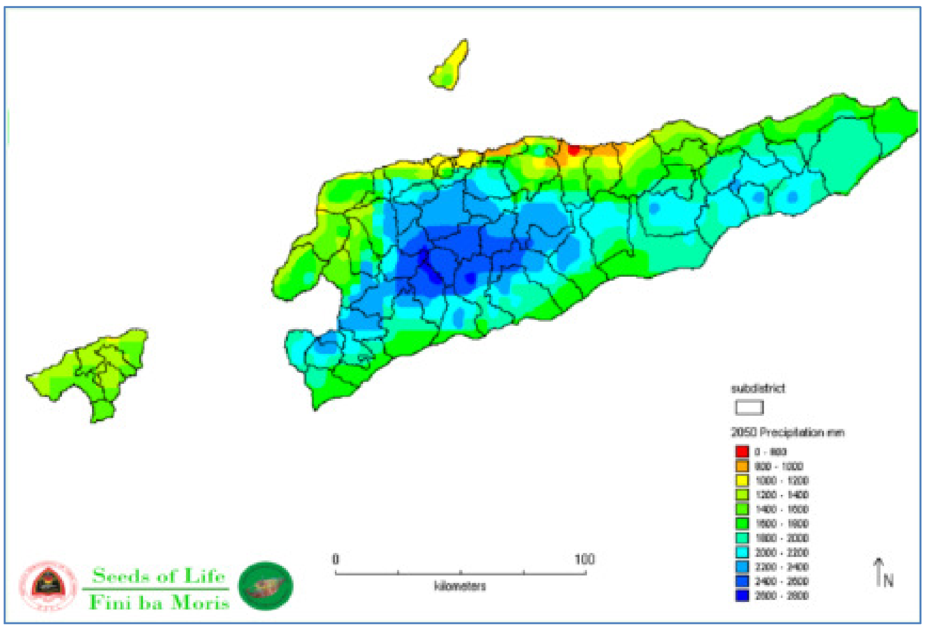


Figure 64. Predicted annual rainfall in 2050

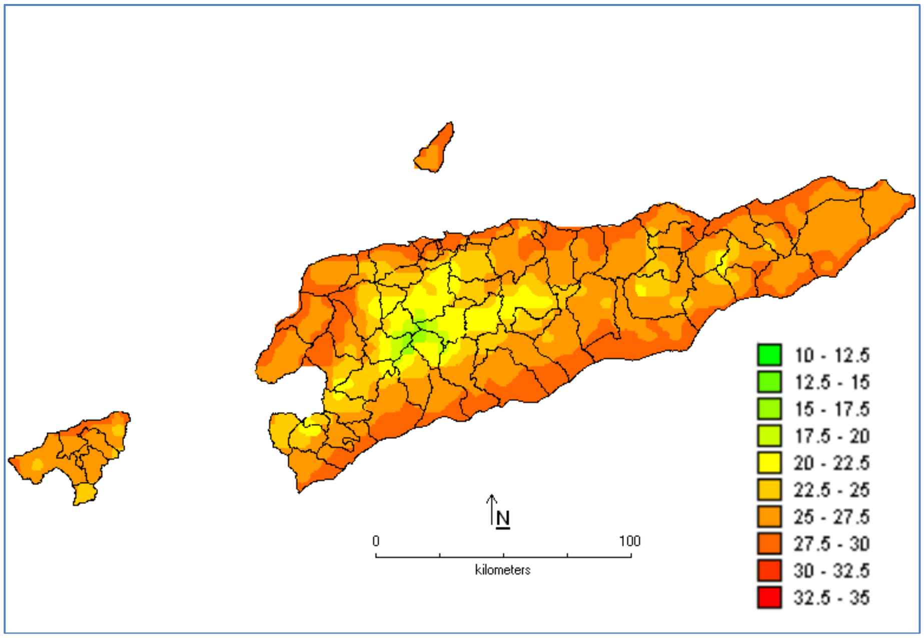


Figure 65. Predicted mean annual temperature in 2050 (CSIRO)

This prediction map allows us to see which areas are likely to experience temperatures that could be deleterious or advantageous to crops in 2050. Coastal areas are darkest orange and will therefore be hottest where as upland areas remain greenest and coolest.

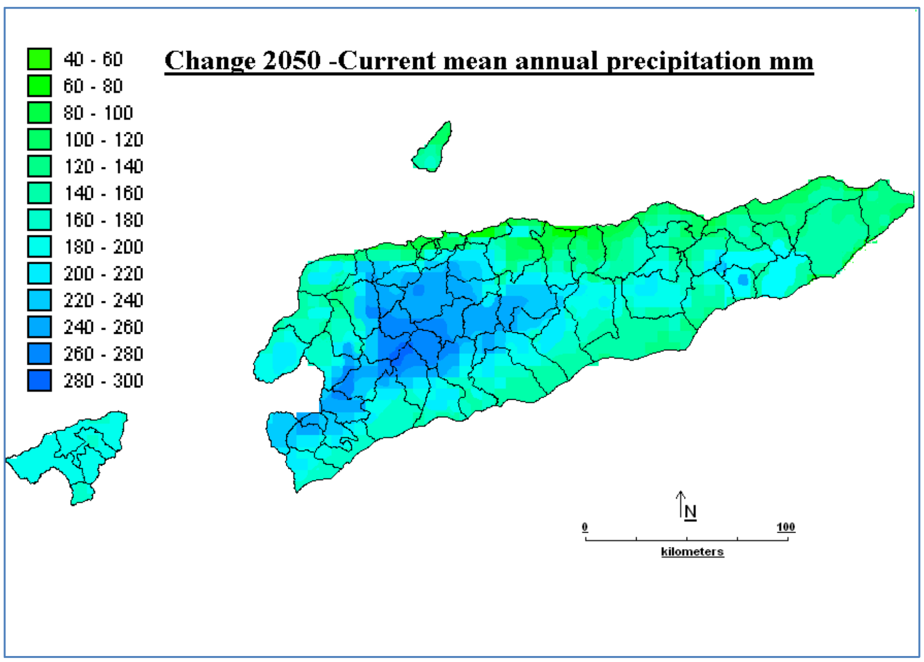


Figure 66. Change in annual rainfall 2000 to 2050 (CSIRO)

Upland areas remain the wettest areas in the country receiving up to an extra 280mm per year

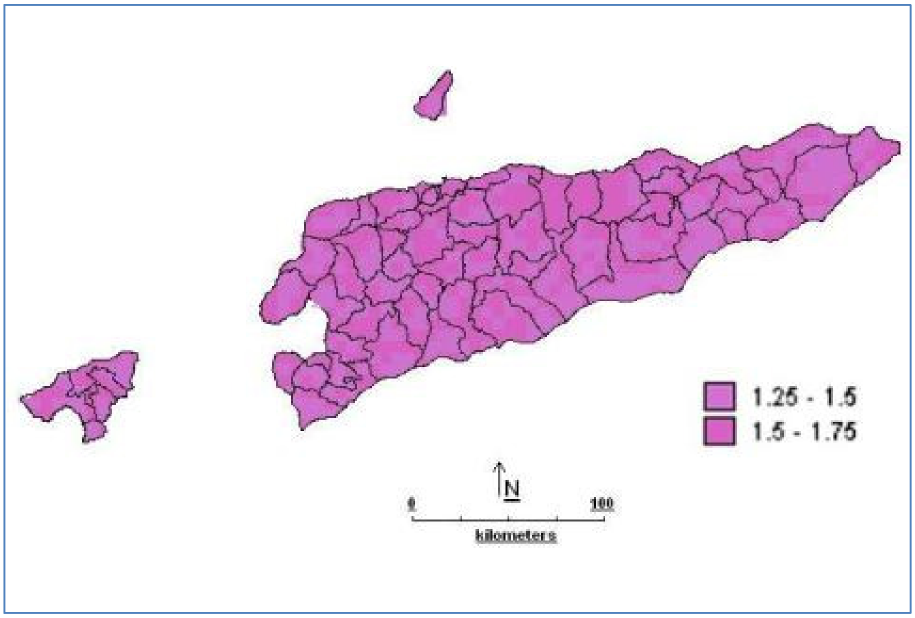


Figure 67. Predicted change mean annual temperature 2000 to 2050

All areas of Timor-Leste will become approximately 1.5 °C warmer by 2050.

Having completed the mapping process, it was possible to use the projections to identify specific areas where SoL have OFDT sites and research stations and their associated weather stations (rain gauges) where available. As we had the historical and contemporary (see Rainfall in Section 1.3) and now future data to work with, it became possible to look at possible trends and changes in rainfall and temperature that may affect future agriculture production.

The graphs in Figure 68 and Figure 69 show the baseline and future monthly mean temperature and rainfall for 6 sites across Timor-Leste. Utilizing these graphs, it was now possible to clearly see which months are wetter, drier or hotter than current conditions. After analyzing and discussing the possible ramifications of this new information, we set about deciphering whether it was possible to make other predictions, including variability, based on this data and any trends observed within current and historical observations. Focusing initially on historic rainfall data it was possible to extract drought information (no of days <1mm rainfall) and pair this with total monthly rainfall. As total monthly rainfall was one of the categories available from the projection models, it was possible to plot the current data against number of days <1mm and read off future predictions.

For example, Figure 69, Baucau, demonstrates that the CCM3 model predicts a decrease in rainfall for March and April. The decrease is from about 200mm to 150mm. Using Figure 70 we see that this corresponds to an increase in dry days from an average of 8 to an average of 9. If we include the natural variability from the average annual rainfall (Table 167) that we have measured from Timor-Leste historic observed recordings, we see that it will not be uncommon for March and April to have monthly rainfall of less than 100mm, and therefore 11 consecutive days without rain (Figure 70).

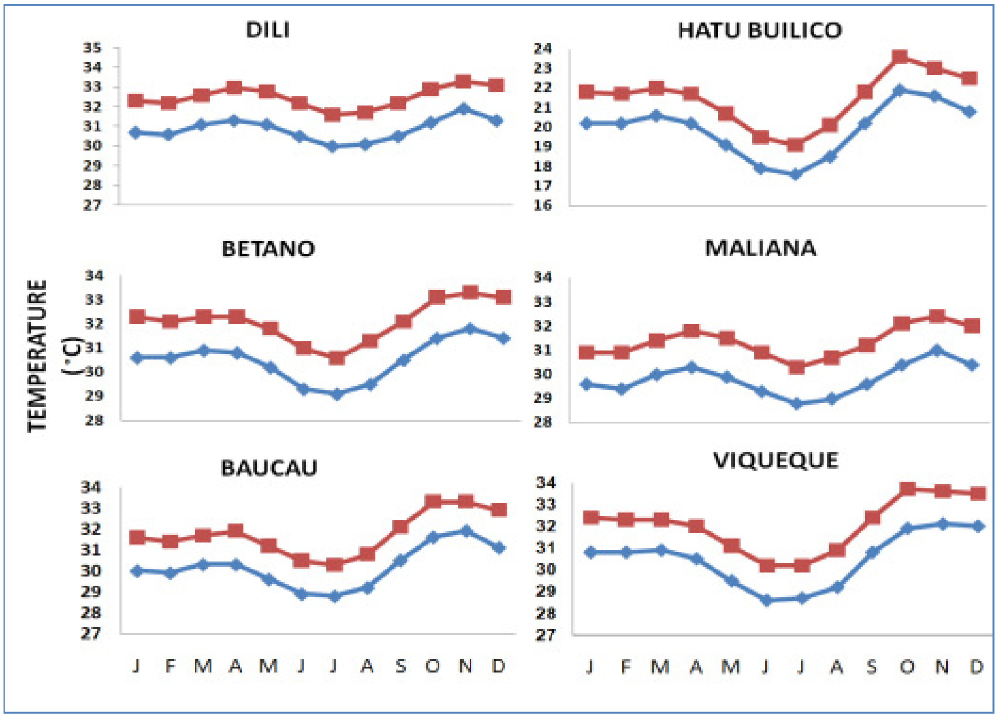


Figure 68. Monthly temperature comparison for 2000 (squares) and 2050 (diamonds)

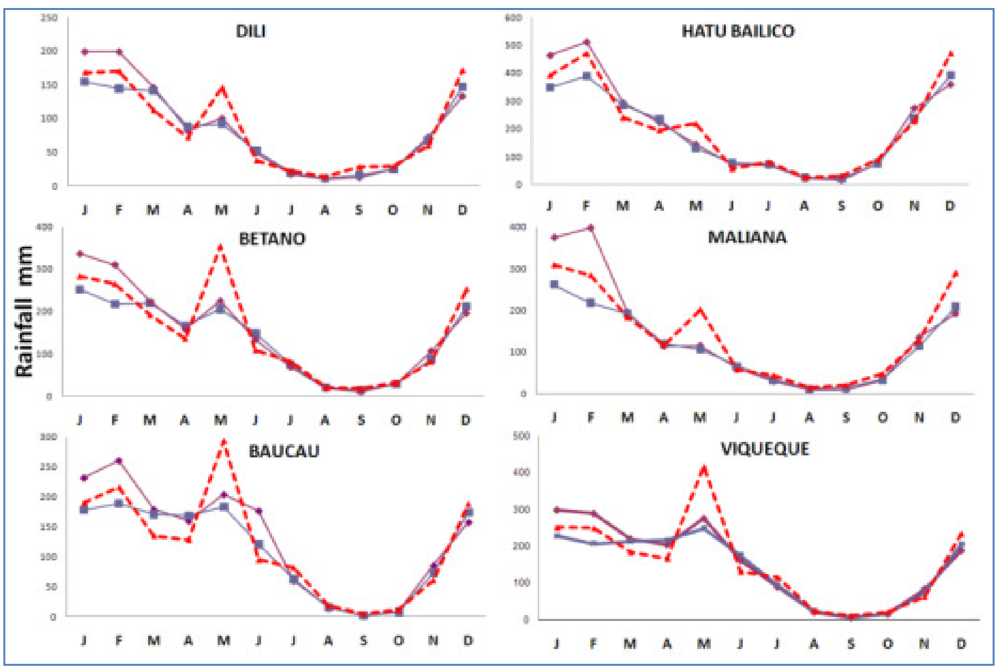


Figure 69. Rainfall comparison for 2000 and 2050*

*CCM3 (dotted), 2000 squares and 2050 CSIRO (diamonds)

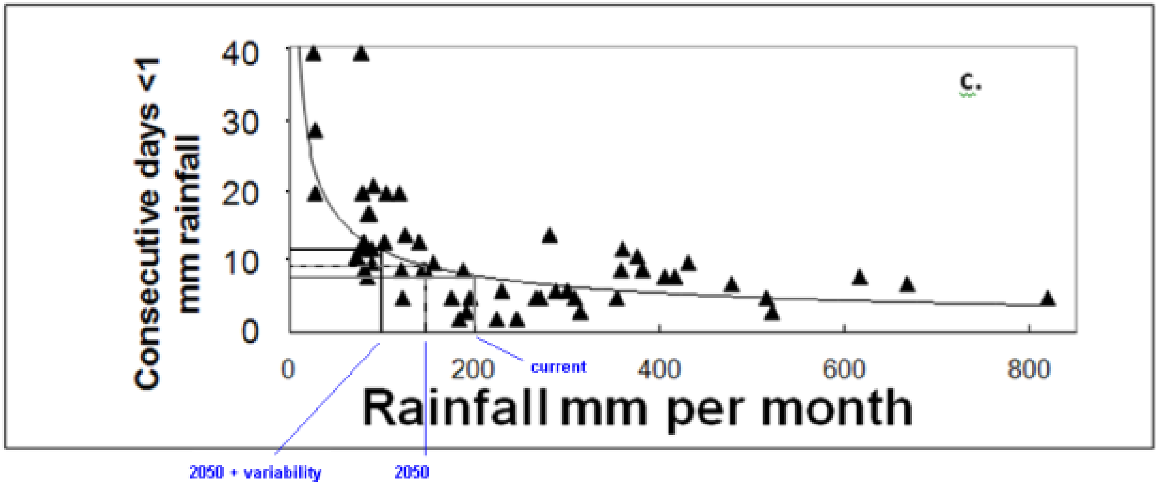


Figure 70. Monthly rainfall totals and number of consecutive days without rain

Despite consensus from the models that annual rainfall will be higher in 2050 (the Hadley model alone predicts slightly drier conditions) 2 of 4 of the models predict some months being drier. If these potential drought conditions that we have calculated in Figure 70 occur in grain filling periods (most likely for upland rice in Vemasse and Viqueque district and for irrigated rice in Venilale) and especially when combined with high temperatures (Figure 68), the effects on yields could be substantial.

Observed rainfall variability

Temporal variability

To test the variability of the observed historical rainfall data, as a more complete data set, the Wet Season Rainfall (WSR) quantities were tested for the standard deviation and coefficient of variation (%CV). The results of six locations are shown in Table 167.

Table 167. Wet season rainfall (WSR) variability

	No. * Years	St. Dev	% CV	Mean WSR	Min.	Max.
Dili	43	251	33	766	409	1647
Baucau	14	309	39	1060	448	1520
Viqueque	18	278	38	1008	715	1498
Ainaro	23	202	29	2136	1592	2884
Same	18	212	30	2096	1187	3207
Alas	22	205	29	1276	849	1896

*Data taken from only those years with complete monthly data sets for the wet season

Table 167 shows the variation of the total WSR across several years of rainfall data at six different locations across Timor-Leste (from 1952 to 1974, but not all-inclusive). All CV figures are between 29-39%, showing the natural variation in the rainfall quantities from the long-term period. In Viqueque for example, 38% of the WSR events deviated from the mean WSR. The table also shows the maximum and minimum WSR years during the period. In Same, the mean WSR is 2096mm, however volumes of up to over 3000mm have been recorded in one wet season. Extremes have also been recorded in Dili, where rainfall exceeded 1600mm in one wet season (in 1955, See Rainfall Chapter).

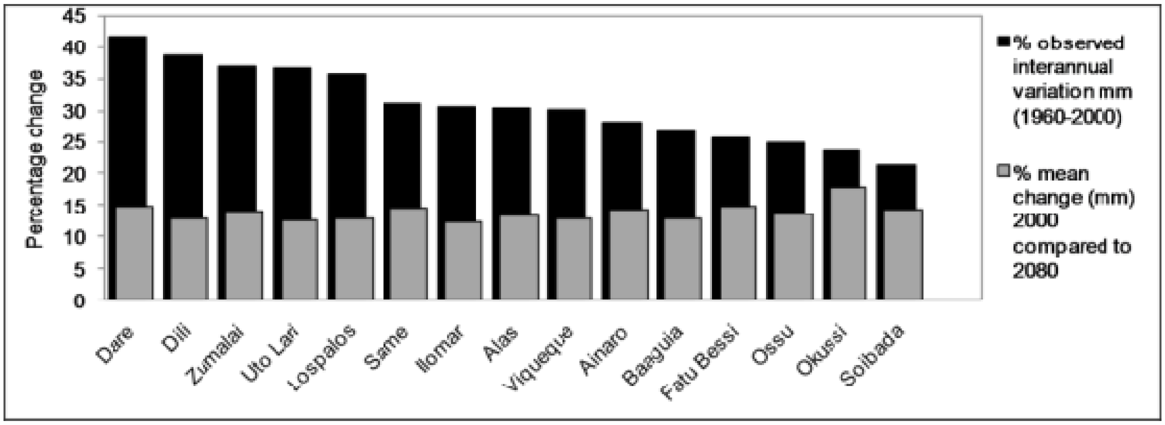


Figure 71. Annual rainfall variability compared to long term average increase

Figure 71 allows comparison of the size of the current inter-annual fluctuation in rainfall quantity (black) with the predicted future mean quantities of annual rainfall i.e. in Dare variability from one year to the next is currently about 40% of annual totals; by 2050, while we have no way of predicting the increase in variability we can predict the increase in total annual rainfall, which is calculated at about 15% over current values. This tells us that the variability experienced today is high compared to the average annual increase predicted over the next 40 years. If farmers' capacity is built to allow them to cope with the challenges of current rainfall variability then they will be prepared for a lot of the mean increase predicted for the future. A mean increase plus a high rainfall year will of course push rainfall into new territory and farmers will need to find new mechanisms to cope with these unprecedented stresses.

Spatial variability

Analysis of the historical data using Genstat software identifies significant differences between locations the sub-district WSR.

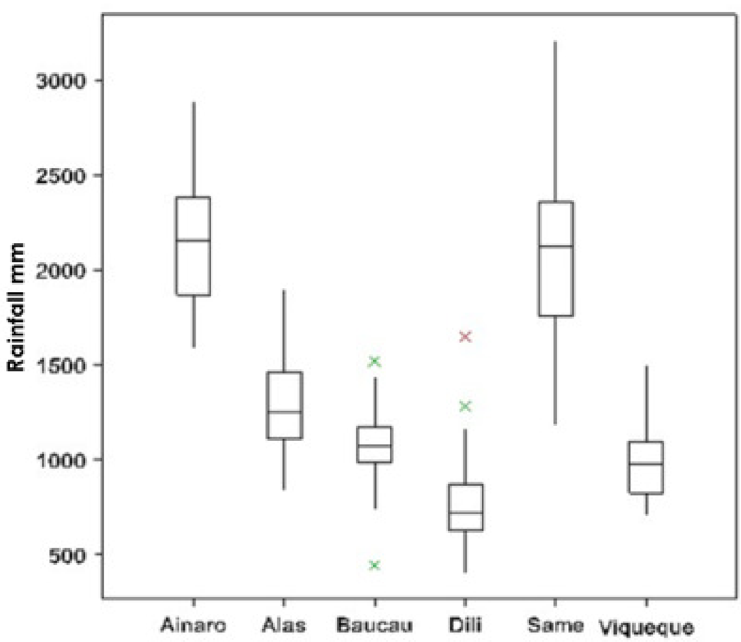


Figure 72. Boxplots spatial variability of rainfall

Figure 72 shows a boxplot of the variation of rainfall between sub-districts. During the historical period it can be seen that the variation in WSR in Same and Ainaro (the high rainfall areas) is much greater than that of Baucau or Dili (despite some extreme events in both areas). The boxplot suggests that the greater the rainfall, the greater the variation in quantity that is expected.

Figure 73 demonstrates the historical variation in frequency of the WSR events. In Dili, it can be seen that during a 43 year period, there is 60% chance that the WSR will be greater than 500mm, with rainfall varying between 500 and over 1500mm. In Same and Ainaro, there is 100% likelihood that the WSR will exceed 800mm. In all areas, there is less than 10% chance that WSR will exceed 2500mm. For further rainfall analysis please see the Rainfall chapter in this report.

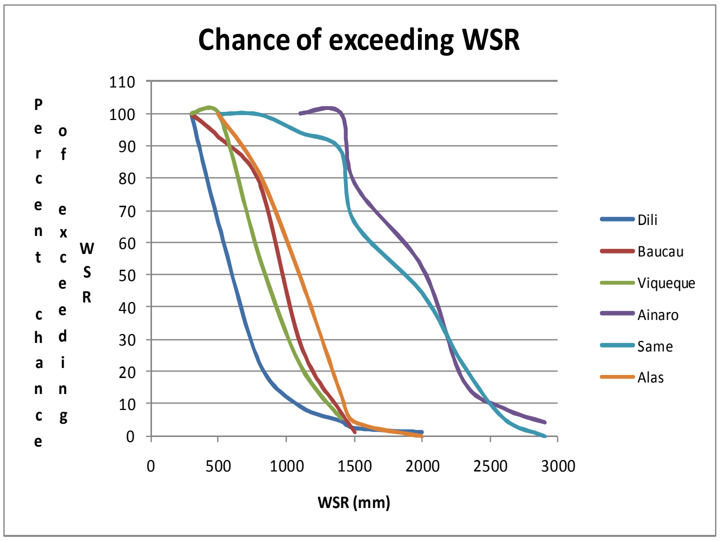


Figure 73. Chance of exceeding wetseason rainfall

Temperature

Correlation between elevation and temperature

Temperature records are the weaker of the 2 climate data sets available for analysis. Temperature recordings are very sparse, with very poor continuity through time and within sites. SoL field staff had no means to record temperature until 2009; elevation is widely used as a substitute value for temperature in the SoL database. Some temperature data from various sub-districts and periods during 1914 to 1975 is available, which includes mean maximum and minimum monthly temperatures collected from nine locations across Timor-Leste (Maumeta, Dili, Manatuto, Suai, Viqueque, Maliana, Ainaro, Ermera and Soibada). This data is recorded together with the elevation (m) of each monitoring site. Analysis of this data shows that the correlation between elevation and temperature is very strong, indicating that for every rise in 100m, the temperature is seen to drop by between 0.5 and 0.60C. Recent (2005-2009) temperature data is available from ALGIS and has been used to analyses daily extreme temperatures over the short term.

A correlation analysis tool was used to examine the movement of the two data variables elevation and temperature in relation to each other. Minimum and maximum mean monthly temperatures were used, with elevations ranging from 4masl (Dili) to 1200masl at (Ermera). Only the rainy season months of October until April were included in the analysis. Figure 74 shows the R^2 values of the monthly correlations between long-term elevation and temperature data.

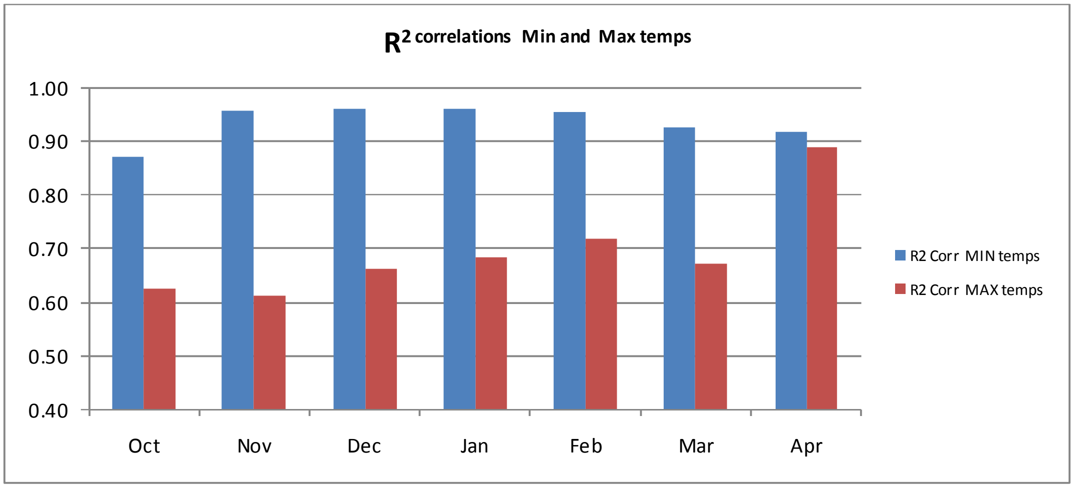


Figure 74. **R^2 correlations between elevation and wet season temperature**

Although minimum temperatures were more strongly correlated to the elevation, all minimum and maximum temperatures correlated to the elevations of the locations with an R^2 value greater than 0.6.

The mean slope gradient formulas of the mentioned correlations for the rainy season months were used as formulas to predict the temperature for data where elevation is recorded without temperature:

Minimum daily temperature: *y= -0.00619x + 23.67286*
Maximum daily temperature: *y= -0.00481x + 31.993*
where x is elevation.

Having established the correlation formulas for minimum and maximum temperatures depending on the elevation variable, the formulas were input into the SoL OFDT database and the mean of the maximum and minimum temperatures used for analysis.

For further clarification on the temperature-elevation correlation, selected temperature data for the years 2005 until 2008 from 12 locations ranging in elevations from 25 to 1500m (Aileu, Ainaro, Betano, Dare, Ermera, Fatumaca, Fuiloro, Maliana, Manatuto, Maubisse, Suai and Viqueque) was sourced from the ALGIS department of MAF. This enabled cross-checking of the correlation between elevation and temperature from historic and present times (2005-2010). Correlations for minimum and maximum temperatures and elevation at present times across the full year were between 0.6 and 0.9.

Average temperature and yield

As can be seen from Figure 75, at low elevations (high average temperatures) maize yields drop with increasing temperature. Due to temperature recording limitations in Timor, temperature has been calculated from elevation recordings at all sites and it is therefore impossible to decipher whether another element of elevation is affecting yields other than temperature. The R^2 value for the line is 0.066 indicating that 6.6% of the decline in yield can be explained by elevation.

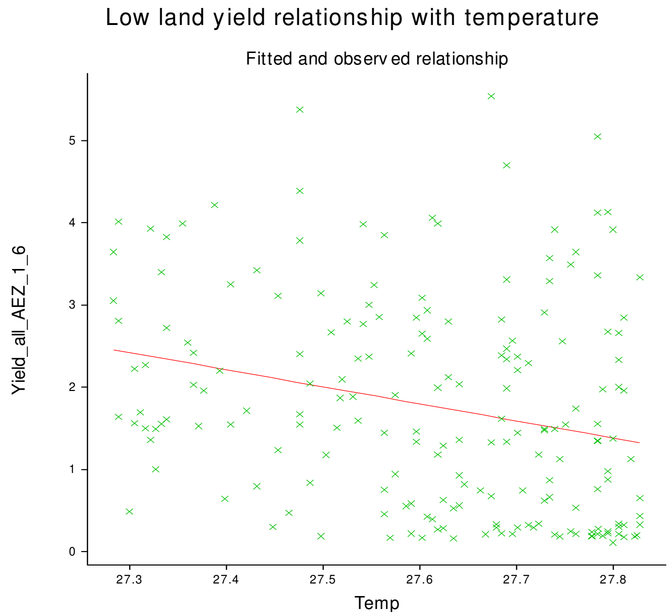
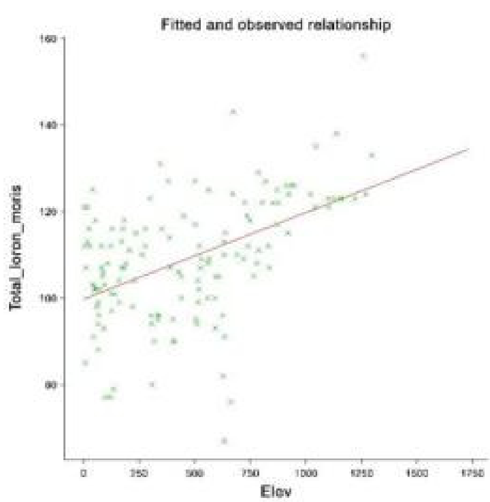


Figure 75. AEZ 1+6 (OFDT sites under 100m) temperature yield relationship

Higher temperatures can have deleterious effects on yields through phenological processes, heat damage to pollen and heat stress during kernel/grain development. The rate of development for a crop is linearly dependent on the cumulative air temperature (growing degree days) above a base temperature which varies with species. Higher temperatures shorten the time to flowering and maturity in photoperiod-insensitive crops such as most rice and modern maize varieties, until an optimum temperature is reached above which time-to-flowering increases with increasing temperature. The increase in temperature of 1.5°C will increase the rate of leaf development, reduce the number of leaves and leaf area, reduce radiation interception, bring forward the time of flowering and maturity and may reduce yields.

Growth duration, temperature and yield

A linear regression of Growth Duration and elevation (inverse relationship with temperature) shows a highly significant correlation between the increases in the days required for maturation of Sele and local maize varieties at higher altitudes (Figure 76)



*The regression uses OFDT data for 2008-2009 only, for the Sele and Local varieties only.

Figure 76. Elevation and growing degree days for maize in Timor-Leste

The regression analysis of elevation and growth duration shows that for every one meter increase in elevation, an extra 0.02 days are added to the growth duration (which is driven by growing-degree days, i.e., temperature). This means for every 100m increase in elevation, an extra 2 days are required increasing the vulnerability of the crop to climate variability over a longer period. This can be directly related to the affect of temperature decrease on growth duration. Theoretically, an increase in the mean temperature will reduce the crop growth duration period and therefore reduce the chance of potential pest or weather-related damage to the crop. However a decrease in growing days is usually associated with a reduction in yield as less time is available for growth prior to maturity, see Figure 77.

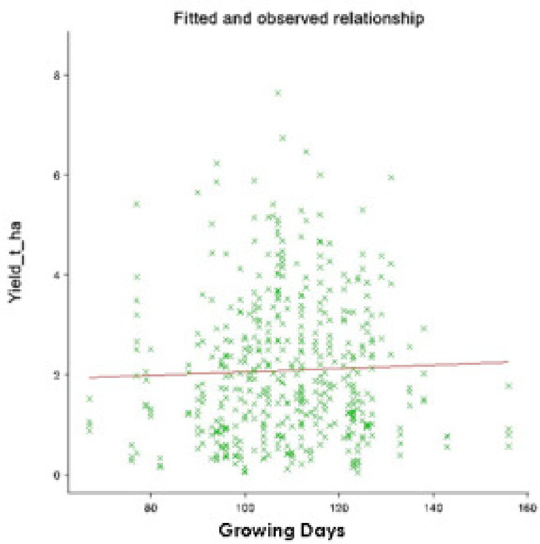


Figure 77. Relationship between yield and growing degree days

The results presented in Figure 77 shows that there is a mild increase in yield for the increase in number of growing days. Mean site yields increase by 0.00342 t/ha for every extra day (t prob <0.001.). However, as mentioned above, the longer the crop growth duration, the more time the crop is vulnerable to weather extremes or pest damage.

Average temperature and extremes

Increased temperatures during pollination periods of maize can desiccate the pollen and anthers seriously effecting potential yields. Heat stress (35°C for 8 days) during grain filling has been shown to reduce mature kernel dry weight by as much as 45% (at 36°C) and can result in as much as 97% kernel abortion. Figure 78 shows the relationship between mean monthly temperatures, no of days, and consecutive days where temperatures exceeded 35°C. The data was sourced from some of the hottest locations in Timor (low elevation North and South coast).

If we refer back to Figure 68 we can see that in Dili, average predicted monthly max temperatures for April reach 33 °C in 2050. Observed data of current and historic conditions shows that mean monthly max temperatures of some months are already reaching 33-35°C in some years (Table 168), and when they do, longer and more heat waves over 35°C are more likely (Figure 78).

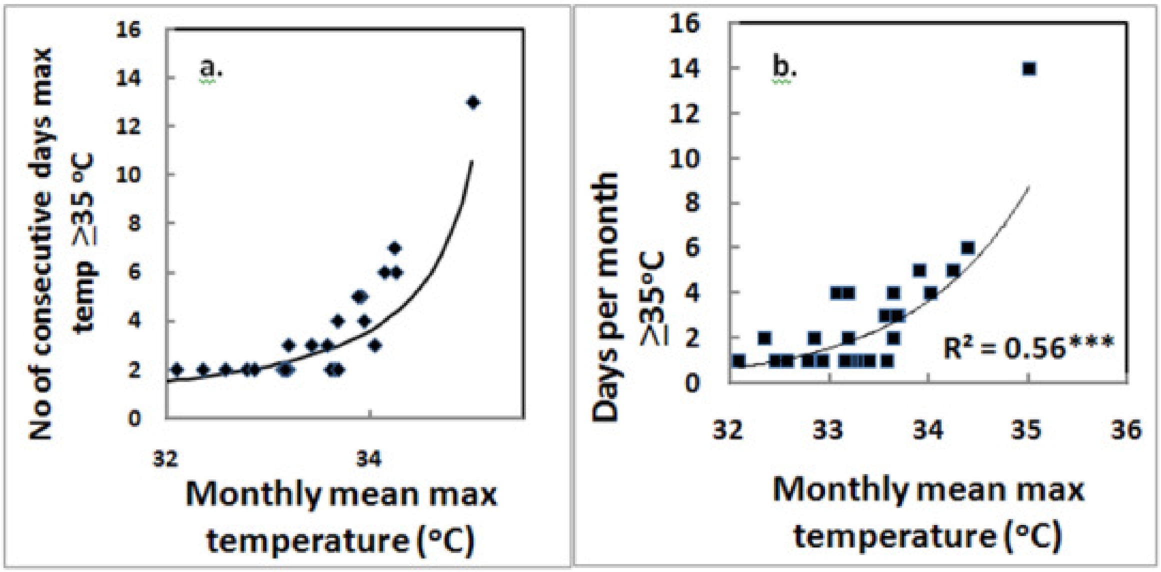


Figure 78. Temperature relationships*

*Relationship between observed mean monthly temperature and consecutive and total days with maximum temperatures >35°C

Increasing awareness

In order to increase awareness and relay this information to the Ministry of Agriculture and Fisheries, farmers, development institutions, civil society and the general public, 3 reports were produced: an 8 page comprehensive scientific report on climate predictions, interactions with observed data and implications for agriculture; a 4 page summarized version of the 8 page report designed to be more accessible for a wider audience; a Tetun version of the 4 page summary designed to be user friendly for a Timorese audience. A scientific journal paper covering the implications of climate change and population on agriculture in Timor-Leste is currently under review.

Google Earth has also been utilized as a platform for displaying the results and to assist in dissemination of the findings of the climate predictions. The maps in Figure 79 and Figure 80 are overlay which files can be downloaded from the SoL server, opened and then manipulated by the end user in order to fulfill individual requirements.

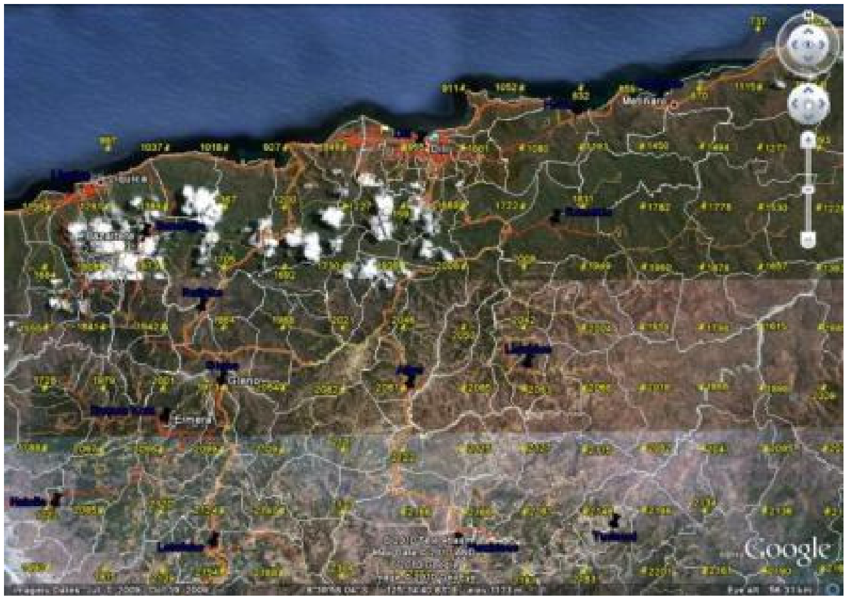


Figure 79. Satellite map of Dili and Aileu overlaid with rainfall projections for 2050 (from Google earth)

Figure 80. Ossu area. yellow figures are rainfall projections in mm at 5km^2 resolution

Temperature record, December 2004 Betano, *Altitude:30masl* *Latitude: -9.42 Longitude: 125.61*			
Day	T min (^oC)	T max (^oC)	T mean (^oC)
1	25.4	33.0	28.5
2	23.6	34.2	28.5
3	23.9	34.7	28.9
4	24.2	33.6	28.5
5	23.4	34.3	28.6
6	23.9	33.7	28.7
7	24.7	34.6	29.2
8	24.0	34.9	29.2
9	25.7	34.5	29.5
10	25.2	34.9	29.8
11	23.9	34.4	29.2
12	25.4	34.3	29.3
13	24.0	34.1	28.8
14	25.7	34.1	29.6
15	26.8	35.4	30.2
16	26.0	35.0	30.1
17	26.0	35.0	30.0
18	25.4	34.7	30.1
19	25.6	35.1	29.9
20	23.6	34.0	29.3
21	23.2	34.1	27.4
22	22.3	33.1	26.2
23	23.5	32.2	27.0
24	23.9	33.4	27.1
25	22.9	34.1	27.2
26	22.3	33.4	26.4
27	23.8	33.6	27.2
28	23.8	33.1	26.8
29	24.7	33.6	27.3
30	24.7	32.8	27.6
31	25.2	33.1	28.7
Decade 1	24.4	34.2	28.9
Decade 2	25.2	34.6	29.7
Decade 3	23.7	33.3	27.2
MONTH	24.4	34.0	28.5

* sourced from ALGIS data

Table 168. Observed temperature recordings, Betano, December 2004

Implications for agriculture

As the number of days when the temperature exceeds 35°C is projected to rise near the coast of Timor-Leste (Figure 78), the potential impact on the yields of crops flowering when temperatures are at a maximum is considerable. As maize flowers in January and February when sown in October on the first rains, and July and August when sown in April in the southern region of Timor-Leste with bimodal rainfall, it is possible for high-temperature-induced sterility in maize sown in October, but unlikely when sown in April on the south coast. However, the greater risk is in rice grown near the south coast which flowers in March and April when maximum temperatures are high and days ≥35°C are more likely. High temperatures around flowering have also been shown to decrease flower number and seed set in peanuts.

There is also the potential for higher temperatures to affect the major cash crop in Timor-Leste, coffee, but as the coffee cultivar grown in Timor-Leste, HDT, is a natural hybrid discovered in Timor between Robusta (*Coffea canephora*) and Arabica (*Coffea arabica*) coffee species, it probably has the temperature tolerance of the Robusta species and is more likely to be able to withstand the higher temperatures than pure Arabica species grown in other parts of the world (DaMatta, 2004). Nevertheless, optimum conditions for coffee are likely to found at higher elevations as Timor warms, and coffee producers may have to move to higher, steeper slopes to maintain production.

It has been shown in Kenya that each 1°C increase in temperature decreased the time to maturity of maize by 5 days and decreased yields by 4%. These yields are in the same range as those in Timor-Leste, so using the same relationship suggests that a 1.5°C rise in temperature will decrease the days to maturity in maize by 7.5 days and decrease yields by 6% (66 kg ha-1 from a median yield of 1100 kg ha-1). For peanut, a 1.5°C rise in temperature will decrease the days to maturity by 12 days and decrease yields by 19% (190 kg ha-1 from a median yield of 1000 kgha-1).

Warmer temperatures are also likely to increase the incidence of insects and fungal diseases that will also decrease yields unless controlled, while more frequent droughts have been shown to increase the aflotoxin, a serious carcinogen, contamination in peanut. An increase in rainfall is likely to increase the incidence of the viral disease groundnut rosette, and particularly near harvest will slow the speed of drying of the maturing seed, decrease its subsequent germination and potentially increase the level of mycotoxins, such as aflotoxins, in the seed during storage.

In order to maintain yields in 2050, farmers in coastal areas may have to move to higher elevations where temperatures are cooler (Figure 63). Figure 81 describes the trend of yield with temperature, and uses elevation to identify which areas will likely see a decrease in production, and which may see an increase. As can be seen, current yield for all sites is approximately 2.3 t/ha at sea-level. Extrapolating from current observed data trends with temperature, an increase of 1.5°C at sea level will see a decrease in yields down to approximately 2 t/ha.

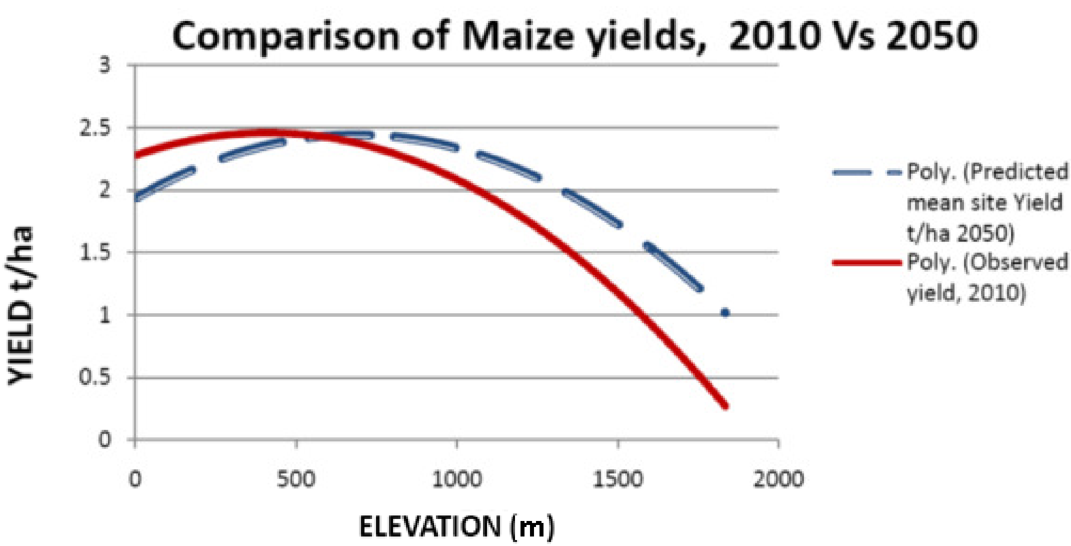


Figure 81. Maize yields by elevation (meters above sea level), 2010 and 2050

Sites that currently experience the hottest temperatures (sea level locations) will be most affected by the increase in temperature to 2050. As sites approach elevations of just over 500m the decrease in yield reduces to 0. Above 500m the increase in temperature due to climate change appears to improve yields for higher elevation locations in 2050.

If we look at the graph for all years and all varieties at all locations (Figure 82), and break the data down into Agro-Economic Zones we can see that the effects of temperature on yield can be broadly divided along these lines. Up to 100m (hottest temperatures) yield increases with increasing elevation (and therefore decreasing temperature). Between 100 and 500m, yield starts to decrease with elevation, and this trend continues from 500 upwards at a slightly stronger rate.

Although this relationship looks straightforward, more work needs to be done to decipher whether it is only a location's temperature that elevation is acting as a proxy for and what are the other factors driving the huge variation between sites of the same elevation and between years.

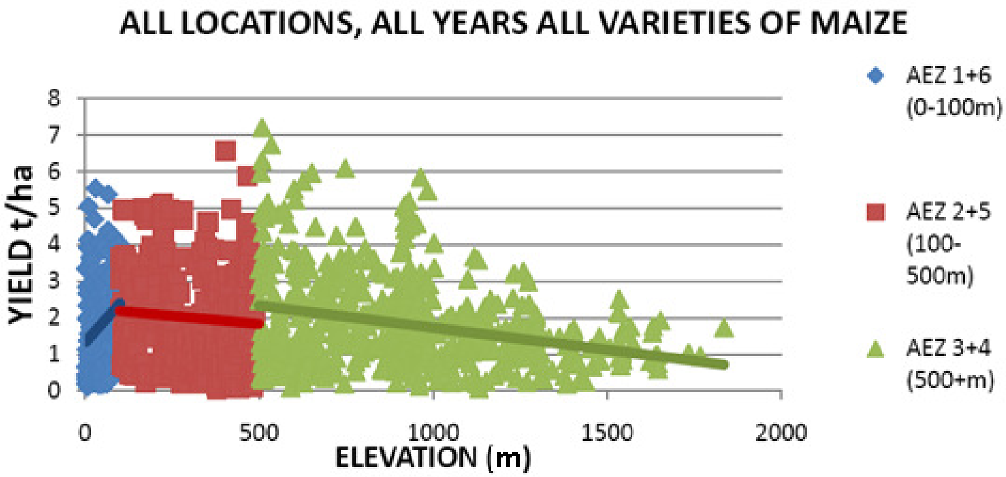


Figure 82. All locations and all years maize yield against elevation

Based on these findings, by 2050 maize production is likely to be negatively affected at low elevations, unaffected or mildly improved at mid elevations and improved at high elevations.

From the SoL OFDT maize database, the combined affect of rainfall and temperature on crop yields was determined. Various factors were input into a multiple linear regression to test what factors had significant affect to yields of Sele and Local maize varieties. It was found that temperature, WSR and WSR squared have significant impact to maize yields for both varieties. All of these factors were put into a multiple linear regression where all gave high significant impact to yields (t prob ,0.001). The output of the regression was used to create Figure 83 which shows the different effects of temperature and rainfall combinations on maize yields (data from the SoL OFDTs, 2005-2009).

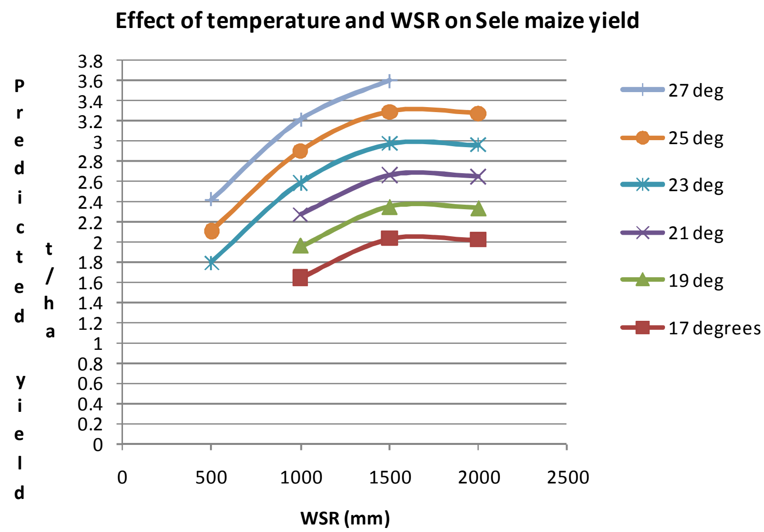


Figure 83. Relationship between yield, rainfall and temperature for sele maize

Figure 83 shows that increasing temperature and rainfall cause an increase in yield for the Sele maize variety, however gains in yield from rainfall volumes are limited to WSR of under 1500mm, above which no further increase in yield is observed due to already sufficient moisture levels. Gains were also only calculated up to a mean temperature of 27°C. Above this temperature it is likely that yields will plateau and then drop, as can be seen at low elevations in Figure 82.

While the slow, steady increases in temperature and rainfall appear to have tangible effects on yield, being trends they can be accommodated and mitigated through breeding, management and adoption. The associated increase in frequency and strength of extreme temperature and rainfall conditions is however less easily addressed and are likely to cause greater challenges for farmers and researchers.

Climate implications for other crops

Other tropical crops are likely to be affected similarly to maize due to preferences for tropical temperatures and similar extreme temperature/ heat stress limitations. However in terms of improved rice production at elevation, because rice is grown in bunded and leveled fields the potential to capitalize on improved yield potential at higher elevations will be difficult without land preparation. Nevertheless, with the potential of increased sterility and crop failure at the warmer sites on the south coast, greater emphasis on development of suitable sites at higher elevation may be necessary, particularly if cultivars with greater heat tolerance cannot be sourced.

Cassava is well adapted to a hot tropical climate with optimum growth reportedly occurring at 25-29°C and requiring a high temperature (35°C) and high solar radiation for optimal leaf development and maximal photosynthesis. Storage root yield and total biomass are positively correlated with photosynthesis. Cassava is also drought tolerant and so may be appropriate as a replacement for maize on the hotter and drier north coast, some areas of the south coast and in the longer term also replace rice on the south coast if it fails to thrive.

A doubling of the level of CO_2 in the atmosphere drastically reduced the total biomass and halved the number and size of tubers, leading to an 80% reduction in harvest index. Furthermore, the high CO_2 doubled the cyanogenic glycoside concentrations in the leaves. As the cyanogenic glycoside breaks down to produce toxic hydrogen cyanide, and leaves are used as a protein supplement, care will be needed in using the leaves of cassava in future. Overall the increase in CO_2 is likely to benefit growth in C3 crop species such as rice, cassava, sweet potato and peanuts through the 'CO_2 fertilization' effect.

Elevated temperatures will also have an effect on soils ability to provide crops with adequate nutrition. Warmer temperatures increase the rate of decomposition of organic matter, which may break down faster than it can accumulate. Improved mulching, green manure and cover crop systems as well as additional application of fertiliser will help to offset the potential reduction in available nutrients caused by higher temperatures.

Conclusions

Timorese farming systems will need to undergo focused development if agriculture is going to absorb the increased rainfall intensity, flooding, runoff, and increased temperatures that have been predicted for the region. The frailty of the current farming practices enforces the requirement for further research which will help adapt Timorese farmers towards a less vulnerable farming environment. Current inadequate nutrition, coupled with future population increase intensifies the pressure to develop more adaptable but productive farming systems. Climate change and agriculture interactions may further exacerbate these problems, or if assessed properly, could become part of the solution to the widespread malnutrition.

Timor-Leste has naturally varying temperature environments, within which the most extreme temperature variations occur with elevation. Average temperatures in Timor-Leste have shown to increase linearly with altitude. Changes to existing temperature environments may lead to impacts on cropping such as altering the number of days to crop maturity, and making crops more vulnerable to drought and other weather extremes. High temperatures can shorten grain filling in maize and rice crops, reducing yields. Increased rate of senescence due to extremes in weather is also likely. Increases of temperature at already high average temperature zones have the potential to cause heat induced sterility in rice pollen and reduce maize yields. These can differ depending on the varieties cropped. Episodic and short term rises in temperature are more likely to be damaging to Timor-Leste, rather than the threat of mean global rises. Increased rainfall is likely to increase erosion rates, nutrient leaching, run-off and the risk of land slides on steep slopes. Increased rainfall in Timor will likely be advantageous for rice crops, though any capitalisation on increased rainfall will require improved bunding and irrigation practices, especially if higher, steeper slopes are brought into use. In locations where average wet-season rainfall is less than 1500mm (Figure 83) there may be some benefit from more rain for maize crops.

Potential changes to the farming environment in Timor-Leste due to climate variability include:

- More crop vulnerability during reproductive phases due to temperature increase and drought
- Later start to the rainy season (longer 'hungry' season until next harvest)
- Increased difficulty for farmers in reading traditional environmental signals to determine the start of the rainy season
- Delayed planting (seed vulnerable to weevil and rat damage and rotting during extended storage phase)
- Loss of seed due to planting at false 'break of season' rains
- Flooding, erosion, leaching of nutrients and landslides due to more frequent intense rainfall events
- High rainfall areas subject to more flooding and loss of paddy stability
- Increased evaporation of water from paddies

- Potential displacements of forest species if farmers move uphill to cooler cropping elevations under increasing temperatures
- Increased aquifer replenishment capacity
- Greater irrigation potential for rice paddies
- Possible increase in maize production at higher altitudes, decrease at lower altitudes

Farming systems

To meet the expanding population growth and food requirements of Timor-Leste, farming systems need to be developed with increased yields, increased nutrition, and more secure promise of food. More efficient use of rainfall and improved soil quality through evaluating systems such as no-till conservation agriculture are essential. Research into cover crops, green manure, crop rotation is also necessary. Better preparedness for cropping times, and more efficient use of seed stores also needs to be researched and supported by the collection of empirical weather data. Variation in the species and varieties cropped will help to buffer potential losses of crops during weather extremes due to different genetic tolerances. It is important to note that increases in production from new varieties, inputs or technology are not necessarily as important to farmers as are reliability, ease of cooking/selling/using and hardiness of varieties.

Research into crop-specific responses to rainfall and temperature extremes under the different AEZ of Timor-Leste needs to be explored. Research into different varieties across temperature and elevation variations would be useful. Intercropping of legume species should also be investigated by the Ministry of Agriculture's research department, to explore the potential benefits of increased CO_2 fertilization supplemented by nitrogen-fixing cover crops.

Further research into alternate crops such as sweet potato and cassava and native wild foods and their use during 'hungry' seasons should also be continued. Social-economic research into other possibilities or cultural limiting factors should also be explored in conjunction with cropping research.

Focus needs to be placed on legume species based interventions. The reasons for this are plentiful and include nitrogen fixation and associated increases in yields, soil stabilisation capacity and appropriateness for use as fodder and forage for livestock. In light of the current malnutrition statistics published by WHO and future population pressure statistics published by GOTL and the World Bank one of the most important reasons to promote legume species maybe due to their high protein content, complimentary diet characteristics with rice and because cassava and sweet potato have very little protein. Protein deficiency is rife throughout Timor-Leste, and adoption of beans and peas within current cropping cycles could go some way to ameliorating this problem.

Potential farming interventions

- Identification of cultivars appropriate to the predicted climate and variability conditions
- Selective inorganic fertiliser promotion, Conservation farming including:
- Universal organic fertiliser promotion
- Legume intercropping and legumes as relay crops, cover crops, green manures
- Terracing, contour planting of hedgerows (Napier grass and other barrier species)
- Mulching with crop residue and no-tillage systems
- Micro-basin research for increasing water infiltration and reducing runoff

Research plans

The SoL program involves a well established variety evaluation research system on five research stations in different AEZs. The protocol involves testing imported varieties in local conditions (replicating local farmers systems) against locally sourced varieties. Variables such as plant establishment rates, plant height, pest damage and yield are monitored and data collected, however the protocol can be improved further to include a separate set of variables for consideration of vulnerability to climate variability. An excerpt from part of the current maize data collection protocol used on the research stations is shown below:

Plot No	*Yield (t/ha)*	*Emergence at 2 weeks %*	*Plants /m² at harvest*	*Cobs/ plant*	*Seeds /cob*	*Seeds weight (g/100)*	*Cob weight, seeds only (g)*	*Shelling (%)*	*Plant height at harvest (cm)*
HAR 05	0.9	94	1.4	1.4	351	23.1	80.7	80.2	156.4
HAR 12	1.8	97	2.1	1.5	485	24.4	119.0	82.7	176.3

The protocol will be improved to include some of the following data as part of the climate change adaptation process. OFDT sites with rainfall collection means will also be required to collect similar climate associated data:

- In-season days/month with rainfall deficit (less than 1mm/day)
- Total days without rainfall per month
- Total number of cumulative days without rainfall (less than 1mm)
- Flooding score (1-5, 5 being entire plot flooded for more than 12hrs)
- Daily maximum and minimum temperatures
- Total temperature units during flowering period (mean daily temperatures to calculate GDG)
- Days to maturity
- Days to flowering

Crops and varieties

In addition to improving the protocol to include some variables for monitoring the individual varieties tolerance to environmental changes, there are extra crops that can be researched by SOL/MAF. Increased occurrences of weather extremes means that farmers need to be more adaptable in order to spread the risk of environmental changes across several crops and varieties. The need to increase protein in the Timorese diets also makes legumes a preference, as maize and rice are high carbohydrate low protein foods. Some potential crops for testing as part of the climate change adaptation programme are listed below:

- **Pigeonpea,** *Cajanus cajan* **-** commonly intercropped with Maize in Africa. Deep tap roots make it drought resistant and non-competitive with cereals. Imported varieties from ICRISAT waiting to be planted.
- **Winged bean,** *Psophocarpus tetragonolobus* - some native species to Timor, requires further investigation
- **Mung bean**, *Vigna radiate* - commonly found in markets in Dili. Inclusion in diet needs to be assessed.
- **Napier Grass,** *Pennisetum purpureum* **–** some use in Remexio (USC). Suitability for contour terracing needs to be investigated. Used as fodder for cattle.
- **Soybean**,*Glycine max* – Some evidence of cropping in Timor, needs more investigation.
- **Cowpea,** *Vigna unguiculata* - Cowpeas are a common leguminous food crop in the semi-arid tropics. Cowpea is a grain legume grown mainly in the savanna regions of the tropics and subtropics in Africa, Asia, and South America. Cowpea grain contains about 25% protein, making it extremely valuable where many people cannot afford animal protein foods such as meat and fish

Conservation agriculture

Conservation Agriculture (CA) is defined by FAO as 'resource-saving agricultural crop production'. Commonly, it includes practices such as reduced or 'no-till' soil management, with residue retained on the field (stalks, husks etc).

Plowing soil acts to increase decomposition of organic matter in the soil, making minerals more available to plants. This however also makes the minerals more vulnerable to erosion by the elements. CA practices aim to reduce erosion by improving soil structure through maintenance of organic matter, also improving water penetration. Higher levels of organic matter also increase the water holding capacity of soils – a highly valuable characteristic of soils in areas of high evaporation.

Moisture management is an important part of CA farming systems, such as leaving residues from the previous crop on the soil surface to reduce runoff and evaporation (mulching). A small percentage of farmers already practice similar mulching systems in Timor. Minimising disturbance to soils also assists in prevention of water loss from the soils. Increased or more extreme temperatures can dry out soils more rapidly, and strategies to increase soil water storage need to be tested in Timor-Leste.

Strategies for soil improvement

Crop rotations will be of benefit in trying to establish soil structure. Micro catchment farming systems could be tested in Timor-Leste. Micro catchments could also be tested with and without sweet potato or cassava as slope stabilizers. World Vision and Care have established some trials to test micro-catchment systems in Timor.

The Philippines offer some good examples of successful sloping land research, such as outputs from the Sloping Agricultural Land Technology (SALT) research. SALT is a form of alley farming in which field and perennial crops are grown in bands 4-5 m wide between contoured rows of leguminous trees and shrubs. When the hedge reaches 1.5-2.0 m in height, it is cut back to 40 cm and the cuttings are placed in the alleys between the hedgerows to serve as mulch and organic fertiliser or green manure.

(http://www.fao.org/ag/AGP/AGPC/doc/PUBLICAT/Gutt-shel/x5556e0y.htm). Species used in this technology include commonly available species in Timor-Leste: *Leucaena leucocephala, L. diversifolia, Calliandra calothyrsus and Gliricidia sepium.*

SALT system research in the Philippines was tested to confirm the assumed benefits in preventing soil erosion. This was done by establishing individual plots measuring 800 m^2, with and without SALT hedgerows with two replications. Soil losses in both systems were assessed using a staking method which measured changes in soil levels throughout the plots. Although the staking method was found to overestimate erosion, correction factors were applied and the final results of the study showed that there was almost 60 times less erosion in the SALT system than in the non-SALT treatment.

Adapting the Mucuna/Abonera cover crop system to one which uses an edible bean species could make a huge difference to steep slope settled agriculture sustainability in Timor. The nitrogen fixing, water capture, run-off reduction potential and protein source benefits could potentially solve much of the issues associated with the movement away from the shifting swidden, slash and burn agriculture.

Coordination with UNTL

Students of UNTL Agronomy department frequently partake in research using SoL seed varieties, and are guided by SoL research advisors in addition to their lecturers. Projects are predominantly for completion of the students theses. There is much scope for climate change research projects at the Hera university research facility, where there are both manual and automatic weather stations, and there is also fenced land available for research plots.

Agronomy department staff can also receive funding from ACIAR and other international bodies (Universities) for undertaking collaborative research with MAF/SoL. Soil erosion tests, weather monitoring and analysis, no-till farming practices and legume research are some potential project fields. Such projects could possibly be guided by the National Focal Point for the United Nations Framework Convention on Climate Change (UNFCCC).

Detailed weather data can be collected at as many locations as possible, covering the different AEZ. Accurate calculations of cropped areas (at least maize and rice) and crop yield figures are also necessary. GIS can be used to make more accurate assessments of cropped area than current MAF crop-cutting sampling practices.

Accurate data will enable Timor-specific modeling and predictions for adaptation to climate variability. Future field experiments will benefit from such data, which should be managed at a central database within the appropriate ministries.

8. Communication and technology dissemination

Seeds of Life activities were disseminated through a number of different avenues during 2009-2010 as presented below:

Audience	Communication medium
Farmers	• Direct contact with SoL OFDT research staff • Farmer field days • Research results meetings
MAF district staff	• Ongoing liaison with SoL district staff & leaders • Farmer field fays • Research results meetings
NGO & agency partners	• Ongoing liaison with SoL district staff & leaders • Research results meetings • Website • Publications
Timorese public	• Print, radio and television news stories • Conferences • Tetun-language publications
Australian & international public	• Website • Print and radio news stories • International conferences • English-language publications

Research staff continued to communicate regularly with farmers during 2009-2010. The farmers were very receptive to SoL RA visits for example and crop yields tended to be higher when the SoL staff visited their on-farm trials (OFDTs) more often. In the process of OFDT establishment, the RAs also communicated with members of the RDU, MAF staff, village chiefs and farmers.

In addition to SoL staff's direct contact with OFDT farmers, NGOs and MAF extension staff also distributed SoL seed and discussed the attributes of each released variety with farmers.

SoL activities were concentrated in seven districts in 2009-2010 and over a five year period OFDTs had been installed in approximately one third of the sucos. The coverage was even higher in the original four districts of Aileu, Liquica, Manufahi and Baucau. NGOs and the MAF also distributed seed of SoL varieties in other districts. The spread of SoL varieties and other technologies is expanding rapidly as an increasing amount of seed was multiplied by the program (Chapter 3). Seventy five field days were held during 2010 and 9 persons are trained each working day allowing more technology transfer.

Farmer field days

Thirty four field days were organized on farmer fields by SoL staff in all sub-districts where OFDTs were established. Attendance at the field days was approximately 20 farmers who were involved in both the harvest and measurement of crop yield. A total of 665 persons attended of which 52% were men and 48% women. These field days allowed an exchange of ideas between the farmers and research staff. In the case of sweet potato, cassava, peanuts and rice the harvest was cooked and tasted. The attributes of each variety were then discussed.

Field days were also held on research stations. These were designed to engage the farmers in evaluation of potential varieties early in the trial process and before they reached the farmers fields. Taste tests were incorporated into the field day to examine promising entries.

Research results meetings

Research results meetings were held in each of the seven SoL districts in early August-September 2010, to present the results from the period September 2009-August 2010. The day-long meetings were well organised and well attended, and provided a valuable opportunity for SoL to engage with local farmers, district administration, MAF district staff and NGO staff.

Publications

2009 Annual Research Report

The 2009 Annual Research Report was published in July 2010 in English and Tetun. 500 copies were printed in English and 1,500 in Tetun, and were distributed to MAF divisions, AusAID, NGOs etc. The research report is also available to download from the Seeds of Life website as a PDF file, together with reports from previous years.

Publications to the end of August, 2010

At the end of August, 2010, 55,500 brochures describing the 9 released varieties and use of the grain pro bags had been printed and most distributed. Brochures for maize, rice, sweet potatoes and peanuts were on their fourth re-printing. 3,500 general descriptions of the program had also been printed along with 6,250 Annual Research Reports (2005-2009).

Website

The Seeds of Life website http://www.seedsoflifetimor.org/ was regularly updated during the year. The site presented the programs research results and was also used for advertising for personnel. This site is regularly visited by the general public with 3759 hits over the period from October, 2009 to August, 2010. During the latter months of this period, the number of visits increased from 200 per month to 350 per month. Visits originated from 105 countries indicating its international interest.

Communications volunteer

A Communications officer recruited by the Australian Youth Ambassadors for Development (AYAD) to work with SoL completed her one year input in March, 2010 after working on a range of communications activities including farmer benefit stories, the website redesign, design of new publications, a photography database and training, and media releases.

Local media coverage

SoL activities were regularly being publicised within Timor-Leste in both the local newspapers, local radio and TVTL news broadcasts. Typical reporting events are "Seed of Life" halo mudancsa bo toos nain sira" in Sura Timor-Leste (2/08/2010). Seeds of life is also a regular part of the weekly RDTL radio show. A special report on SoL was presented on 15/09/2010.

Articles were also included in Ministry of Agriculture and Fisheries "Jornal Agrikultura":

February, 2010	Description of the ABC crew to Timor-Leste to film SoL activities.
May, 2010	Article on the Seeds of Life Phase 3 program plan outline

August, 2010	Seeds of Life/ACIAR in Timor-Leste – improving agricultural production through release of good quality varieties
September, 2010	Reporting SoL research results meeting in the District of Baucau

In addition, general interest stories were posted on the SoL website for use by the international media. These were titled:

Introducing Ai-Luka 2 and Ai-Luka 4 (September, 2009)

Cassava field day, Aileu (October, 2009)

Visit to Hermitage Research Station, Queensland (May, 2010)

Australian media coverage

Beanstalk. Centre for Legumes in Mediterranean Agriculture Newsletter, Vol 10 no 2. December, 2009

Seeds of Life was featured on the Australian Broadcasting Commission program, Landline two times in 2010 – the first on 14 March, 2010 and two weeks later on 28 March, 2010. Links to these websites are as follows:

http://www.abc.net.au/landline/content/2010/s2845293.htm
http://www.abc.net.au/landline/content/2010/s2858179.htm

9. Capacity building

The training program for 2009-2010 was based on a needs assessment conducted in 2006 by personnel from the International Rice Research Institute (Shires and Balasubramanian, 2006). Their study suggested that the program possess elements of (1) post graduate courses, (2) on-the-job training (OJT) and (3) short courses with the long term aim of having sufficient trained researchers at the national research institutes and trained extension staff in the districts to satisfactorily handle the research and development needs of Timor-Leste. The training program implemented during the year also involved farmers and other technology adopters including NGOs.

The long term goal is for Government personnel formal qualifications to reach the levels presented in Table 169.

Table 169. Long term goal for qualifications of personnel working in MAF

- National research institutes: 40% M.Sc., 30% B.Sc., and 30% diploma holders.
- District level: One M.Sc. level crops extension specialist trained in general agronomy and crop management, one B.Sc. level plant protection extension specialist trained in entomology and pathology, and one extension specialist with diploma in livestock extension.
- Sub-District level: Three to four extension staff at diploma level for each district.
- Suco level: A suco extension officer and 2-3 locally trained lead farmers as para-extension staff to promote technologies in their respective target areas.

In 2010, the Directorate of Research and Special Services was manned by one PhD, two MSc graduates, the remainder possessing either a Diploma or undergraduate degrees. There were no MAF personnel with MSc qualifications residing in the districts. MAF staff numbers by National Directorate are presented in Table 170. There was also an extra 409 extra staff members in the Districts making a total of 1793 staff members in the MAF. Approximately 10% of Headquarters staff was considered to be Professionals and 6% of District staff classified as Professionals (MAF, 2009) as opposed to Technical or Non Technical. These statistics emphasize the need for a wide ranging human capacity building program within MAF if international levels of education are to be equaled.

Table 170. Staff and budget of MAF Directorates

National Directorate	*Permanent staff*		*Temporary staff*		*Total*	*Budget ('000 USD)*
	HQ	*District*	*HQ*	*District*		
Research and Special Services	8	3	39	45	95	523
Agriculture and Horticulture	22	13	136	51	222	16,363
Agricultural Community Devel.	2	0	56	398	456	412
Total research and ext'n	32	16	231	494	773	
Total in National Directorates	161	10	521	692	1384	
TOTAL in MAF					1793	29,802

Source: MAF Overview on Policies and National Directorates: Their Resources, Activities and Plans for 2009

The MAF allocates approximately 1.75% ($523,000/$29,802,000) of its budget to agricultural research. Little of this is spent on training compared with salaries and operational costs. SoL contributes to the training program directly and indirectly through facilitating MAF personnel gaining access to opportunities with other agencies.

In 2010, six Timor-Leste researchers had been or were being assisted with their post graduate training. Two were directly sponsored by SoL to attend Bogor Agricultural University in Indonesia (commencing July, 2009) and two further students were assisted with applying for John Allwright scholarships to attend courses at the University of Western Australia (UWA).

The John Allwright scholars commenced English language training in January, 2010 and will start their MSc courses at the beginning of 2011. A fifth student received support from SoL to complete the last two units of his Master Degree of Geographical Information Science (MGISc) at the University of New England (completed in 2009). In addition one student was partially supervised by the SoL Australian Program Coordinator and financially supported by SoL to complete his PhD candidature at the end of 2010. A further masters degree student has been identified to commence studies in 2011

On-the-job training for local SoL staff visiting Australia was limited during the year mainly because of poor English language skills. However, assistance was provided to one SoL team member who received a Crawford Fund scholarship to work with a private plant breeding company in Australia.

A similar number of training days were provided by the program in 2009/2010 compared with 2008/2009 (Figure 84). The total number of training days during the year was 2306 or equivalent to 10 training opportunity days per working day. The researchers and agronomists become more confident and took an increasing amount of responsibility due to this training. Competencies in various fields, such as agronomic, computer and management skills, are recorded and monitored to enable more tailored training programs for future phases of the program.

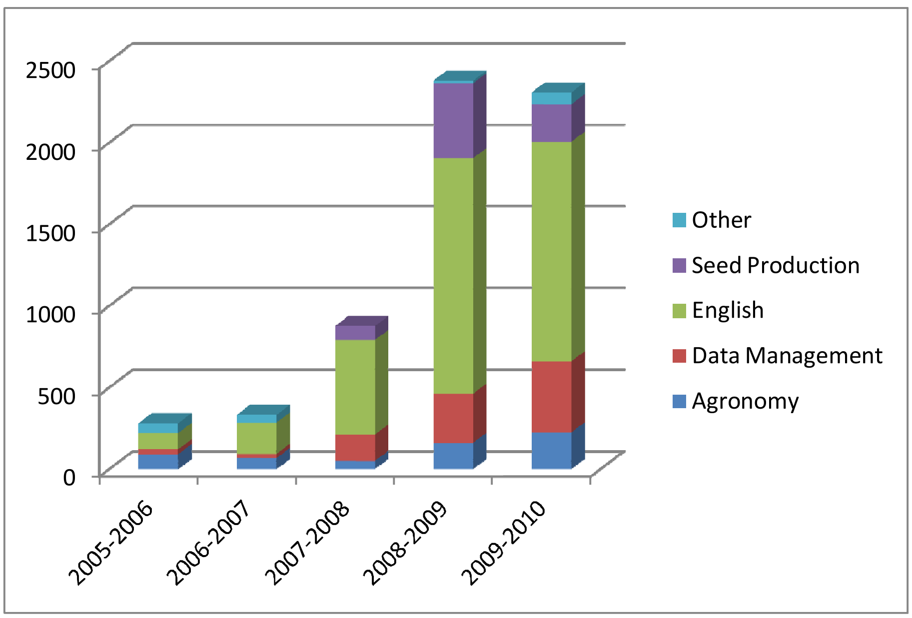


Figure 84. Annual total training days, 2005 - 2010

English language training constituted a major proportion of the formal courses (Figure 84). Data management training was also important followed by seed production. Many of the courses were presented in either Tetun or Bahasa Indonesian. Training material was often translated from English or Indonesian into Tetun. Indonesian professors from Bogor University of Agriculture visited SoL and presented 2 courses over the year in Bahasa. Seed production training was presented by the Indonesian SoL advisor in Bahasa, a language which is often the medium of instruction in Timor-Leste universities. English language training remains important in the SoL training program to improve the potential for MAF personnel to work with computer programs and attend training courses abroad.

English language capacity within MAF research staff improved significantly over the period from 2005-2010. During this time, the average staff English level has increased from 1.9 to 2.4 on a scale of 1-4.

Training was primarily directed towards MAF/SoL personnel but a range of participants in the agriculture and food security community in in Timor-Leste also attended the courses. Included were members of MAF, local and international NGOs District personnel and farmers. MAF staff from the research and crops divisions (external to SoL staff), were also often invited to training activities overseas. Figure 85 shows the percentages of participants.

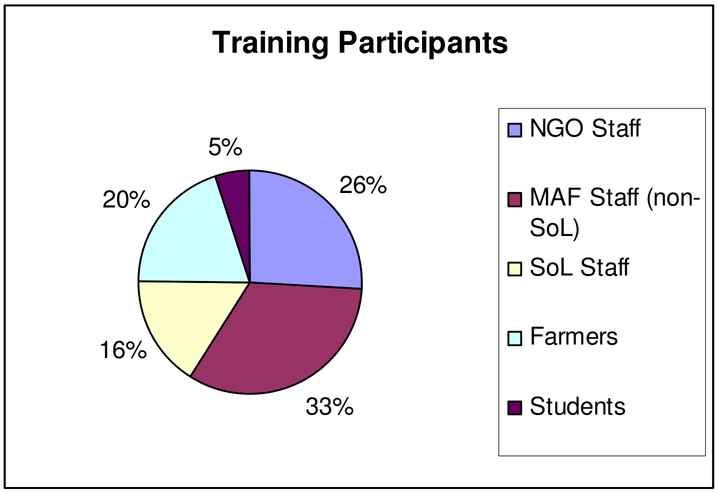


Figure 85. Percentage of training participants from various organizations

10. Technology recommendations

10.1 Released and potential varieties

Nine improved crop varieties identified by SoL had been released by the MAF at the end of August, 2010. The first seven varieties were recommended to the MAF by the varietal recommendation committee (VRC) at its first meeting on 8 March 2007. This committee was chaired by the Minister of Agriculture and Fisheries. Two of the seven varieties are yellow maize, three sweet potato, one rice and one peanut. All released varieties had undergone evaluation under on-station conditions over the period 2000-2005. In the 2005/06 wet season, both replicated trials and non replicated on-farm trials were established, the results of which are presented in the Annual Research Report for 2006 (SoL, 2006). A similar program of installing replicated and on-farm trials continued during the dry season of 2006 and wet season of 2006/07, the dry season of 2007 and wet season of 2007/08. These trials were described in the Annual Research Reports for 2007 and 2008 (SoL, 2007, 2008). Some of these varieties were further evaluated in 2008-2009 and 2009-2010 in comparison with local varieties and some potential new releases.

Two cassava varieties were released by the MAF on 27 August, 2009 and multiplied in 2009-2010 for distribution to seed producers. Both varieties were bred at the Indonesian Legumes and Tuber Crops Research Institute (ILETRI) (sometimes referred to as RILET) or selected by the Center Research Institute of Food Crops (CRIFC). The responsible breeders from ILETRI attended the VRC meeting chaired by the Minister of Agriculture and Fisheries and were present when the varieties were officially released. Both varieties were evaluated over at least 13 sites (13 sites for Ca26 and 16 sites for Ca15), are high yielding and considered by farmers to be either sweet or very sweet. These varieties were released as Ai-Luka 2 and Ai-Luka 4. A description of the newly released cassava varieties is presented SoL, 2009. A detailed description of the results leading to the release and productivity information after release is presented in earlier reports (SoL, 2008; SoL 2009). An update on the variety selection results for each crop is presented below.

10.1.1 Maize

Sele and Suwan 5

Of the two released varieties, Sele and Suwan 5, Sele is by far the most popular with farmers and seed multiplication and distribution has been concentrated on this variety. In 2010 approximately 40 tons of Sele seed was produced. Sele is yellow grained and, for yellow maize, possesses characteristics preferred by most of the population. It is high yielding, possesses good pounding characteristics and is sweet to eat. It also appears to perform particularly well in drought conditions. Descriptions of these characteristics and farmers reactions to Sele are summarized in SoL, 2008.

Sele continued to perform well in replicated trials and in OFDTs during 2010 (See Chapter 2.1, Table 171, Table 172). As the preferred released variety, it was also used as a standard against which other varieties were measured. Most of the entries in the replicated trials in 2010 were white grained as these varieties are preferred by farmers in many parts of Timor-Leste. White grained HAR 12 and P07 were included in OFDTs for the second year in 2010. P07 demonstrated good progress during the year and may be released in 2011 if the results of the third year of evaluations are as encouraging.

Table 171. Select maize yields and yield advantages, research stations, 2001-2010

Year	*Yield (t/ha)*						*Yield advantage (%)*				
	Suwan 5	*Sele*	*Har12*	*Har05*	*P07*	*Local*	*Suwan 5*	*Sele*	*Har12*	*Har05*	*P07*
2001-2005	3.5	3.1	na	na	na	1.7	106	82	na	na	na
2006 (Four sites)	1.6	1.5	na	na	na	1.1	41	39	na	na	na
2007 (Six sites)	1.9	2.6	2.7	2.0	2.6	1.5	27	73	80	33	73
2008 (Four sites)	1.5	1.5	1.3	1.2	1.3	1.0	53	53	33	22	33
2009 (Five sites)	1.9	1.8	1.6	1.6	1.6	1.0	87	81	53	58	58
2010 (Four sites)	1.9	1.7	1.4	1.1	2.1	1.2	58	42	17	-8	75
Mean (2006-2010)	1.8	1.8	1.7	1.5	1.9	1.2	51	58	45	23	58

Table 172. Select maize yields and yield advantages, OFDTs, 2006-2010

Year	*Yield (t/ha)*						*Yield advantage (%)*				
	Suwan 5	*Sele*	*Har12*	*Har05*	*P07*	*Local*	*Suwan 5*	*Sele*	*Har12*	*Har05*	*P07*
2006 (170 sites)	2.6	2.3	na	na	na	1.7	53	35	na	na	na
2007 (278 sites)	2.5	2.4	na	na	na	1.7	47	41	na	na	na
2008 (220 sites)	na	2.4	1.8	na	na	1.6	na	50	13	na	na
2009 (235 sites)	na	2.2	1.9	1.6	1.7	1.4	na	57	36	14	21
2010 (188 sites)	na	2.7	2.1	na	2.5	1.8	na	51	17	na	40
Mean (2006-2010)	2.6	2.4	1.9	1.6	2.1	1.6	50	47	21	14	31

10.1.2 Peanuts

Utamua

The released peanut variety, Utamua, continued to show a high level of adaptation in all agro-ecosystems in Timor-Leste. When successfully included in replicated trials, it was high yielding (Table 173) and contined to perform well against the test entries in OFDTs (Table 174).

Pt 15 and Pt 16 performed reasonably well in replicated trials but were below the yields of local varieties in OFDTs. A new set of potential peanut varieties were imported from India in 2009 and were evaluated in 2010 (Chapter 2.5). These will be investigated further in 2011.

Table 173. Utamua peanut yields and yield advantages, research stations, 2001-2010

Year	*Yield (t/ha)*					*Yield advantage (%)*			
	Utamua	*Pt14*	*Pt15*	*Pt16*	*Local*	*Utamua*	*Pt14*	*Pt15*	Pt16
2001-2005	2.1	na	na		2.0	7	na	na	
2006 (Two sites)	1.1	1.8	1.3	1.6	1.2	-9	50	8	33
2007 (Five sites)	2.0	2.4	2.3	1.8	1.7	17	40	34	6
2008 (Four sites)	1.3	1.1	1.1	0.7	0.9	43	26	23	-22
2009 (Six sites)	1.5	1.2	1.5	1.8	1.1	32	5	32	58
2010 (Four sites)*	1.2	0.7	0.8	0.9	0.8	71	-1	10	14
Mean (2006-2010)	1.5	1.6	1.5		1.2	31	24	21	18

* Only two sites for Utamua and only respective controls considered for this evaluation

Table 174. Utamua peanut yields and yield advantages, OFDTs, 2006-2010

Year	*Yield (t/ha)*					*Yield advantage (%)*			
	Utamua	*Pt14*	*Pt15*	*Pt16*	*Local*	*Utamua*	*Pt14*	*Pt15*	Pt16
2006 (168 sites)	1.8	na	na	na	1.2	50	na	na	na
2007 (138 sites)	2.0	na	na	na	1.6	24	na	na	na
2008 (175 sites)	2.0	na	na	na	1.5	33	na	na	na
2009 (166 sites)	2.0	1.1	1.4	na	1.1	82	0	27	na
2010 (132 sites)	3.5	na	2.3	2.3	2.4	43	na	-6	-7
Mean (2006-2010)	2.3	1.1	1.9	2.3	1.6	47	0	3	-7

10.1.3 Sweet potato

Hohrae 1, Hohrae 2 and Hohrae 3

Hohrae 3 performed extremely well across a range of environments compared with other sweet potato varieties in 2010. The other two released varieties, Hohrae 2 and Hohrae 1 also yielded reasonably well but not as high as the controls in replicated trials (Table 175). The inclusion of Hohrae 3 in OFDTs provided an opportunity to compare potential new releases in CIP 17 and CIP 8 with it (Table 176). Neither of these two varieties compared well with Hohrae 3 and will be discarded in the future, being replaced in the OFDTs by more recent breeding material such as CIP 72 or CIP 83.

Table 175. Sweet potato yields and yield advantages, research stations, 2001-2010

Year	*Yield (t/ha)*				*Yield advantage (%)*		
	Hohrae 1	*Hohrae 2*	*Hohrae 3*	*Local*	*Hohrae 1*	*Hohrae 2*	*Hohrae 3*
2001-2005	12.7	13.2	13.3	5.6	128	137	138
2006(One site)	2.8	4.8	1.3	0.6	367	700	117
2007 (One site)	29.6	23.9	26.5	9.8	202	144	170
2008 (Two sites)	22.2	15.9	21.9	8.9	149	79	146
2009 (Five sites)	9.2	13.8	19.6	8.9	3	55	121
2010 (4 sites)	5.0	6.6	9.5	5.9	-15	12	61
Mean (2006-2010)	13.8	13.0	15.8	6.8	102	91	131

Table 176. Sweet potato yields and yield advantages, OFDTs, 2001-2010

Year	*Yield (t/ha)*				*Yield advantage (%)*		
	Hohrae 1	*Hohrae 2*	*Hohrae 3*	*Local*	*Hohrae 1*	*Hohrae 2*	*Hohrae 3*
2001-2005	na	na	na		na	na	na
2006 (None harvested)	na	na	na		na	na	na
2007 (83 sites)	4.0	4.7	4.5	3.1	29	52	45
2008 (115 sites)	6.1	6.3	6.5	3.0	103	110	117
2009 (76 sites)	na	na	15.6	3.8	na	na	311
2010 (109 sites)	na	na	15.8	6.5	na	na	143
Mean (2006-2010)	5.1	5.5	10.6	4.1	66	80	159

10.1.4 Rice

Nakroma

Nakroma, the SoL/MAF variety released in 2007 did not perform well compared with other varieties in replicated trials during 2009-2010 (Table 177). It did however, perform well in the OFDTs averaging 31% more yield on 51 sites (Table 178). This variety was selected by MAF personnel and farmers in trials conducted in 2005 for targeting to release in Timor-Leste. It remains a popular variety amongst the rice farming population and is spreading rapidly in the rice growing areas. PSB RC 80 is another variety which has also performed extremely well in some rice areas and is favourabley received by farmers. It will be further examined in OFDTs during the 2010-2011 growing season.

Table 177. Rice yields and yield advantages, research stations, 2008-2010

	Yield (t/ha)			*Yield advantage (%)*	
Year	*Nakroma*	*PSB RC80*	*Local*	*Nakroma*	*PSB RC80*
2008 (Three sites)	1.8	1.9	1.7	5	13
2009 (One site)	1.2	1.7	1.0	12	64
2010 (1 site)	5.5	6.3	6.2	-11	2
Mean (2008-2009)	2.1	2.5	2.2	-4.5	11.2

*significant for a pairwise comparison between mean yields of Nakroma and local only

Table 178. Rice yields of OFDT, all districts, 2005 to 2010

Variety	*Mean yield (t/ha)*			*Yield advantage (%)*		*LSD*
	Local	Nakroma	PSBRC 80	Nakroma	PSBRC 80	*(p=0.05)*
2005/06 (47 sites)	2.9	3.3	na	17	na	
2006/07 (52 sites)	3.0	3.7	na	20	na	0.5
2007/08 (76 sites)	3.6	4.8	na	30	na	0.6
2008/09 (71 sites)	3.2	3.8	3.3	18	4	0.5*
2009/10 (51 sites)	2.9	3.8	3.5	31	21	0.7
Total (297 sites)	3.1	3.9	3.4	24	11	

10.1.5 Cassava

Ai-luka 2 and Ai-luka 4 continue to be the varieties most preferred by farmers when evaluated at field days (See Section 2.3). No other varieties are yet ready for release.

10.2 Farming systems recommendations

Maize

Agro-ecological zone (AEZ). Research conducted during the year did not reveal a variety by AEZ interaction. This indicates that Sele and Suwan 5 are well adapted over all testing regions. There is no indication that Sele or Suwan 5 should be recommended in some areas and not others. However Sele is often reported by farmers to show significant drought resistance.

Soil pH. The growth of all maize varieties was reduced when grown in either acidic or basic soils. Of all maize production sites, 18% had a soil pH acidic enough to reduce maize yield. Future research could evaluate different varieties to see if it is possible to expand the pH tolerance of maize varieties, or ameliorate the soils to increase grain yields. There may also be a role for extension staff to work with farmers to identify acid soils. Once identified, farmers could avoid the acid soil sites, and produce higher yields at other locations.

Seeds per hole. Research results indicate that the optimum number of seeds per hole is three or less and that farmers who plant more than this suffer significant yield reductions. Farmers will be encouraged to maintain their hill seeding density at below 4 for local and new varieties.

Plant density. Grain yields are not influenced by whether the maize is planted in rows or randomly. Although there is no yield advantage in plant densities exceeding four plants per square metre, there is a yield reduction when plants/m^2 drops below four. Maize crops should be managed to achieve at least four plants/m^2 at harvest time.

Weeding. Two weedings, preferably early in the season are recommended for maize. More than three weedings do not increase yields. The first weeding, within 4 weeks after planting, is critical in achieving high yields.

Fertilizer. Farmers in Timor-Leste currently do not use fertilizers, either organic or chemical, on maize, although soil improvement could significantly increase yields.

Insect pests and diseases. Maize crops were not significantly affected by insect pests and diseases during the year. However downy mildew can sometimes devastate susceptible crops, so varieties that are resistant to downy mildew are essential.

Rice

Plant density. Grain yields are not influenced by planting either in rows or randomly in the OFDT data set. However for ease of weeding, especially with mechanical weeders, planting should be at approximately 20-25cm intervals in lines.

Weeding. A second weeding was shown to be very beneficial to rice yield. At least two weedings – preferably early in the season are recommended for rice.

Peanuts

Seeds per hill. Planting two seeds per hill increases yields in both Utamua and local varieties.

Replanting. Replanting poorly germinated hills will increase plant population and subsequent yields.

Weeding. Research in 2007 indicated that pod yields are higher with an increased number of weedings. Peanuts may need to be weeded up to four times to maximize yields.

General

Grain storage Weevils are a renowned problem in stored grain in Timor-Leste. Techniques for improving storage life of maize includes storing grain in air tight containers (plastic containers and bags) or selecting varieties with known weevil resistance. The trials conducted during the year confirm that weevil tolerance is partially due to sheath characteristics but also on characteristics of the grain itself. Further research will focus on investigating both improved storage techniques and releasing varieties with better resistance.

Velvet bean The use of velvet bean (*Mucuna pruriens*) to both suppress weeds and improve soil nutrition through mulching is well known in other parts of the world. This technology was used by Timor-Leste farmers in the past and can be extended to farmers during future on-farm evaluation. Research conducted during the 2006/07 wet season indicated that velvet bean will need to be planted after maize to avoid smothering the crop during the wet season. These results were supported by trials conducted in 2007/08. Planting velvet bean the same time as the maize crop leads to velvet bean dominating the maize crop, reducing maize yield. It is recommended that Velvet bean be used as a technology to increase maize yield and reduce the weed burden of farmers.

On the south coast where farmers plant 2 crops a year, velvet bean grown in the main wet season has been shown to significantly increase maize yields in the second season crop (planted May-June).

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