Annual Research Report
2013

Seeds of Life
Fini ba Moris

'Improved food security through increased productivity of major food crops'

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 Department of Foreign Affairs and Trade (DFAT) plus the Australian Centre for International Agricultural Research (ACIAR) and is managed by ACIAR. The Centre for Plant Genetics and Breeding (PGB) within The University of Western Australia (UWA) coordinates the Australian funded activities.

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Foreword

On May 3, this year I had the pleasure of inaugurating the nation's first National Seed Laboratory and in June, guidelines for commercial seed production were endorsed by my Ministry. Such activities follow the development of a policy on the management of the national seed system and the formation of a commercial seed sector in Timor-Leste. These are exciting developments in the establishment of a sustainable national seed system for released varieties (NSSRV). The release of varieties suitable for the agro-ecosystems of Timor-Leste are highly dependent on the completion of a successful research program. This report, the Annual Research Report for 2013, describes activities of the Ministry of Agriculture and Fisheries' (MAF) research and development program for the 2012-2013 wet season.

As in previous years, most of the research described in this report was conducted in the Districts of Aileu, Ainaro, Baucau, Bobonaro, Liquiça, Manufahi, and Viqueque. These Districts possess one or more of the six recognized Agro Ecological Zones (AEZ) in Timor-Leste. Research was also conducted in the high altitude areas suggested in this report to constitute a seventh agro-ecosystem.

Introduced, high yielding varieties are first evaluated under research station conditions and the best of these undergo field testing on farmers' fields in the different rainfall, temperatures and soil regimes of the country. The MAF then oversees the multiplication of seed of these released varieties both for certified and commercial purposes. We have a network of seed inspection services and quality control laboratories to ensure the seed remains pure and of high quality. The bulk of seed utilized by farmers is, however, grown by farmers both as community seed production groups and as individuals. All levels of the seed system rely on researchers identifying valuable germplasm for inclusion in the system. The researchers also develop other technologies to improve agricultural productivity including farming systems possessing weed control and soil enhancing characters. In addition, our program possesses climate change and social science research.

Replicated trials were conducted on six research centres and stations during the year. These are located in Loes (Liquiça, AEZ1), Betano (Manufahi, AEZ6), Quintal Portugal (Aileu, AEZ3), Urulefa (Ainaro, AEZ3), Darasula (Baucau, AEZ2) and Raimaten (Bobonaro, AEZ2). All stations are well equipped and have undergone extensive renovations. Meanwhile, in the area of capacity building, MAF staff members continue to receive short term training, conduct comparative studies, have access to national and international conferences and, in some cases, researchers are enabled to attend MSc training in Australia and Indonesia. MAF personnel will take increasing responsibility for research and seed multiplication activities over the next few years.

Finally, on behalf of the Ministry of Agriculture and Fisheries, I would like to extend our gratitude to the Australian Government, especially Australian Centre for International Agricultural Research (ACIAR) and the Australian Department of Foreign Affairs and Trade (DFAT) who have made financial support available for the implementation of the research and seed multiplication program. My high appreciation also, to all parties who have collaborated in the development of agriculture in Timor-Leste to eradicate hunger, food insecurity, and poverty.

September, 2014

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

Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ALGIS	Agricultural Land Geographical Information System
AEZ	Agricultural Ecological Zone
ANOVA	Analysis of variance
ATCFC	Australian Tropical Crop and Forages Collection
CCT	Cooperative Café Timor
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CSPG	Community Seed Production Group
DFAT	Australian Department of Foreign Affairs and Trade
FAO	Food and Agriculture Organization
GIS	Geographic Information Systems
ICRISAT	International Centre for Research in the Semi-Arid Tropics
ILETRI	Indonesian Legumes and Tuber Crops Research Institute
IRRI	International Rice Research Institute
M&E	Monitoring and Evaluation
MAF	Ministry of Agriculture and Fisheries
NDA&H	National Directorate for Agriculture and Horticulture (MAF)
NDR&SS	National Directorate of Research and Special Services (MAF)
NDP&P	National Directorate of Policy and Planning (MAF)
NDACD	National Directorate of Agricultural Community Development (MAF)
NGOs	Non-Government Organizations
OFDTs	On-Farm Demonstrations and Trials
PDD	Program Design Document
PGB	Centre for Plant Genetics and Breeding
PSC	Program Steering Committee
QPM	Quality Protein Maize
SEOs	Suco Extension Officer (MAF extension officer)
SoL	Seeds of Life
SoL3	Seeds of Life 3
SOSEK	Social Science and Economics (Sosial Ekonami)
TAG	Technical Advisory Group
TL	Timor-Leste
TLMSP	Timor-Leste Maize Storage Project
UNTL	University of Timor Lorosae
UWA	University of Western Australia

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Ms. Anita Ximenes	Dili	
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Mr. Abril Fatima Soares	Dili	
Mr. Marcelino de Jesus da Costa	Dili	
Ms. Dorilanda da Costa Lopes	Bobonaro	Maliana
Ms. Maria Fernandes	Dili	
Mr. Cipriano Martins	Aileu	Aileu Villa
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Ms. Juliana de Jesus Maia	Manufahi	Same
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Ms. Maria Martins	Aileu	Aileu Villa
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Ms. Julieta Lidia	Dili	
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Mr. Amandio da Costa Ximenes	Viqueque	Ossu

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Mr. Agostinho Alves	Manufahi	Same, Alas
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Mr. Sabilio dos Santos	Dili	
Mr. Fernando Soares	Liquiça	Maubara
Mr. Leão Mauleto	Bobonaro	Maliana
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Mr. Moises Sarmento	Viqueque	
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Maize Sweet potato Rice

Figure 1. Selected research/demonstration sites in Timor-Leste, 2012-2013

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) which assists the identification of productive varieties suited to local conditions, the development of a seed system, multiplication of planting material of improved varieties to feed into the system and strengthening of the institutional capacity for the seed system to become self-sustaining in the future. The vision of the program is to "have the foundations of a national seed system for Timor-Leste established, capable of providing a high level of access to seed of improved varieties to farmers throughout the country". The focus crops for the program have, to date, been maize, rice, sweat potato, cassava and peanuts. The crop diversity was expanded in 2013 with trials on mung bean, wheat, barley, potatoes, red beans and winged beans.

This report details research conducted in the 2012-2013 wet season, months which straddle the second and third years of Phase 3 of SoL. Phase 3 builds on gains made in SoL1 (2000-2005) and SoL 2 (2005-2010) plus the SoL2 extension (September 2010 to January, 2011). SoL 3 commenced on 01 February, 2011 and will run to 31 January, 2016. Apart from maintaining a core focus on the seed system, support is forthcoming to analyse and develop strategies to overcome climate variability and change; improving agronomic practices to reduce weed burdens and increase soil fertility; reducing post-harvest storage losses and improving input supply arrangements for seed.

SoL3 was being implemented in all districts in 2013. However, research activities were concentrated in the Districts of Aileu, Baucau, Viqueque, Bononaro, Manufahi, Ainaro and Liquiça.

This is the eighth Annual Research Report prepared by Seeds of Life. The report details the results of the research conducted by the research component trials completed after August, 2012, including trials conducted in the dry season of 2012 and the 2012-2013 wet season. The achievements and activities of the formal seed (Component 2 of SoL 3) and informal seed production (Component 3 of SoL 3) and plus management activities (Component 4) for the September, 2012 to August, 2013 period are also included. Training and communications activities are reported for the 2013 calendar year.

1.2 Program summary

This summary follows the outline of the Program Design Document (PDD) which is designed with four components possessing specific activities for each. These are 1) Evaluation of improved food crop varieties, 2) Formal seed production and distribution, 3) Informal seed production and distribution and 4) Seed system management. Capacity building is an integral part of the program and is imbedded in each component but a summary of the year's training activities is presented separately.

The activities and progress of each component for 2012-2013 are presented below:

1.2.1 Component 1: Evaluation of improved food crop varieties

Component objective: Improved varieties of food crops identified and released.

Activities in this component include:

- National agricultural research centres and research stations established

- Genetic material of potential improved varieties identified and sourced
- Potential new varieties evaluated on-station
- Potential new varieties evaluated on-farm
- Selected new varieties officially released
- Sufficient foundation seed being produced
- Capacity of MAF staff to manage the identification and release of new varieties strengthened

A key part of the agricultural research is conducted on two research centres (Loes and Betano), four research stations (Quintal Portugal, Urulefa, Darasula and Corluli) and two other upland locations where land is rented from farmers on an as-needs basis (Venilale, Larigutu). Table 1 shows some main characteristics of these research locations.

Table 1. MAF/SoL supported research centres and research stations

Research centres and stations [District]	*Location characteristics*	*Crops grown in Jan-Jun 2013*
RC Loes [Liquiça]	Elevation: 10m Soil: Alluvial AEZ: 1	Maize, peanut, sweet potato, winged bean, cassava
RC Betano [Manufahi]	Elevation: 3m Soil: Alluvial AEZ: 6 Area: 20 ha, of which 5 in use	Cassava, sweet potato, wing beans, maize, mung beans, velvet beans
RS Quintal Portugal [Aileu]	Elevation: 900m Soil: Heavy red clay AEZ: 3 Area: 0.8 ha, of which 0.8 in use	Peanut, wing beans, sword beans, maize, sweet potatoes, cassava
RS Urulefa [Ainaro]	Elevation: 1200m Soil: Heavy clay, limestone origin AEZ: 3 Area: 1.5 ha, of which 1.5 in use	Maize, sweet potato, wheat, barley, potato, climbing beans
RS Darasula [Baucau]	Elevation: 400 Soil: Heavy red clay AEZ: 2 Area: 8 ha, of which 2 in use	Maize, cassava, sweet potato, peanuts, upland rice, mung beans
Raimaten [Bobonaro]	Elevation: 300 Soil: heavy clay AEZ: 2 Area: 1.7 ha, of which 1.7 in use	Rice

Most of the upgrading of these stations and centres was done in earlier years of the program. During 2012-2013 an irrigation scheme at Loes research centre was upgraded, a prefabricated building at Maliana rice research farm constructed and the installation of a water borehole at Darasula station commenced.

A Quality Protein Maize (QPM) population was imported from Indonesia for evaluation in Timor-Leste but lacked downy mildew resistance and was rejected from the trials.

Nineteen replicated dry season trials were conducted during 2012 and included in the 2012-2013 period of this report. During the wet season, a total of 43 replicated trials were conducted. These were conducted for ten crops (ranging from one to seven trials per crop), and two trials were conducted on liming, to assess if adding lime could improve crop productivity on poor acid soils.

On-farm demonstration trials (OFDTs) were installed across a range of agro-ecosystems in seven core districts during 2012-2013. The Districts included Aileu, Baucau, Bobonaro, Manufahi, Ainaro, Liquiça and Viqueque. A total of 302 OFDTs were established for maize (162), rice (4), cassava (53), sweet potato (77) and legumes (6). The results of these trials are included in this report.

A high yielding white maize variety named Noi Mutin was released in July 2012. It is proposed that the Ministry officially releases a bitter cassava variety which has been promoted by the Cooperative Café Timor (CCT) as a second cash crop for coffee farmers. This cassava variety, known as KU50 (Ca109), originally from Thailand, was suggested to CCT based on research conducted at the research centres. It has a high yield and high starch content, but also a high level of cyanide. This "bitter" variety has good storage properties as it is not frequently predated by animals.

Sufficient nucleus, breeder and foundation seed was produced in collaboration with the formal seed production group for the 2013-2014 research and seed multiplication programs.

Capacity building of the researchers working at the research centers and stations, and of the OFDT researchers took place during field visits, and during staff meetings in Dili and formal short term training. Included was short term training on soils, statistics, report writing, climate change and other technical matters. Stronger links between Indonesia and Timor-Leste were also developed through the visit of MAF research staff to the Institute for Adaptive Research for Agriculture in Kupang, West Timor. The researchers also presented papers at an international conference in Dili during July, 2013. In addition, 9 university students were supervised with their final year theses of "skripsis". One MSc thesis was supervised in Australia and two MAF personnel were sponsored to fulfil the requirements for MSc qualifications in Indonesia.

1.2.2 Component 2. Formal seed production and distribution

Component objective: Sufficient high quality seed being produced through formal channels to maintain the genetic quality of released varieties.

Activities in this component include:

- Formal seed being produced through farmer contracts
- Quality assurance systems established
- Technical extension support provided to contracted seed producers
- Seed grading, packing and storage facilities established
- Formal seed distributed through preferred distribution channels
- Capacity of MAF staff to manage the production and distribution of formal seed strengthened

In collaboration with 134 (29 women and 105 men) contracted seed growers, a total area of 98.8 ha was cultivated with seed crops in the rainy season 2012-2013. This included 46.5 ha of Sele, 10.3ha of Noi Mutin, 28 ha of Nakroma and 14 ha of Utamua. Nearly 40 t of maize seed, 3 t of Nakroma and 9 t of Utamua was produced over the period.

Seed processing (i.e. drying, cleaning, grading, storage and packaging) and seed testing (for purity, germination and moisture content) is being done in six purpose-built and equipped seed warehouses spread across Timor-Leste. There are two district seed testing laboratories (at the research centers in Loes and Betano), and since May, 2013 there is also a central seed testing laboratory in Dili.

A seed crop can be rejected during field inspection if other varieties are found to be growing within the seed plot, or if the occurrence of off-types is above standard. During seed processing it may also be rejected if for some reason germination rates are low. On average, there is a 20% seed loss for each crop.

The seed quality assurance system is implemented by the seed service, which currently consists of 19 persons, supported by the Formal Seed Production Advisor. All the seed service personnel are affiliated with MAF's Seed Department (established in June 2011).

In order to produce quality seed, six seed warehouses and seed processing centres have been established in six districts, namely in Aileu, Manufahi, Liquiça, Bobonaro, Baucau and Viqueque. Each warehouse can store about 30 ton of seed. The seed warehouses are equipped with 2,000 l silos, and each silo is able to store about 1.3 ton of rice seed. Basic seed processing equipment has been installed in the seed warehouses.

Most of the seed produced by the component 2 is distributed before the next rainy season. Seed harvested in 2011-2012 for example was distributed prior to the rainy season of 2012-2013. The seed being produced this year will be mostly distributed to fulfil the seed requirements of the coming 2013-2014 growing season.

In February and March, 2012, 95,075 cuttings of cassava and 229,375 cuttings of sweet potato were distributed to 512 groups in 234 sucos in 11 districts. Of the 234 sucos, 60 (26 %) were sucos where SoL already supported CSPGs; the majority of the cutting recipients were thus to households in 174 sucos that had little or no previous interaction with SoL.

Training is part of an important component to make the seed system run well. Over a twelve month period training included seed testing, post-harvest technologies, attendance at conferences and on the job training was conducted (See Section 9).

1.2.3 Component 3. Informal seed production and distribution

Component objective: Mechanisms for the production and distribution of seed through informal and market channels strengthened.

Activities in the component include:

- Community Seed Production Groups (CSPGs) established
- Farmer Seed Marketing Groups established
- Focal seed merchants in local markets established
- Access to seed for vulnerable groups improved through seed fairs
- Systems linking informal seed producers with potential buyers enhanced
- Capacity of MAF extension staff to establish CSPGs strengthened

In 2012-2013 the number of CSPGs increased to 681 in 135 sucos. For the 681 CSPGs, there were 348 maize seed plots, 173 peanuts seed plots, 114 rice seed plots, 10 cassava plots, and 36 sweet potato plots.

The total membership of the supported CSPGs is 8,687 persons, of whom 32% were women. Three percent of the CSPGs are reportedly women-only groups. The total amount of seed produced by these groups and farmers associations during the wet season was 54 t maize, 8 t rice and 7 t peanuts. As of June 2013, 135 SEOs (121 men, 14 women) were directly involved in supporting 681 CSPGs in 135 sucos in 11 districts.

On 16 July, 2013 the first three Farmers Associations (one from Liquiça and two from Baucau) were registered to sell seed under the National Seed System for Released Varieties

(NSSRV). An additional 21 FAs have been identified to be upgraded from CSPGs to FAs. In 2012, of the 15,005 kg Sele maize seed produced by CSPGs, 6,578 kg seed was sold to different NGOs like World Vision and CRS for the 2012-2013 season.

The program has attempted to provide improved seed access for vulnerable households using existing CSPGs. The approach was piloted in February, 2013 in suco Maumeta, sub-district Bazartete in Liquiça. In each of the four aldeias of the suco, 30 vulnerable households (including women headed vulnerable households) were identified and each of them received 200 cuttings of sweet potato.

In 2012, SoL facilitated CSPGs and FAs to market their produce by linking them with leading international NGOs (iNGOs) including World Vision and CRS as seed buyers. These two iNGOs purchased more than eight ton of seed from 31 CSPGs and 3 FAs. As mentioned for output 3.2 above, more CSPGs will be supported to establish FAs. CSPGs have also sold substantial quantities of seed to neighbouring communities.

Between January and June, 11 training activities were conducted by component 3 (see Section 9). The training is not limited to capacity improvement of MAF extension staff, but also includes capacity strengthening for CSPG members, for people linked to the Farmer Associations, and for suco-level facilitators of the IFAD-supported Timor-Leste Maize Storage Project. Some 16 % of the participants in these trainings conducted by MAF/SoL were women.

1.2.4 Component 4. Seed system management

Component objective: MAF capacity to manage the national seed system strengthened

Activities in this component include:

- Seed planning and management systems established
- M&E systems established
- Seed system gender strategy implemented
- Improved-variety technical and promotional materials developed
- Awareness of improved varieties increased
- Environmental and climate change impacts addressed
- Capacity of MAF staff to manage the national seed system enhanced

The national seed system for released varieties is rapidly developing. The system was initially drafted and accepted by the MAF in March, 2013 and endorsed by the Vice Minister of MAF on 27 June, 2013. On 16 July, 2013 the first three Farmers Associations (one from Liquiça and two from Baucau) were registered to sell seed under the NSSRV. This follows the formulation of a national seed policy by Government and Non-Government (including farmers and other members of civil society) over a period of months in 2012.

The SoL M&E/ Sosek unit focused mostly on SoL-specific activities. This included nine case studies five of which are presented in Section 6 of this report. A mid-term survey was also completed

The gender action plan for 2013-2014 was prepared, and is being implemented by each of the components, in line with the activities that are relevant for that component. During the year the formal seed production component maintained a ratio of approximately 32% women in the CSPGs. As of June, 2013, component 3 was working with 8,687 CSPG members.

During the year, some 35 technical and promotional materials were designed in Tetun and English. These were distributed to key stakeholders including ministry staff, development partners, local and international NGOs, and farmers, and for display in MAF and SoL offices (both in Dili and in the districts). Many of the brochures, posters and banners continue to be distributed and used at MAF/SoL events to promote the varieties.

SoL was mentioned in 59 articles and stories in international and local media over the last the calendar year. Three major outlets covered SoL and related topics in June focusing on food security and nutrition - IRIN News, Al Jazeera and Radio France International. From the 59 articles, six mentioned Sele, while the rest covered various topics including nutrition, food security, the seed policy, maize harvests, Indonesian study visits, and the seed laboratory. Together, these articles are projecting a positive image of SoL's work and improved varieties.

The training activities are summarized in Section 9.

The four outputs of the climate change activities during the year were a) Promoting understanding of climate change, climate variability and farmer adaptation strategies; b) Conducting assessment of future climate impacts on crop production, c) Formulating crop adaptation strategies and climate change impacts by agro-ecological zone (AEZ), and d) Strengthening the capacity of MAF staff to manage the weather stations and analyze weather and crop related data. These activities are summarized in Section 7 of this report.

1.3 Rainfall

Introduction

Rainfall data were collected at a number of sites in the near proximity of replicated agronomic trial sites and some On-Farm Demonstration Trials (OFTDs) during 2012-2013. The locations of seven sites by latitude and longitude plus the altitude of the rain gauges are presented in Table 2. One site was located in Agro-ecological zone 1, one site in AEZ2, two sites in AEZ3, one site in AEZ4 and two sites in AEZ6. The average rainfalls for the year at each site, also presented in Table 2, indicate that some areas received heavier rain than normal (Maliana and Viqueque) while others were received either close to long term averages recorded during the Portuguese era (Aileu and Baucau) or lower (Liquiça, Manufahi and Ainaro).

Table 2. Location, altitude and Agro-ecological zone of rain gauges

Sites	*Latitude*	*Longitude*	*Alt (m)*	*Rainfall 2012/2013 (mm)*	*Portuguese data rainfall average (mm)*	*AEZ*
Maliana/Bobonaro	-8.9925	125.2235	233	2524	2054	2
Kabas Fatin/Aileu	-8.7105	125.5215	1109	1760	1725	3
Ostico/Baucau	-8.5347	126.3363	695	1805	1849	3
Caraubalun/Viqueque	-8.8710	126.3673	41	1438	1617	6
Loes/Liquiça	-8.7372	125.1396	20	1033	938	1
Betano/Manufahi	-9.1630	125.7185	9	1812	2289	6
Horai Kiik/Ainaro	-8.8724	125.5900	1650	2082	2604	4

Although the mean annual rainfall for these seven sites (1037 mm) compared reasonably with the long term average (1153 mm), the average monthly falls were vastly different (Figure 2).

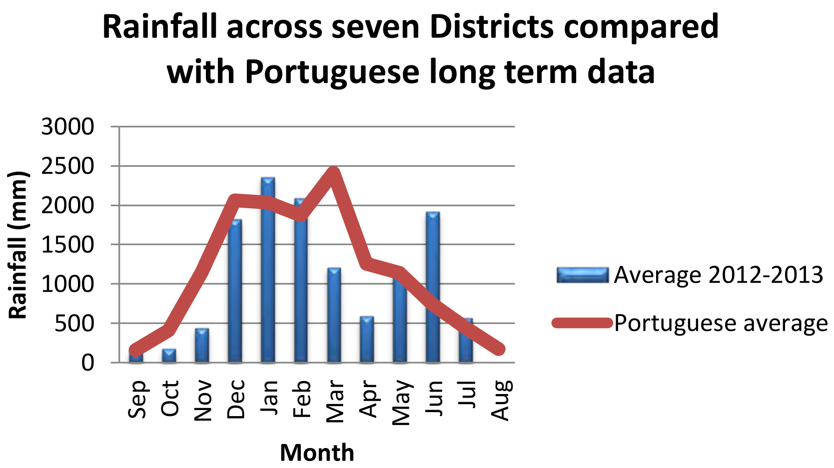


Figure 2. Comparison of average rainfall (7 sites) with long term average.

The months of April-October, on average, receive lower rainfall than the months of November-March. However, rainfall on average across the country during 2012-2013 was particularly wet in May and June. Different patterns were observed in many of the districts, all affecting farming operations and crop productivity.

Rainfall data at select sites

At Aileu, high rainfall during the three months from December to February helped the successful installation of maize crops. Farmers in the uplands were also able to prepare their land during the dry period beforehand and harvest into the dry month of March (Figure 3). The dry months from April through to August also reduced the possibility/potential for a second crop but improved conditions for sowing into 2013-2014.

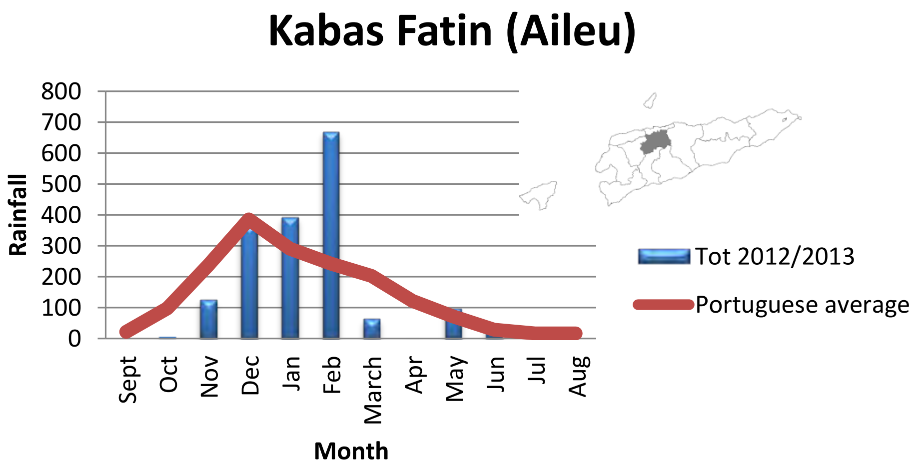


Figure 3. Rainfall (mm) at Kabas Fatin, Aileu, 2012-2013.

The farmers around the research station at Betano, Manufahi, usually experience a long wet season extending from November through to May and a dry season from June to October. The rainfall pattern for 2012-2013 was completely different from the norm with the two wettest months being June and July (Figure 4). This rainfall pattern reduced the potential of crops planted in November- December and at harvest in June-July.

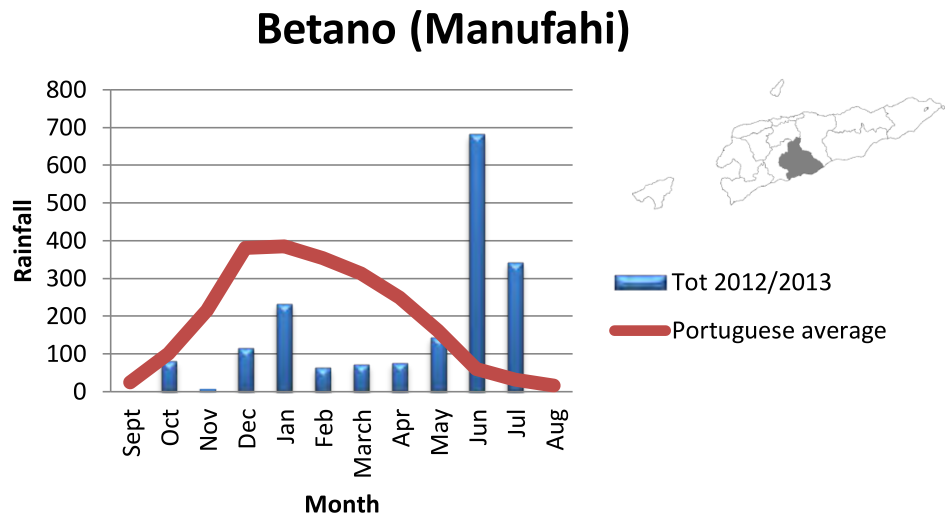


Figure 4. Rainfall (mm) at Betano, Manufahi 2012-2013.

In Ainaro, farmers experienced a good start to the wet season with strong rainfall in December continuing throughout the season until March (Figure 5). Abnormally high rainfall was experienced during May and June which would have supported crops growing after the main maize crop. This "mini second wet season" came to an abrupt end in July.

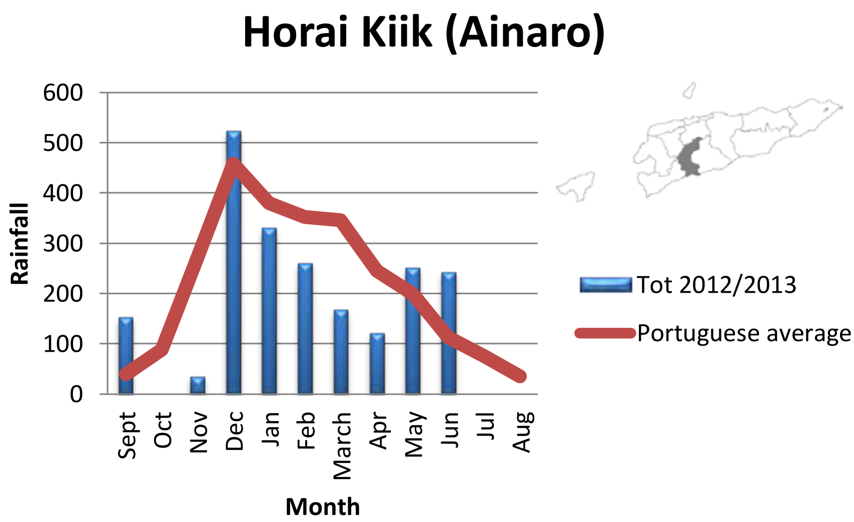


Figure 5. Rainfall (mm) at Hohrai Kiik, Ainaro, 2012-2013.

Ostico is an area with an elevation of approximately 700m in the eastern Districts. This area experienced an excellent lead up to the wet season in 2012 and the weather dried off sufficiently in March-April to dry the maize (Figure 6). There was not a second season as is often experienced in that part of the country.

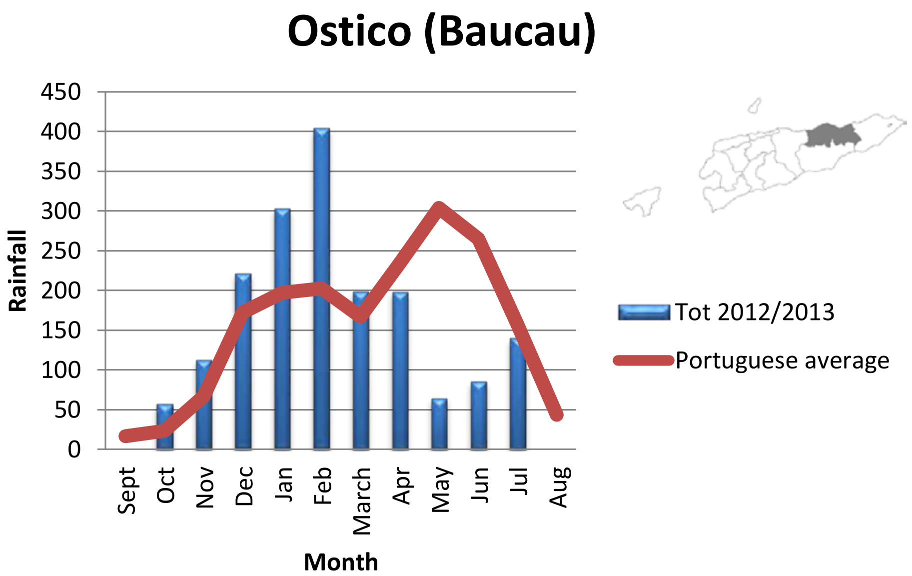


Figure 6. Rainfall (mm) at Ostico, Baucau, 2012-2013.

Maliana had a very high annual rainfall during the period September, 2012 to August, 2013 with more than 25% of it falling in January, 2013. There was an exceptional amount of rainfall during the December 2012 to March 2013 growing period (Figure 7). There was also unseasonably high rainfall in May-June 2013.

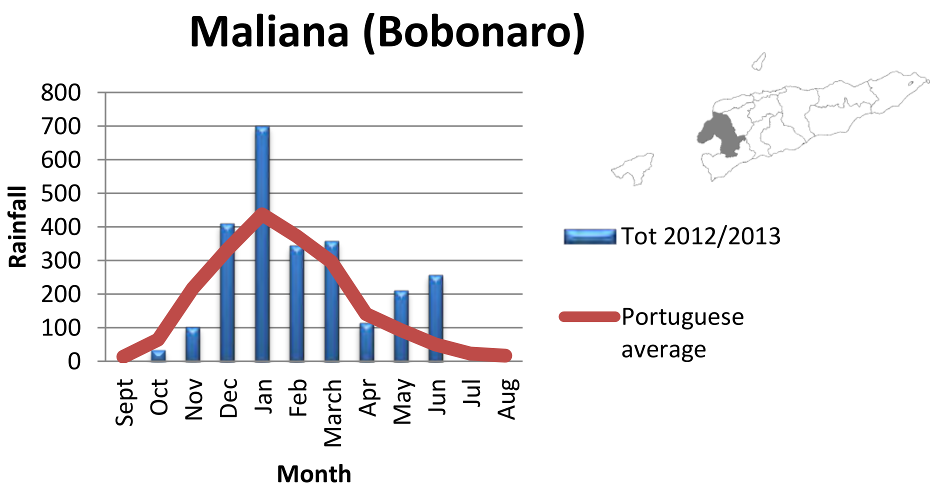


Figure 7. Rainfall (mm) at Maliana, Bobonaro, 2012-2013.

The research station at Loes received only slightly higher rainfall in 2012-2013 compared with the Portuguese data average (1033 mm compared with 938 mm) and the pattern also followed the long-term trend. There was a good lead up to the wet season of 2012-2013 and April was particularly dry allowing grain to be dried off. A “mini” second wet period was also experienced in May (Figure 8).

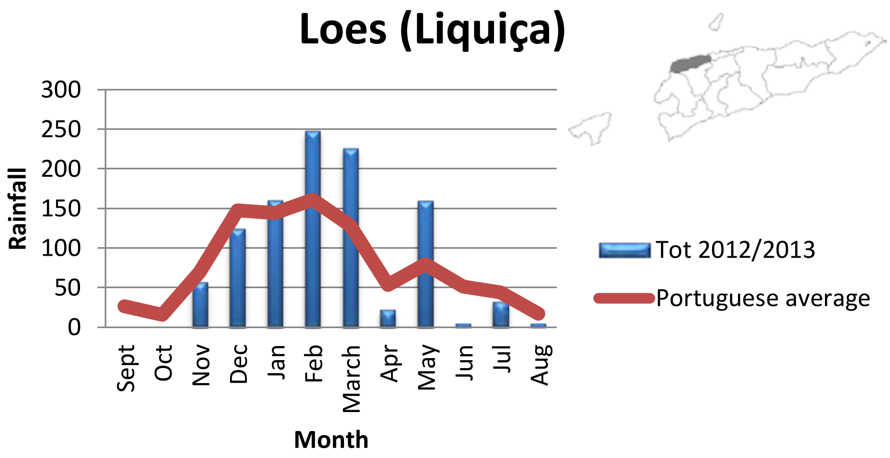


Figure 8. Rainfall (mm) at Liquiça, 2011-2012.

In the District of Viqueque, rainfall was below average for three of the four-month wet season. A 600 mm rainfall month in June 2013 caused considerable flooding and skewed the rainfall pattern sufficiently for the annual mean to be approximately that of the long-term mean. However, crops suffered from drought conditions during part of the growing season (Figure 9).

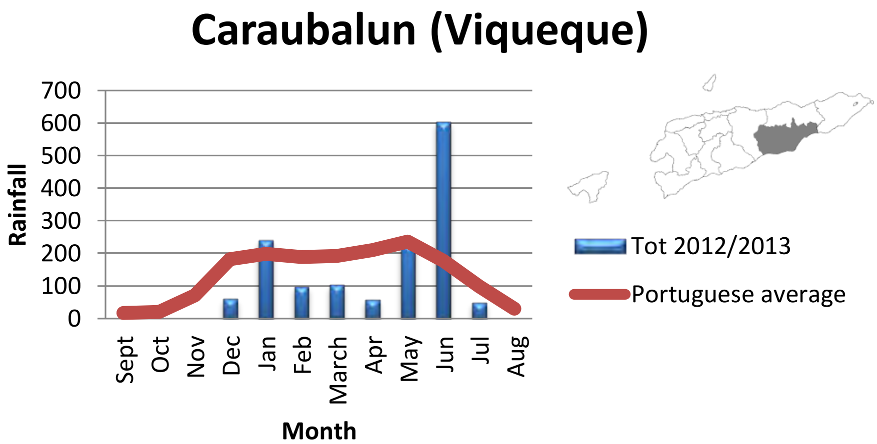


Figure 9. Rainfall (mm) at Viqueque, 2011-2012.

In summary

Most of the rainfall data presented in the seven figures above, indicate that many farmers experienced large and unpredictable rainfall patterns during 2012-2013. These rainfall patterns may follow average conditions for three to four months before an unexpected peak or drop in rainfall is experienced, making farming difficult. The erratic rainfall affects farmer's ability to maintain soil moisture and control erosion. Increasing soil organic matter may assist in maintaining soil moisture content and extend the growing season. The use of cover crops such as velvet bean may also protect the soil during high rainfall events.

2. Evaluation of new germplasm

2.1 Maize

2.1.1 Replicated maize trials, 2012-2013

Eleven white maize (*Zea mays* L.) short-listed from populations imported from CIMMYT-Zimbabwe and the Central Mindanao University, Philippines were evaluated against two local varieties plus Noi Mutin, Suwan 5 and Sele during the 2012-2013 wet season at five locations. The trial was repeated at two locations during the dry season of 2013. One of the local checks (Kakatua) and the high yielding Sele and Suwan 5 are all yellow grained. The released variety, Noi Mutin, is white seeded. The code names and source of material used in the 2012-2013 trials are presented in Table 3. All populations are open pollinated and available at no cost for multiplication and cultivation in Timor-Leste if suitable material can be identified.

Table 3. Name, code and source of 15 entries used in seven trials, 2012-2013

Code	*Full name*	*Source*
Har12	V036=PopDMRSRE(MOZ)F2	CIMMYT Zimbabwe
*M45**	*Local Fatulurik*	*Timor-Leste*
M47	*Local Kakatua*	*Timor-Leste*
P07 (Noi Mutin)	CMU Var 12	Philippines
P11	CMU Var 10	Philippines
P7H12	Cross of P 07 and Har 12	Timor-Leste
S07	07SADVE3	CIMMYT Zimbabwe
S08	08SADVE2	CIMMYT Zimbabwe
S09	09SADVE-F2	CIMMYT Zimbabwe
Sele*	LYDMR	CIMMYT India
Suwan 5*	Suwan 5	Thailand
V11	VP0711	CIMMYT Zimbabwe
V15	VP0715	CIMMYT Zimbabwe
V41	VP0741	CIMMYT Zimbabwe
V83	VP083	CIMMYT Zimbabwe

* Yellow grained varieties in use in Timor-Leste

Methods and materials

Replicated trials including the above fifteen varieties were installed at research stations located in the Districts of Aileu, Manufahi, Liquiça, Ainaro and Bacau during the wet season of 2012-2013 and in Liquiça and Baucau during the dry season of 2013 (Table 4). Each trial possessed three replicates and fifteen maize entries. The trials were arranged as a randomized complete block with the plots being 5m x 5m in size.

Table 4. Planting and harvest dates, maize variety trials, 2012-2013

Location	*Season*	*Planting date*	*Harvest date*	*Maturity (days)*	*Rainfall* (mm)*	*Yield (t/ha)*
Aileu (K. Portugal)	Wet	27 Nov 2012	15 May 2013	150	352	0.44
Manufahi (Betano)	Wet	08 Jan 2013	15 April 2013	120	286	4.41
Manufahi (Betano)	Dry	08 May 2013	02 Aug 2013	90	1132	2.42
Liquiça (Loes)	Wet	18 Dec 2012	16 April 2013	120	683	1.34
Liquiça (Loes)	Dry	19 June 2013	22 Oct 2013	120	42	1.86
Baucau (Darasula)	Wet	22 Nov 2012	18 March 2013	120	928	1.29
Ainaro (Urulefa)	Wet	22 Nov 2012	17 April 2013	150	2071	3.21

* Rainfall recorded during growing period

Six rows were planted in each plot spaced at 75 cm between rows and 25 cm between hills. One or two seeds were planted per hill, which if required, were later thinned to one plant per hill. Any missing hills were replanted soon after emergence. None of the trials were either fertilized or irrigated.

A number of parameters were recorded from the middle four rows both during plant growth (health and phenotype) and at harvest (wet cob weight, dry cob weight, plant height, plant density, cob size, seed weight). The total grain weights were used to calculate the final yields. Cobs of the two outside rows were used for taste testing and other trials such as weevil testing. The data of each trial were analyzed separately using GenStat Discovery 15th Edition SP1 in order to determine varietal effects. Yield advantages were calculated from the resulting predicted means over the average of the locals. All trial data was examined for row effects.

Results

Maize yields and yield components from seven locations, 2012-2013

Data on the plant population, number of cobs/plant, seed weight and weight of seeds per cob for each site were recorded at each research station site.

Grain yields, plant populations, number of cobs per plant, seeds per cob and seed weights of the trial at Betano Research Centre in Manufahi are presented in Table 5. Grain yields during the wet season were relatively high but not significantly different from each other. Plant populations were slightly different from each other and the number of cobs per plant varied from 0.9 to 1. Cob sizes also varied.

Table 5. Maize yield and components, Betano, wet season 2012-2013

Variety	*Yield (t/ha)*	*Plants/m^2*	*Cobs/Plant*	*Seeds/cob*	*Seed weight 100 (g)*
P07	5.3	5.2	1.0	362	28
V83	4.8	5.0	0.9	358	29
H12	4.7	5.1	0.9	345	29
S08	4.5	4.8	1.0	283	34
P7H12	4.4	5.2	0.9	320	28
V15	4.4	4.5	1.0	297	32
V41	4.4	5.0	1.0	332	27
V11	4.4	4.6	1.0	326	29
M03	4.4	4.7	1.0	326	30
S09	4.2	5.1	0.9	287	31
S07	4.2	5.2	0.9	284	31
P11	4.2	5.3	0.9	312	30
M02	4.2	5.0	0.9	312	29
M47	4.1	5.1	1.0	276	30
M45	4.0	5.0	1.0	260	33
F pr.	0.37	<.001	0.05	0.03	0.85
LSD.	*ns*	0.32	0.08	5.8	*ns*
%CV	12.2	3.9	5.3	11.2	2.4

Grain yields were lower at Betano during the dry season (Table 6) and there was no significant varietal difference between yields. The cobs of some varieties were larger than others as were seed sizes.

Table 6. Maize yield and components, Betano, dry season 2013

Variety	*Yield (t/ha)*	*Plant pop. (/m²)*	*Cobs/plant*	*Seeds/cob*	*100 seed weight (g)*
Sele	3.0	3.0	0.92	282	30
S08	2.9	2.9	0.91	261	31
L. Fatulurik	2.8	2.8	1.01	270	29
S09	2.6	2.6	0.98	229	30
PTH12	2.5	2.5	0.92	253	31
H12	2.4	2.4	0.84	222	29
S07	2.4	2.4	0.97	218	30
P11	2.4	2.4	1.02	227	29
Noi Mutin	2.4	2.4	0.93	201	29
V83	2.3	2.3	0.94	250	29
V11	2.3	2.3	0.86	240	30
L. Kakatua	2.3	2.3	0.83	217	30
V15	2.3	2.3	0.84	228	30
SW5	1.9	1.9	0.83	202	29
V41	1.7	1.7	0.83	175	29
F. pr.	0.118	0.16	0.331	0.05	0.01
LSD	*ns*	*ns*	*ns*	56.5	1.2
%CV	18.6	7.4	9.3	14.6	2.5

Grain yields at Quintal Portugal research station in Aileu were extremely low during the wet season of 2012-2013 averaging only 0.44 t/ha (Table 7). There was no significant difference in yield between the treatments despite a reasonably even plant population entries. Seed weights were different.

Table 7. Maize yield and components Quintal Portugal, wet season, 2012-2013

Variety	*Yield (t/ha)*	*Plants/m²*	*Cobs/plant*	*Seeds/cob*	*100 seed weight (g)*
Sele	0.89	4.5	0.4	295	20
Noi Mutin	0.74	4.7	0.5	268	28
SW5	0.73	4.7	0.5	285	32
L. Kakatua	0.69	4.5	0.8	294	42
L. Fatulurik	0.68	4.6	0.4	227	35
P07 H12	0.57	4.6	0.4	277	32
P11	0.53	4.6	0.5	162	29
Har12	0.40	4.7	0.3	273	31
S08	0.35	4.2	0.3	284	35
S09	0.35	4.5	0.2	268	38
S07	0.32	4.5	0.4	163	26
V41	0.21	4.6	0.3	217	18
V11	0.10	4.6	0.1	77	11
V15	0.05	4.7	0.1	91	21
V83	0.03	4.5	0.0	63	10
F prob	0.41	0.16	0.14	0.1	0.03
LSD	*ns*	*ns*	*ns*	*ns*	18.4
% CV	54.2	1	24.1	29.7	21.4

Grain yields at Urulefa Research Station in Baucau were between 2.2 and 4.2 t/ha and there were significant differences between entries (Table 8). S08 and Sele were the highest yielding varieties.

Table 8. Maize yield and components Urulefa, wet season, 2012-2013

Variety	*Yield (t/ha)*	*Plant density (/m²)*	*Seeds/cob*	*Cobs/plant*	*100 seed weight (g)*
S08	4.23	4.84	257	0.92	34
Sele	4.16	4.77	252	1.01	32
S07	3.66	4.80	244	0.94	33
V41	3.55	4.76	243	0.96	32
S09	3.35	4.89	211	0.93	35
L.Fatulurik	3.30	4.87	222	0.95	32
H12	3.30	4.53	255	0.94	31
V11	3.21	4.73	211	0.94	33
V15	3.13	4.64	223	0.93	31
M02	3.03	4.93	210	0.96	29
P11	2.90	4.64	208	0.96	31
P07	2.89	4.76	236	0.88	29
L.Kakatua	2.66	4.82	171	0.95	34
V83	2.53	4.82	181	0.93	31
P07H12	2.20	4.64	178	0.87	31
F.Prob	*0.02*	*0.63*	*0.1*	*0.33*	0.13
LSD	*1.01*	*ns*	*ns*	*ns*	*ns*
% CV	*18.70*	*4.30*	*16.1*	*5.5*	5.7

Maize yields at Loes (Table 9) showed significant difference between varieties on yield t/ha and plant density but only for yield t/ha using *covariate*. However, there was no difference between varieties on seed/cob, cob/plant and weight/cob in Loes research station.

Table 9. Maize yield and components Loes, wet season, 2012-2013

Variety	*Yield (t/ha) Covariate*	*Plant density /m²*	*Seeds/cob*	*Cob weight (g)*	*100 seed weight (g)*
SW 5	1.47	2.8	265	783	27
V41	1.49	2.6	173	762	27
S07	1.53	1.8	151	865	30
HAR12	1.71	1.5	176	841	30
P07H12	1.53	1.7	236	819	29
P07	1.79	1.3	148	854	31
Sele	1.36	1.6	196	817	29
V11	1.64	1.2	144	866	31
P11	1.41	1.5	262	877	29
L.Kakatua	1.63	0.9	269	852	30
V83	0.95	1.7	150	884	26
S09	1.10	1.3	180	847	28
S08	1.07	1.3	455	858	30
V15	1.24	0.9	91	861	28
L.Fatulurik	0.84	1.4	137	852	27
Lokal Loes	0.77	1.5	127	778	30
F.prob	<.001	0.10	0.71	0.87	0.51
LSD	*1.215*	*ns*	*ns*	*ns*	*ns*
% CV	11	14.2	6.2	0.8	4.6

Maize yields for the dry season trial at Loes, Liquiça are presented in Table 10 using covariate. Plant density was different but other components were not. Downy mildew was also identified at Loes research station which affected maize yields. Minimum downy mildew damage was noticeable for varieties Sw 5, P7H12, Sele and L. Fatulurik while Noi Mutin showed medium damage compared to the other varieties.

Table 10. Maize yield and components Loes, dry season 2013.

Variety	Yield t/ha (Covariate)	Plant density /m^2	Cobs/plant	Seeds/cob	100 seed weight (g)	Downy mildew
Noi Mutin	2.3	3.9	0.88	246	28	13
V41	2.3	4.5	0.85	246	27	10
V11	2.2	3.0	0.83	248	29	13
SW5	2.2	5.0	0.86	219	29	6
S08	2.1	3.9	0.88	208	30	16
S09	1.9	3.6	0.83	220	28	10
S07	1.9	3.5	0.85	204	28	10
L.Kakatua	1.9	3.0	1.05	176	28	11
L.Fatulurik	1.8	3.7	0.85	181	29	9
Sele	1.7	5.1	0.89	172	30	9
P07H12	1.6	4.0	0.76	204	30	7
P11	1.6	4.2	0.67	200	29	14
V15	1.6	3.0	0.72	184	29	10
V83	1.4	3.6	0.78	172	29	15
HAR12	1.4	3.4	0.64	186	29	13
F.prob	0.005	0.027	0.827	0.426	0.177	0.174
LSD	1.020	1.247	*ns*	*ns*	*ns*	*ns*
% CV	31.5	19.5	5.7	11.3	0.1	16.5

Table 11 showed no difference between varieties on all components even though using covariate on yield at Darasula research station (Baucau).

Table 11. Maize yield and components Darasula, wet season 2012-2013.

Variety	*Yield t/ha (Covariate)*	*Plant density /m²*	*Seeds/cob*	*Cobs/plant*	*100 Seed weight (g)*
V11	2.1	3.4	236	1.0	25
Har12	1.8	2.7	239	1.0	29
V15	1.8	4.3	163	1.0	25
L.Kakatua	1.8	3.5	185	1.0	28
S09	1.5	1.9	249	0.9	28
S08	1.5	2.9	118	0.9	29
V41	1.4	2.6	169	1.0	27
P11	1.4	2.6	188	0.9	24
S07	1.3	1.8	212	1.0	24
SW5	1.1	3.7	100	1.0	29
V83	0.9	2.9	125	1.0	24
P07H12	0.8	2.2	160	0.9	23
Noi-mutin	0.8	2.6	120	0.9	24
SELE	0.7	3.1	81	1.0	28
L.Fatulurik	0.5	2.2	89	1.0	25
F prob.	0.86	0.44	0.55	0.43	0.25
LSD	*ns*	*ns*	*ns*	*ns*	*ns*
%CV	83.3	40.4	36.5	4.7	13.2

Figure 10 presents a yield comparison of S09 and S07 compared to Noi Mutin at the seven test sites during the 2012/2013 wet season and 2013 dry season. Figures above the line yielded better than Noi Mutin on that occasion and those below the line yielded less.

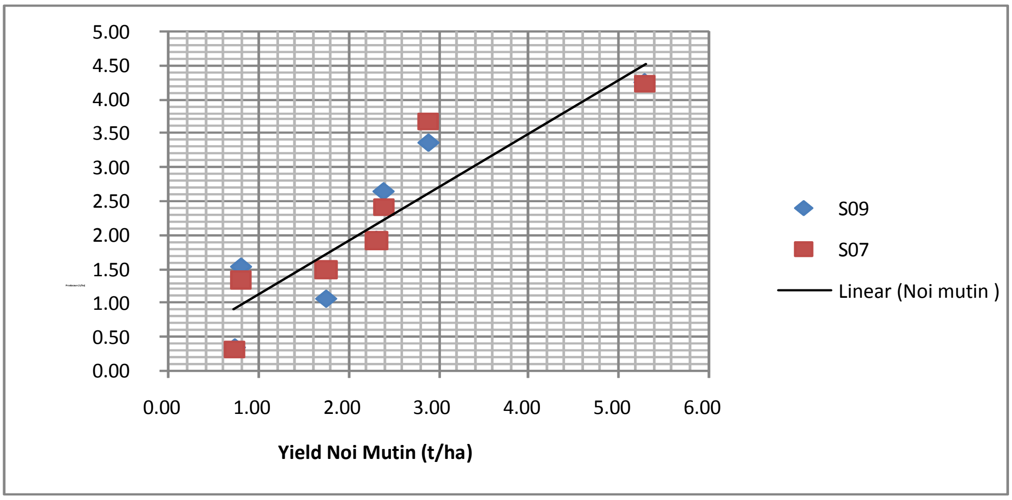


Figure 10. Yield comparison between Noi Mutin, S09 and S07 2012-2013.

The yield and yield advantage of all seven evaluation sites in 2012-2013 are presented in Table 12. The highest mean yield across sites was achieved by Sele and Suwan 5 demonstrating the success of the selection process to date.

Table 12. Summary of yield and yield advantages from 7 locations, 2012-2013

	Yield (t/ha)								
Variety	*Aileu (K. Portugal) Wet season*	*Betano (Wet season*	*Betano (Dry season*	*Loes (Maubara) Wet season*	*Loes (Maubara) Dry season*	*Baucau (Darasula) Wet season*	*Ululefa (Maubisse) Wet season*	*Yield adv. (%)*	*Mean Yield (t/ha)*
Sele	0.96	4.37	3.03	1.32	1.71	0.7	4.16	16.10	2.32
Suwan 5	0.73	4.17	1.92	1.42	2.23	1.1	3.03	4.68	2.28
V11	0.09	4.39	2.32	1.60	2.24	2.1	3.21	13.98	2.16
S07	0.32	4.21	2.40	1.49	1.91	1.3	3.66	9.50	2.15
S08	0.34	4.54	2.91	1.03	2.07	1.5	4.23	18.72	2.10
S09	0.34	4.24	2.64	1.06	1.93	1.5	3.35	7.90	2.05
Noi Mutin	0.73	5.29	2.39	1.75	2.31	0.8	2.89	15.32	2.03
V41	0.20	4.41	1.72	1.44	2.26	1.4	3.55	7.10	2.02
P07H12	0.56	4.42	2.52	1.49	1.63	0.8	2.20	-2.26	2.02
Har12	0.40	4.70	2.40	1.67	1.41	1.8	3.30	12.47	2.01
V15	0.05	4.41	2.28	1.21	1.55	1.8	3.13	2.92	1.99
L.Fatulurik	0.67	3.96	2.78	0.80	1.77	0.5	3.30	-1.53	1.92
L.Kakatua	0.69	4.06	2.30	1.59	1.86	1.8	2.66	6.65	1.92
P11	0.52	4.21	2.39	1.36	1.57	1.4	2.90	2.31	1.87
V83	0.02	4.82	2.34	0.91	1.43	0.9	2.53	-7.37	1.76
F.Prob	0.451	0.37	0.118	<.001	0.005	0.855	0.37		
LSD (P<0.05)	*ns*	*ns*	*ns*	1.1926	1.0195	*ns*	*ns*		
cv (%)	108.19	12.2	18.6	53.5	31.5	83.3	12.2		

A biplot analysis of sites and varieties is presented in Figure 11.

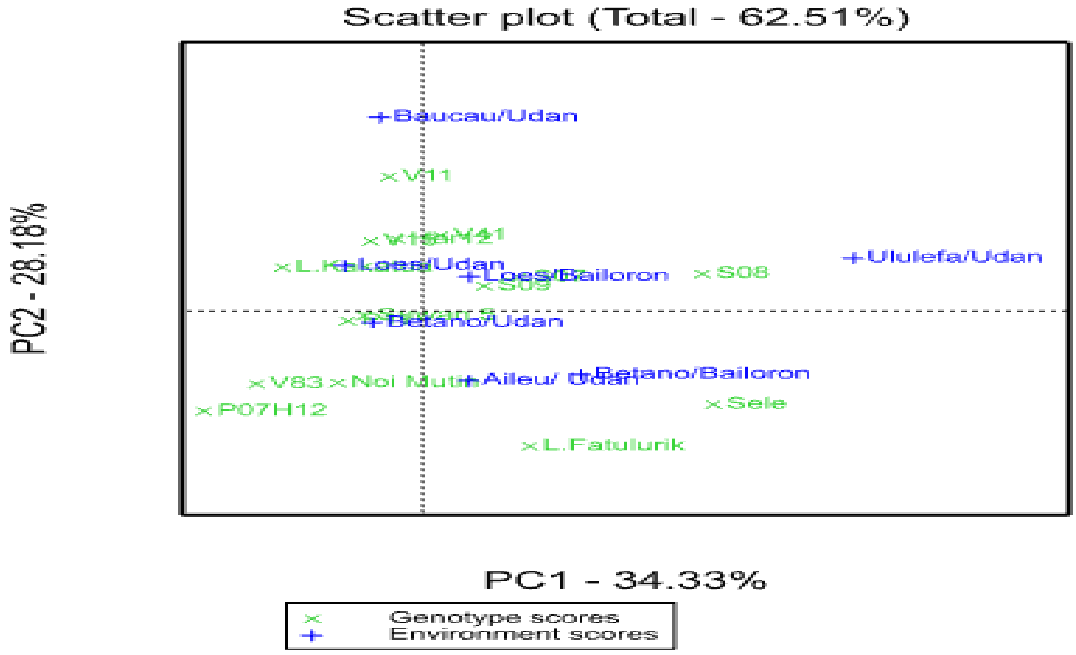


Figure 11. Biplot analysis, maize varieties and yield at 7 locations, 2012-2013

Farmers' preferences

Field days were held at Betano, Loes and Urulefa stations during the year to evaluate farmers' reactions to a select number of varieties. The test entries were similar at the three sites excepting for V83 which was only tested in Betano, SW5 which was only tested in Loes and L. Fatulurik which was included at Urulefa. Twenty three to 42 farmers attended each field day, examined the research sites and discussed the trial results with the researchers. The quality of the maize grain was then examined. The grain was then pounded and consumed as cooked grits. Twenty five farmers completed the evaluation forms.

At Betano, the farmers preferred maize varieties that easy to pound and were tasty (Table 13). From all varieties tested, 40% of farmers chose Sele followed by V83 and Noi Mutin. Even though some other varieties had a higher preference rating for "easy to pound" and "tasty" the farmers did not choose them.

Table 13. Taste test in Betano research station (% of farmer' preference)

Variety	Easy to pound (%)	Tasty (%)	Overall Choice (%)
Sele	87	54	40
V83	15	44	33
Noi Mutin	75	67	31
V11	83	35	29
S08	60	35	27
L.Kakatua	44	42	21
H12	8	23	10
P7H12	27	35	6
V15	85	19	4
V41	12	21	0

Different varieties were preferred at Loes (Table 14) where SW5 and L. Kakatua rated highly as did the new variety V41.

Table 14. Taste test at Loes research station (% of farmer' preference)

Variety	Easy to pound (%)	Tasty (%)	Overall Choice (%)
SW5	13	71	63
L.kakatua	79	75	42
V41	79	46	33
P11	96	38	21
Sele	29	58	17
P07H12	25	65	13
H12	38	58	4
Noi Mutin	46	33	4
V11	79	29	4
S07	21	21	0

At Urulefa, the farmers preferred a different set of varieties compared with Loes and Betano (Table 15)

Table 15. Taste test at Urulefa Research Station (% farmers preference)

Variety	Easy to pound (%)	Tasty (%)	Overall Choice (%)
S08	78	65	43
S07	13	65	39
S09	13	52	35
Noi Mutin	13	52	30
SELE	78	43	17
V15	100	52	13
V41	96	83	13
H12	74	65	4
Local Fatulurik	39	17	4
Local Kakatua	65	57	4

Weevil damage resistance

Farmer's generally store their maize on the cob and consume the grain over the year. Cobs are often tied together and stored over the fire place in an attempt to keep the cobs dry. Maize is also hung from trees and other locations safe from rats and other pests. Resistance to weevil infestation is a particularly important character for farmers who do not have good on-farm storage facilities.

To examine the resistance to weevil damage in 2013 harvest, 15 cobs of each were stored for 9 months in a shed at Betano, Loes, Baucau, Aileu and Urulefa research station and for nearly 10 months at Loes Research Station. At the conclusion of the period, weevil damage to the grain in each cob was assessed. A summary of the results is presented in Table 16. Weevil damage to the test varieties was significantly different at three of the seven sites. On average, the two local varieties were less damaged by weevils when stored traditionally. Noi Mutin was also damaged to a less extent than other varieties. Suwan 5, P7H12 and Sele also performed well.

Table 16. Weevil damage (%) of stored cobs from seven sites, 2012-2013

Code	Bet (w)	Bet (d)	Loe (w)	Loe (d)	Dar (w)	Ail (w)	Uru (w)	Mean
L. Kakatua	24	37	7	24	56	41	16	29.3
L. Fatulurik	49	5	16	38	38	68	12	32.3
Noi Mutin	30	29	31	32	62	24	19	32.4
Suwan 5	52	39	8	24	58	54	13	35.4
P7H12	53	43	27	31	40	61	10	37.9
Sele	56	38	16	28	68	55	4	37.9
S09	59	43	19	28	43	57	18	38.1
P11	48	40	25	27	52	53	23	38.3
S08	55	44	26	27	51	59	13	39.3
Har12	55	45	17	31	54	66	20	41.1
S07	61	34	37	33	60	72	24	45.9
V41	68	44	55	46	47	59	14	47.6
V11	59	61	38	37	56	61	22	47.7
V15	68	35	57	44		80	22	51.0
V83	64	60	20	45	73	68	31	51.6
Mean	52	37	26	31	50	56	16	38.4
LSD	21.9	ns	36.1	ns	ns	25.1	ns	

Bet (w) = Betano wet season; Bet (d) = Betano dry season; Loe (w) = Loes dry season; Loe (d) = Loes dry season; Dar (w) = Darasula wet season; Ail (w) = Aileu wet season; Uru (w) = Urulefa wet season

2.1.2 Maize On-Farm Demonstration Trials (OFDTs) 2012-2013

Introduction

Maize on farm demonstration trials (OFDTs) were conducted during the 2012-2013 wet season to evaluate the yield and quality of test varieties Sele and Noi Mutin. These two varieties were compared with the farmers' best local variety.

Noi Mutin, a white grained variety was released by the MAF for general use in 2011. Sele, a yellow variety was released in 2007.

Materials and methods

Ninety seven on-farm trials were established in all six of Timor-Leste agro-ecological zones across the 15 Sub-Districts of Aileu vila, Laulara, Lequidoe, Remexio, Maubisse, Baucau vila, Vemasse, Venilale, Balibo, Maliana, Liquiça vila, Maubara, Alas, Ossu, and Viqueque vila. Researchers worked within each Sub District to identify farmers to host the trials. The trials received the same agronomic treatment that the farmer normally applies to the rest of his crop. Small amounts of seed were provided to plant a trial area of 25 m^2 (5 m x 5 m). In addition, each collaborating farmer received 5 kg of Sele for their own multiplication. The host farmer supplied the local seed for each trial.

In order to properly establish the trials, researchers generally assisted the farmers during site establishment and planting. Each trial was visited by the researcher an average of 6 times from planting to harvest. During each visit, the researcher used a data collection protocol for recording information. The protocols included measurements of plant height, identification of pests and diseases, geographic data, soil information, agronomic methods, harvest data etc. At harvest, the fresh weight of cobs from the whole plot (25 m^2) was recorded. A sub-sample of 5 cobs was taken from the fresh cobs at harvest time, for threshing, drying and weighing to convert the site yield into yield of dry grain per hectare.

Site charaterisation

Latitude, longitude, and elevation were recorded at all sites using a 12 channel GPS receiver (Garmin ETrex) to an accuracy of ± 6 m. In addition, the slope of the land was defined at each site as was the orientation 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 17).

Table 17. Definition of the 6 agro-ecological zones in Timor-Leste.

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

All sites were tested for soil pH using the commercially available "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 to remove 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 colour of the indicator, and pH value identified by comparing that colour with a standard colour sheet.

Soil texture (Table 18) (from McDonald *et al*) 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 18. 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

Analysis

Data from the protocols were first entered into an MS Excel spreadsheet database before being transferred for further analysis to GenStat Discovery 16th Edition. Yield data were 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 a factor was 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

Timor-Leste has a wide range of growing environments with differences in elevation, soil pH, and soil texture. The OFDTs were spread over as much of this diversity as possible.

In 2012-2013, sites ranged from 1 masl in Baucau villa to 1870 masl in Maubisse (Table 19). Nearly 40% of sites were at an elevation of 0-150 m.

Table 19. Distribution of maize OFDT sites by elevation, 2012- 13

Elevation (m)	*Locations 2008-09 (%)*	*Locations 2009-10 (%)*	*Locations 2010-11 (%)*	*Locations 2011-12 (%)*	*Locations 2012-13 (%)*
0-150	27	28	34	32	39
150-350	15	14	6	11	14
350-550	12	10	4	7	4
550-750	12	11	12	13	8
750-950	12	15	13	16	12
950-1150	10	11	16	6	12
1150-1350	7	4	7	4	1
1350-1550	3	5	7	5	5
>1550	2	2	0	6	4

Trial losses

Only 2% of trials planted during the 2012-2013 were reported as losses and unharvested. This failure rate was lower compared to previous years when 3-25% were not reported. Animal predation was the reason for most crop losses. In a few cases, farmers did not follow planting directions or the plots were harvested in the absence of the OFDT staff. Most sites received sufficient rainfall and crops losses due to drought were small.

Soils

Soil pH at the testing sites represented the range normally encountered in Timor-Leste (Table 20). Average pH across all sites was 6.8 with the majority of sites falling in the 6 – 8 range. Few sites represented the more extreme ends of the scale (Table 4).

Table 20. Distribution of soil pH across maize OFDT sites, 2008 - 2012.

Soil pH	*Locations 2007-2008 (%)*	*Locations 2008-2009 (%)*	*Locations 2009-2010 (%)*	*Locations 2010-2011 (%)*	*Locations 2011-2012 (%)*	*Locations 2012-2013 (%)*
4.5	2	1	0	0	1	0
5.0	3	2	2	0	1	0
5.5	9	12	6	10	6	3
6.0	11	18	18	19	15	21
6.5	13	18	30	22	20	20
7.0	24	14	19	25	22	22
7.5	9	14	16	19	23	16
8.0	15	16	7	5	6	14
8.5	12	9	1	0	6	1
9.0	3	2	0	0	1	2

Soil pH and elevation differed statistically (F Pr. <0.001) between Sub-Districts (Table 21). The lowest recorded elevation was in Viqueque (12 m) with soil pH 7.3 and highest elevation in Maubisse (1508 m) with soil pH 6.9.

Table 21. Mean soil pH and elevation of maize OFDT locations, 2012-13

District	*Sub-district*	*Elevation (masl) 2011-12*	*Elevation (masl) 2012-13*	*Soil pH 2011-12*	*Soil pH 2012-13*
Aileu	Aileu Vila	926	979	6.0	6.6
Aileu	Laulara	1259	1298	6.4	6.5
Aileu	Liquidoe	1230	-	6.2	-
Aileu	Remexio	1045	971	5.9	6.0
Ainaro	Maubisse	1635	1584	7.0	6.9
Baucau	Baucau	488	488	7.3	7.6
Baucau	Vemasse	556	714	7.1	6.1
Baucau	Venilale	861	-	7.3	-
Bobonaro	Balibo	267	262	6.5	6.9
Bobonaro	Maliana	166	176	7.5	6.3
Liquiça	Liquiça	717	717	6.7	6.3
Liquiça	Maubara	113	233	6.5	6.9
Manufahi	Alas	45	37	7.7	7.4
Viqueque	Ossu	395	591	6.1	7.3
Viqueque	Viqueque Vila	21	12	7.1	7.3

Data regarding soil texture in the experimental sites is presented in Table 22. Clay loam and sandy loam soils were the most commonly encountered soil types. There were also a few heavy clay soils.

Table 22. Distribution of soil texture of maize OFDT, 2012-11

Soil texture	*Location 2009-10 (%)*	*Location 2010-11 (%)*	*Location 2011-12 (%)*	*Location 2012-13 (%)*
Sandy	0	1	0	0
Sandy loam	20	27	35	24
Silty loam	11	13	9	12
Loam	14	14	8	14
Clay loam	23	22	20	25
Fine clay	23	15	22	15
Heavy clay	8	8	6	6

Variety

Yields of both the released varieties Sele and Noi Mutin were significantly higher than local maize populations (Table 23). Cob size and number of seeds per cob of the test varieties were also larger. The performance of both varieties continued to support their status as released varieties. Noi Mutin's colour and taste proved to be popular at field days.

Table 23. Yield components for OFDT maize varieties over all OFDTs, 2012-13

Variety	*Yield (t/ha)*	*Yield advantage (%)*	*Density (plants/m^2)*	*Cobs/plant*	*Seeds/cob*	*Cob weight (g)*	*100 seed weight (g)*
Local	1.83b	0	4.7	0.76	212b	56	26.9
Noi Mutin	2.36a	29.0	4.6	0.76	275a	77	28.4
Sele	2.48a	35.5	4.6	0.77	254a	117	28.8
Variety LSD (<.05)	0.4		ns	ns	40.4	13.1	2.23
AEZ LSD (<.05)	0.8		1.8	0.31	ns	ns	4.3
Variety*AEZ	ns		ns	ns	ns	ns	ns

Figure 12 demonstrates graphically the yield relationship between the local and released varieties at each site. Each data point that lies above the 1:1 line represents a site where the released variety outperformed the local check. With both varieties, the majority of the points lie above the line, a fact borne out in the ANOVA analysis where the released varieties achieved a statistically significant advantage over local maize.

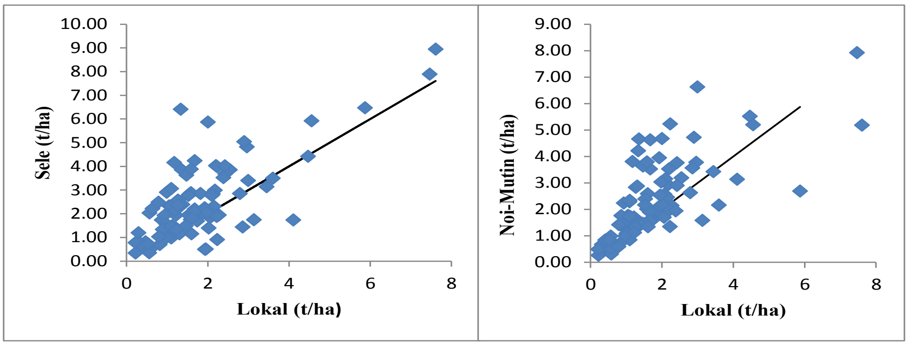


Figure 12. Yield comparison (t/ha) between local and test varieties

Maize yields for all varieties tended to increase as plant densities rose to around 4-6 plants/m^2. There was no significant interaction between plant density and variety for grain yield. However, the released varieties outperformed the local at most plant density ranges (Figure 13). Based on this information, there is no indication that there should be a different planting density recommendation for the released varieties.

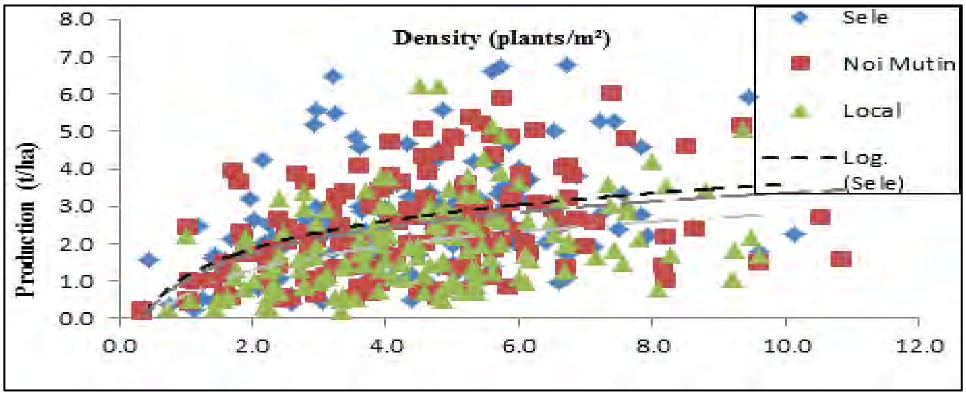


Figure 13. Regression graph comparing plant density and yield.

Agro Ecological Zones (AEZ) and yield

Yield results for the two test varieties and their comparison with the local in each AEZ is presented in Table 24. Both Sele and Noi Mutin produced a yield advantage over local maize in all AEZs. However, there was no interaction between variety and AEZ. This indicates that both released varieties can be grown successfully in all agro-ecosystems. All varieties performed the best on the northern coast and the worst in the Southern uplands (AEZ 4).

Table 24. Maize OFDT mean yield by AEZ, 2012-2013

AEZ Class	*Local (t/ha)*	*Noi Mutin (t/ha)*	*Sele (t/ha)*	*Yield advantage Noi Mutin over local (%)*	*Yield advantage Sele over local (%)*	*Number of trials harvested*
1 Northern coast	2.74	3.11	3.38	14	23	19
2 Northern slopes	1.69	2.17	2.24	29	32	13
3 Northern uplands	1.79	2.52	2.82	41	58	29
4 Southern uplands	1.11	1.28	1.27	15	14	19
5 Southern slopes	2.12	2.76	2.90	30	37	6
6 Southern coast	1.85	2.75	2.40	48	30	11

Elevation and yield

Figure 14 compares the yields of the two test maize varieties against locals at various elevations. Grain yields decreased with elevation but both the test varieties gave higher mean yields at all elevations.

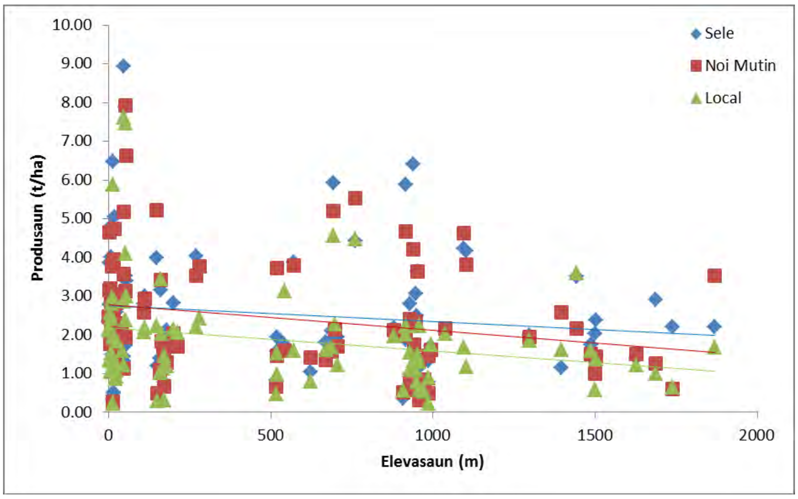


Figure 14. Effect of elevation on the yield of three varieties.

The effects of a series of agronomic factors on maize yields are presented in Table 25. From this table it can be seen that there was a significant effect between varieties, and that AEZ, Sub District and soil colour significantly affected the yields each year since 2007-2008. Only during a few years was grain yield not significantly affected by soil pH, number of seeds per hill, soil texture and number of staff visits. In 2012-2013, yields were significantly correlated by variety, AEZ, Sub District, soil pH, soil colour, soil texture, number of staff visits and slope class. A few of these factors are examined further below. The significant varietal effect is presented in Table 23. The effect on yield of the number of researcher visits to the OFDT per season and the field slope class are presented in earlier research reports.

Table 25. Factors affecting maize OFDT yields, 2008-2013

Factor	*F Pr.*	*Significant 2012-13*	*Significant 2011-12*	*Significant 2010-11*	*Significant 2009-10*	*Significant 2008-09*	*Significant 2007-08*
Variety	<0.001	✓	✓	✓	✓	✓	✓
AEZ	<0.001	✓	✓	✓	✓	✓	✓
Sub-District	<0.001	✓	✓	✓	✓	✓	✓
Number of seeds per hill	<0.001	×	✓	✓	✓	✓	×
Planting distance	ns	×	×	✓	×	×	✓
Soil pH	0.050	✓	✓	×	✓	✓	✓
Soil colour	0.004	✓	✓	✓	✓	✓	✓
Soil texture	<0.001	✓	✓	✓	✓	✓	×
Number of staff visits	<0.001	✓	✓	✓	✓	×	✓
Random or line planting	<0.001	×	✓	×	✓	✓	×
Slope class	0.005	✓	✓	✓	✓	×	×
Number of weeding events	-	×	-	✓	✓	×	×
Mixed planting or monoculture	ns	×	×	×	✓	×	×
Gender of the head of household	ns	×	×	✓	×	×	×
Tools used for land preparation	<0.001	×	✓	✓	×	-	-

AEZ and maize yields

Maize yields were significantly affected by the AEZ in which the OFDT was conducted. Grain yields of crops grown below 100 masl on the North coast were the highest but not significantly more than those in AEZ 3, 5 and 6 (Table 26). As shown in Figure 14, grain yields tended to be lower at higher elevations. This effect is being examined in further detail and will be reported in the 2014 ARR.

Table 26. Impact of AEZ on maize OFDT yield, 2012-13

AEZ	*Yield*
1	3.10a
2	2.03b
3	2.40ab
4	1.22c
5	2.60ab
6	2.33ab
LSD	*0.75*

Soil colour and maize yields

Soil colour had a significant effect on the maize crops (Table 27). Trials installed on black, brown, gray and red soils produced higher yields than those on yellow soils. Soils analyses of these soils will be completed during 2014 to further understand this effect.

Table 27. Effect of soil colour of maize yield 2012-2013.

Soil colour	*Yield*
Yellow	0.70b
Gray	2.40a
Brown	1.62ab
Red	2.33a
Black	2.53a
LSD	*0.94*

Maize yields and Sub District

Table 28 presents the OFDT maize yields by Sub District. Grain yields in Balibo, Vemasse, and Liquiça Vila were the highest yielding Sub-Districts. This difference may be due to soil fertility and will be examined further in 2014.

Table 28. Maize OFDT yield per sub-district, 2012-13

Sub-district	*Yield (t/ha)*
Aileu vila	2.92ab
Alas	2.10c
Balibo	3.40a
Baucau vila	1.93c
Laulara	2.02c
Liquiça vila	3.33a
Maliana	1.71cd
Maubisse	1.80cd
Ossu	1.10d
Remexio	1.95c
Vemasse	3.44a
Vicq vila	2.40bc
LSD	*0.82*

Soil texture and maize yields

Silty loams, sandy loams and heavy clays tended to be the highest yielding soil texture types (Table 29).

Table 29. Impact of soil texture on maize yield 2012-2013.

Soil texture	*Yield (t/ha)*
Clay loam	1.73b
Fine clay	1.80b
Heavy clay	2.80a
Loam	1.70b
Sandy loam	3.11a
Silty loam	2.62a
LSD	*0.61*

Random planting and line planting

Past measurements have shown that farmers who plant in lines manage higher grain yields in approximately 50% of the years (Table 25). The 2012-2013 cropping season was one of those years (Table 30).

Table 30. Effect of planting method on maize yield, 2012-2013.

Planting method	*Yield (t/ha)*
Planting in line	2.41b
Random	1.93a
LSD	*0.29*

Farmer's preferences for maize populations

A total of 328 farmers participated in taste test field days during the 2012-2013 harvest season, 35% of whom were female (Table 31). Sele and Noi Mutin far outperformed local maize for yield and yield components in the opinion of a vast majority of farmers. Both released varieties rated highly for colour, despite their obvious differences. Sele maintained a small advantage over Noi Mutin in most categories, though the difference was negligible which suggests that the varieties are equally well perceived by farmers.

Table 31. Farmer preferences (%)* for maize variety characteristics, 2012-2013

Characteristics	*Local*	*Noi Mutin*	*Sele*
Big cobs	6	95	100
Big kernels	4	21	93
High yield	5	97	100
Full cobs	13	92	100
Colour	22	100	100
Tight sheaths	15	92	89
Taste	90	95	100
Weevil resistant	98	92	88
Wind resistant	79	95	99

* Many farmers made more than one choice from each criterion

Conclusions

The 2012-2013 trials provided further support for the released varieties Sele and Noi Mutin. The varieties performed well and maintained a significant yield advantage over local maize regardless of elevation or other locational factors. 2012-2013 saw the highest yields among local maize in eight years of OFDT testing. This trend warrants attention in the coming years as farmers have been exposed to released varieties for some time and may be using these as a standard local.

2.2 Sweet potato

2.2.1 Sweet potato replicated trials, 2012-2013

Sweet potato *(Ipomoea batatas* L.*)* is an important food for Timorese people. The plant is often used to diversify cropping systems on subsistence agriculture farms by being grown beneath maize, cassava, beans, banana, taro and other crops. It may also be grown as a cash crop. Sweet potato roots (technically roots but referred to as tubers in this report) are generally eaten at breakfast in rural areas but, in times of food shortages, also consumed at lunch and dinner. Both the tubers, leaves and stems may also be fed to animals. Sweet potato tubers are not often stored over the long term but may be done so by peeling the skin and drying.

The results of previous research indicates that sweet potatoes are able to grow well in Timor-Leste at an elevation of less than 500m from sea level. Yields (often less than 10 t/ha) are limited by poor quality planting material and lack of plant maintenance. The trials presented here are designed to identify higher quality varieties to feed into the national seed system.

Methods and materials

The trials were conducted at research sites in Betano (Manufahi), Loes (Liquiça), Darasula (Baucau), Kintal Portugal (Aileu) and Urulefa (Ainaro). Each trial consisted of a randomized complete block design with three replicates, the plots being 5 x 5 m in size. Stems for planting were sourced from Betano. One cutting per hill was planted at a 100 x 50 cm spacing (i.e. 2 plants/m²). The trials were neither fertilized nor irrigated. Wet season trials were planted between December 2012 and January 2013 and harvested between May and August 2013 (Table 32). A dry season trial planted at Betano was planted in May and harvested in October 2013. Fifteen entries were planted at each site sourced from 20 varieties including the three released varieties (Hohrae 1, 2 and 3), 10 improved varieties from CIP, Indonesia and 7 locally sourced materials.

Table 32. Planting and harvest dates of replicated sweet potato trials, 2012-2013

Location	*Season*	*Planting date*	*Harvest date*	*Days to maturity*	*Rainfall (mm)*	*Mean yield (t/ha)*
Aileu	Wet	22/01/2013	22/07/2013	181	712	6.4
Betano	Wet	8/01/2013	23/05/2013	135	117	7.8
Betano	Dry	8/05/2013	2/10/2013	131	255	7.1
Darasula	Wet	21/01/2013	20/06/2013	150	212	1
Loes	Wet	8/01/2013	10/07/2013	204	122	11
Urulefa	Wet	24/12/2012	29/08/2013	248	2846	8.3

Observations commenced three days after planting (for viability) and continued for disease and pest damage from three weeks until harvest. The number of plants per plot were counted prior to harvest and at harvest, tubers per plant (small and large), tuber weight per plot (kg) and vine weight were measured.

Yield advantages were calculated from the resulting adjusted predicted means (BLUPs) over the local averages. The existence and degree of correlation between the predicted means of the yields and of the other parameters were often identified using simple linear regressions. There were no row effects.

Farmer field days

Farmer field days were held at both Betano and Loes after the wet season harvest and at Betano after the dry season trial to evaluate farmer preferences of the product as a food source. Farmers were presented with boiled samples of 11 varieties and asked to evaluate taste and texture (dry, crumbly or mushy) characteristics. The samples were coded prior to evaluation to reduce bias. Finally, all the participants were asked to select three varieties they were willing to plant. Fifty eight persons (20% women) attended the wet season field day and 59 (29% women) during the dry season field day at Betano. Twenty (20% women) attended the wet seaon field day at Loes.

All field day data were collected and analysed using Genstat 15th edition.

Results

Sweet potato yields and yield advantages

Sweet potato yields from the six trials are presented in Table 33. The entries CIP 71, CIP 78 and Hohrae 3 were particularly high yielding compared with the other varieties. The local at Urulefa also yielded well. There was yield variation between trial sites. Loes research station showed the highest yield compared with other research stations, followed by the dry season site at Betano. Variation within sites was high (CV=29.6%) to very high (CV=52.1%).

Tuber yield was related to the number of tubers per plant at Aileu (R^2=0.61), Loes (R^2 = 0.56 and Urulefa (R^2=0.5). Yield was also related to plant populations at Loes (R^2 = 0.67) and at Betano during the dry season (R^2 = 0.77). Most of the introduced varieties produced large tubers when compared with the locals. In Betano, Maubisse, and Loes research centres variety CIP 71 gave higher yield than the other varieties.

Table 33. Sweet potato yields and yield advantages, 2012-2013

Variety	*Betano (wet season)*	*Betano (dry season)*	*Urulefa*	*Loes*	*Baucau*	*Aileu*	*st dev*	*Av yield (t/ha)*	*Yield adv (%)*
CIP 71	21.1	12.6	18.2	18.9	1.5	4.1	7.1	14.5	169
L.Urulefa			13.9					13.9	158
CIP 78	13.6	16.1	9.7	14.4	0.3	2.6	5.7	10.8	101
Hohrae 3	12.6	13.1	5.4	20.3	1.6	5.3	6.5	10.6	97
CIP 72	10.8	5.4	4.1	27.5	0.6	1.6	9.5	9.7	80
Hohrae 2	7.4	8.7	15.1	15.1	2.1	8.4	5.0	9.6	79
CIP 83	5.2	12.5	6.4	21.2	1.8	2.7	6.8	9.4	75
CIP 77	13.8	16.6	6.2	10.0	0.6	3.8	5.7	9.4	75
Hohrae 1	3.5	14.1	11.9	12.3	1.2	23.1	5.2	8.6	60
L. Baucau			10.3	11.2	1.3		4.5	7.6	42
CIP 68	9.5	7.1		0.8		0.1	3.7	5.8	8
L.mutin	8.9	9.2	4.1		0.8		3.5	5.7	7
CIP 73	1.5	7.5	6.8	9.2	1	4.9	3.3	5.2	-3
CIP 70	5	9.8	5.4	4.0	0.6	1.3	2.9	5	-8
L. Atabae	3.2	5.1			0.4		1.9	2.9	-46
CIP 65	0.6	5.7	4.4	0.1	0.5	3.5	2.3	2.3	-58
CIP 76	1.1	5.5	2.5	0.3	1.3	0	1.8	2.1	-61
L. Loes				0.0					-100
L. Foun						25.1			
L. Seloi						9.4			
F prob.	<.001	0.002	<.001	<.001	0.46	<.001			
LSD	6.1	6.1	4.1	7.1	ns	5.6			
%CV	46.3	36.7	29.6	38.6	87.9	52.1			
Mean site	7.8	9.9	8.3	11	1	6.4	4.2	7.4	
Mean local	2.5	9.2	4.1	1.1	0.7	17.3	1.9	5.4	

Farmers' preferences

Farmers preferred the characteristics of Hohrae 2 at all three evaluations followed by CIP71, Hohrae 1 and Hohrae 3 (Table 34). The Local Mutin, CIP 71 and CIP 72 were also preferred at two of the field days. Farmers did not take yield into consideration when choosing the varieties (they were coded) and preference was given to tubers that were crumbly rather than dry or mushy (Figure 15)

Table 34. Farmers preferences for different sweet potato varieties, 2012-2013

Variety	*% farmers liking the variety* Betano wet season	*Betano dry season*	*Loes wet season*	*Mean*
Hohrae 2	83	64	65	71
L.mutin	80	61		71
CIP70	83	52		68
CIP71	68	61	65	65
CIP72	38		88	63
Hohrae 1	68	68	53	63
Hohrae 3	40	39	71	50
CIP83	15	36	82	44
CIP73		43	41	42
CIP77	33	50	35	39
CIP78	25	50	18	31
CIP68	35		18	27
L. bcu			100	100
LSD(p<0.001)	19	19	19	
%CV	89	74	115	

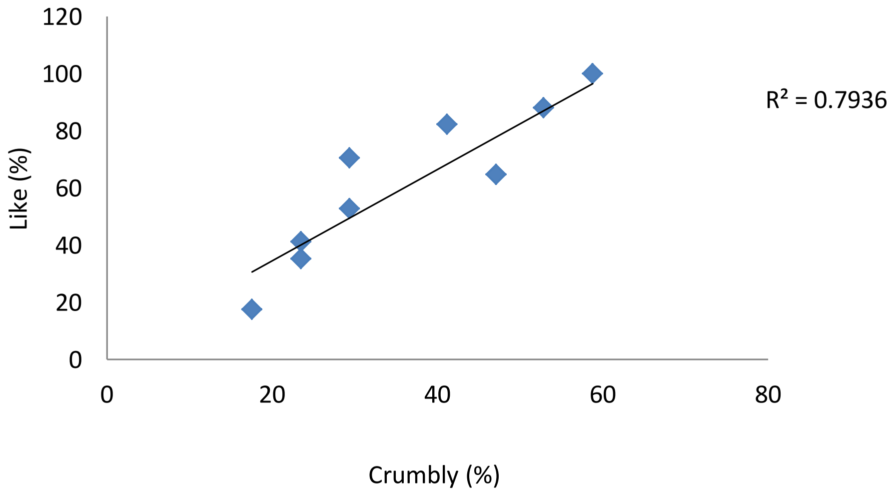


Figure 15. Correlation between like (%) vs crumbly (%), sweet potato, 2013

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

Thirty three successful sweet potato variety trials were implemented by SoL over the period from 2005 to 2013 at different sites and seasons (Aileu, Betano, Baucau, Loes, and Maubisse) in both the dry and wet seasons. The data of 28 varieties (including eight local varieties as controls) were included in a yield comparison . Some varieties were not included in all trials and some trials were not conducted at every site every year.

Results

The average yield of the entire dataset (17 environments, 426 data points) was 7.4 t/ha (st.dev = 7.1). Yield averages from trial to trial varied from a minimum 3.4 t/ha to a maximum of 13.3 t/ha. Wet season yields at Betano research station reached 12 t/ha during several years. Similar yields were also achieved during the dry season of 2013 at both Betano and Loes. Two introduced varieties (CIP71 and CIP72) tested in 2012 to 2013 showed high yields compared to other varieties.

Figure 16 presents a biplot analysis investigating the performances of 15 varieties in 13 environments (the last two years). This graph shows that when the variety (grey color) is close to the site (black color), the variety showed higher yield than other varieties in that location. Based on this result it can be concluded that varieties CIP71 and CIP72 were well adapted across lowland to upland (Betano, Loes, Baucau and Maubisse) ecosystems. Results represent 54% of the observed variation. Hohrae 3 and Hohrae 2 were consistent mean yielding varieties.

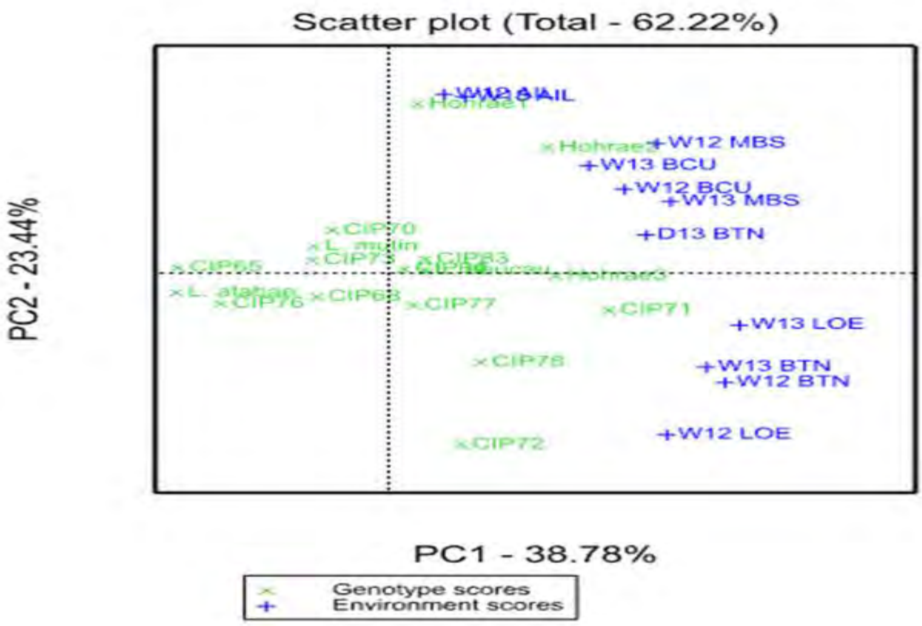


Figure 16. Biplot analysis on 15 sweet potato varieties at 13 environments (set 1), 2012-13

The biplot analysis presented in Figure 17 showed a correlation between sweet potato variety and trial site in data set 2 (2011-13). Based on this data CIP72 performed well at all sites, as did Hohrae-3.

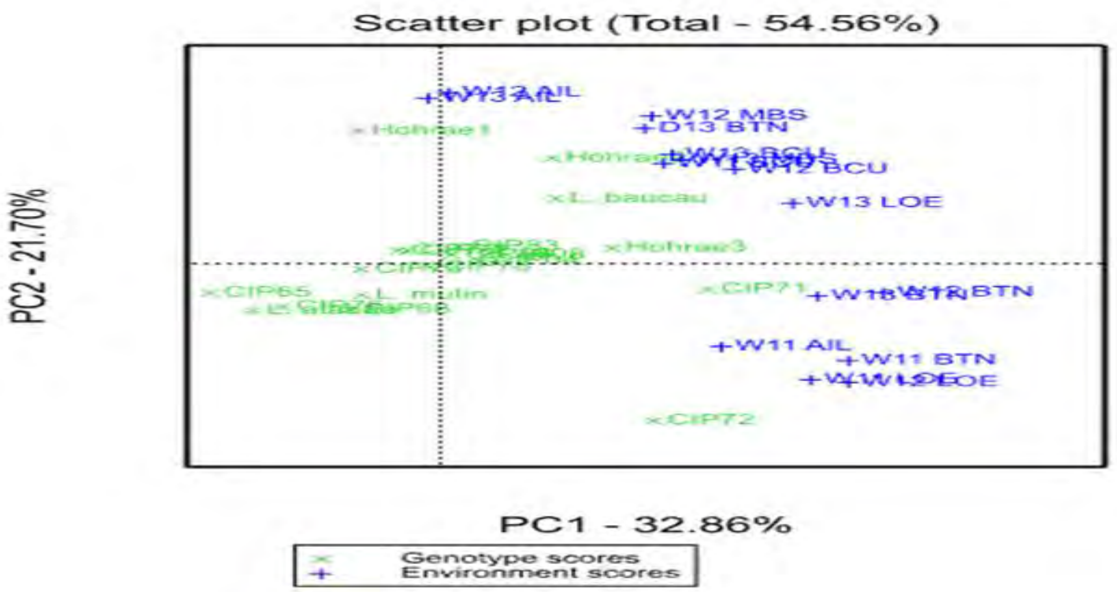


Figure 17. Biplot analysis on sweet potato variety base on environment (set 2), 2011-13

Conclusions

The released variety Hohrae 3 continued to produce consistently well across all ecosystems. Two other varieties (CIP71 and CIP72) also performed well plus the yellow fleshed CIP83. These three varieties will be investigated further, possibly in OFDTs.

2.2.3 Sweet potato OFDTs 2012-2013

Introduction

Three sweet potato varieties, CIP 71, CIP 72 and CIP 83, which showed promise in replicated trials on research stations during 2011-2012 were compared against a local and the high yielding released Hohrae 3 in on-farm unreplicated trials during 2012-2013.

Methods and materials

On-farm demonstration trials (OFDTs) were installed during the wet season at 95 sites across 4 Sub-Districts. The objective of the research was to determine which variety would meet the farmers' needs. The three test varieties were CIP 71, CIP 72 and CIP 83. These were compared with the released Hohrae 3 and a local variety commonly grown in the area.

The method in establishing OFDTs for sweet potato was the same as during the previous years (SoL 2012). Trials were established in Baucau and Viqueque Districts in the Sub-Districts of Baucau Vila, Vemasse, Ossu and Viqueque Vila. The sites were spread across at least four Agro Ecological zones (AEZ) in Timor-Leste from sea level to approximately 961 masl. Poor weather and a lack of planting material prevented the installation of more sites.

At harvest, the researcher and farmer harvested 5 pre-determined and marked sweet potato plants per plot. This method was developed in previous years when it was discovered that farmers were harvesting early the largest roots as needed for the household. For each site, researchers collected the number of roots per plant, weight of sweet potatoes from 5 plants and farmers opinions about the taste and cooking attributes of each variety. Farmer field days were often held at the Sub District level to measure the latter such as taste, disease resistance, and adaptation.

Site characterization

A number of characteristics were recorded for each site including soil pH, colour, texture, latitude, longitude, and elevation. Soil texture was recorded based on a ribbon testing method, pH was measured with a mobile testing kit, and colour was classified according to a list of 7 pre-determined colours. A number of management factors were also recorded from each host farmer. A range of measured soil pH, elevations and dates of planting for the different Sub Districts are presented in Table 35

Table 35. Soil pH and elevation, sweet potato OFDTs by Sub-District, 2012-2013.

Sub-District	*Soil pH*	*Elevation (masl)*	*AEZ*	*Date of planting*
Baucau vila	6.9	257	2	29-01-2013
Ossu	7.6	962	3	17-12-2012
Vemasse	6.0	733	4	09-01-2013
Viqueque vila	7.2	10	6	19-01-2013

Analysis

Data entry and analysis was as done for other OFDT trials. Raw data was entered into an Excel spread sheet and then analyzed using Genstat Discovery 16 ed. The results were analyzed by ANOVA (Unbalanced Model). In addition to the main analysis, the effects of variety and AEZ, soil pH, yield components, Sub-District and management practices were examined.

Results

Ninety five trials were established on farmer's fields, but only eighty five of these were harvested in such a manner as to collect meaningful results.

Trial losses

It is very difficult to determine the yield of root crops including sweet potato and cassava from trials conducted on farmer's fields in Timor-Leste. Farmers normally harvest root crops piece by piece instead of at one time. This makes it more likely that they will harvest some of the plots early. In this set of OFDTs, of the 95 trials established, yields were only recorded at 85 locations. Trial losses were mainly from farmers harvesting early but there was also animal predation especially by cows, buffalos as well as wild and domestic pigs.

Testing environments

Sweet potato OFDTs were conducted on a wide range of soil textures, pH, soil colour and elevation. Half of the sites were in the lowlands, either on the north or south coasts while others were planted at altitudes of nearly 1000 masl (Table 36).

Table 36. Distribution of sweet potato OFDT sites by elevation 2012-2013

Elevation (masl)	*Number of sites*	*Location (%)*
0-100	46	53
400-500	5	6
500-600	5	6
700-800	9	11
900-1000	20	24
Total	*85*	*100*

All test varieties (CIP 71, CIP 72, CIP 83 and Hohrae 3) yielded nearly double that of the local variety (Table 37). However, there was no significant difference in yield between test varieties despite the large yield advantage observed by CIP 83. CIP 83 and CIP 72 possessed particularly large roots.

Table 37. Yield components for OFDT sweet potato varieties, 2012-2013

Variety	*Yield (t/ha)*	*Roots per plant*	*Weight per root (g)*	*Yield advantage (%)*
CIP 71	9.5	4.5	132	82
CIP 72	11.0	6.5	169	112
CIP 83	14.8	3.0	176	184
Hohrae 3	10.8	5.1	158	108
Local	5.2	3.1	124	
LSD = (P<0.05)	*5.7*	*2.9*	*ns*	

Yield by Sub-District

The different varieties did not perform significantly different from each other by Sub District (Table 38). However, all varieties appeared to yield more roots at in Baucau vila and Viqueque vila compared with Ossu and Vemasse.

Table 38. Sweet potato OFDT root yield (t/ha) by Sub-District 2012-2013

Sub-District	*CIP 71*	*CIP 72*	*CIP 83*	*Hohrae 3*	*Local*
Baucau vila	10.8	13.5	11.5	14.2	8.6
Ossu	*	7.0	6.5	5.8	3.4
Vemasse	2.5	5.8	6.2	2.8	0.8
Viqueque vila	10.3	13.9	24.5	14.1	5.6
LSD = (P<0.05)			*6.3*		

* no yield

Agro-Ecological Zone (AEZ) and yield

As indicated in Table 38, sweet potato yields appeared to be higher in some Sub Districts than others. This is illustrated by the fact that root yields were generally higher at elevations below 500 masl (Table 39). All varieties were well adapted and provided good yields on north coast and northern slopes plus on the Southern slopes. There was no variety by AEZ interaction.

Table 39. Sweet potato OFDT mean yield by AEZ, 2012-2013

AEZ	*CIP 71*	*CIP 72*	*CIP 83*	*Hohrae 3*	*Local*
1 Northern coast (0-100m)	10.4	15.8	14.6	17.3	8.9
2 Northern slopes (100-500m)	15.2	16.1	9.6	11.2	10.4
3 Northern uplands (>500m)	4.0	6.0	6.5	7.0	2.7
4 Southern uplands (>500m)	*	7.0	6.5	5.8	3.4
5 Southern slopes 100-500m)	10.3	13.9	24.5	14.1	5.6
LSD = (P<0.05)			*13.8*		

Examining the effect of altitude in more detail, CIP 83 performed extremely well at lower elevations (Table 40), while Hohrae 3 tended to perform better at 500-600 masl compared with other varieties. Such differences, however, were not statistically different as shown in Table 41. This result is surprising considering that yields of all sweet potatoes were halved or less than halved at altitudes over 900 m. This occurs because temperatures are colder at higher elevations. The soil fertility may also be poorer, although this did not be the case in 2012-2013 as shown in Table 41.

Table 40. Yield comparison of sweet potato variety by elevation, 2012-2013

	Yield (t/ha) by elevation (masl)				
Variety	*0 - 100*	*400 -500*	*500 - 600*	*700 - 800*	*900 - 1000*
CIP 71	10.3	15.2	7.2	2.5	*
CIP 72	14.4	16.1	6.4	5.8	7.0
CIP 83	22.5	9.6	7.2	6.2	6.5
Hohrae 3	14.9	11.2	11.2	6.8	5.8
Local	*6.3*	*10.4*	*6.4*	*0.8*	*3.4*
LSD =(P<0.05			*7.13*		

Agronomic factors affecting yield

A wide range of agronomic characters were tested to see whether they affected sweet potato root yields. These are presented in Table 41. The results are similar to previous years where potato yields were affected by variety, Sub District and AEZ. The slope of the land also affected yields in four out of the past five years.

Table 41. Significance of management factors affecting sweet potato yield.

Factor	*Significance P<0.05*				
	2012/13	*2011/12*	*2010/11*	*2009/10*	*2008/09*
Variety	✓	✓	✓	✓	✓
Sub-District	✓	✓	✓	✓	✓
AEZ	✓	✓	✓	✓	✓
Soil pH	ns	ns	✓	✓	✓
Soil colour	ns	✓	ns	✓	ns
Elevation	ns	✓	✓	ns	ns
Soil texture	ns	ns	✓	✓	✓
Slope of land	✓	ns	✓	✓	✓
Plant in lines or not	ns	ns	✓	ns	ns
Mixed planting or monoculture	-	✓	ns	ns	ns
Weeding before planting	-	-	ns	-	-
Cuttings planted per hill (1 or 2)	-	-	✓	-	-

Farmer's preference for sweet potato clones

Each variety included in the OFDTs was evaluated at farmer field days during harvest and through general farmer observations noted by researchers. These are as follows:

Hohrae 3. This released variety is known to produce high yields. It is particularly favoured by farmers as a product for sale as buyers prefer the large root size and sweet taste of Hohrae 3 compared with local clones.

CIP 83. Many farmers like CIP 83 because it matures fast and the root is finer than Hohrae 3. Some farmer commented that they like the CIP 83 because the root is almost as large as Hohrae 3. The yellow flesh of CIP 83 was also one of the preferred characteristic. CIP 83 was also noted by some farmers to be resistant to drought. When the roots were boiled during consumption tests, farmers said that the taste of CIP 83 was dry, powdery and had no veins compared with Hohrae 3. Other farmers considered that it is difficult to distinguish between Hohrae 3 and CIP 83 because of characteristics almost identical.

CIP 72. This variety also gives higher yields than the local and is almost equal to the CIP 83 and Hohrae 3. Farmers were interested to this variety because the growing shoots are considered to be similar as spinach that can be cooked as a vegetable and taste sweet.

CIP 71. Farmers consider that this variety also possessed finer roots but they were not as big as the Hohrae and yielded only slightly more than local. Because of its lower yield compared with other test varieties in the OFDTs, farmers in some places do not want to plant it.

Conclusions

All test varieties out yielded the control, particularly CIP 83, CIP 72 and Hohrae 3. The first of these two varieties will be included in OFDT research in 2013. CIP 83 is orange fleshed as with Hohrae 3. From previous research (SoL, 2012) their β-carotene concentrations are known to be 802 and 1209 µg 100 g-1, respectively. Clones (including CIP 71) with lighter flesh coloured roots had non-detectable levels of carotenoids.

2.3 Cassava

Cassava (*Manihot esculenta* Crantz) is grown as a staple food crop in most areas of Timor-Leste. It is eaten in a variety of ways with fresh roots either boiled or fried, dried roots soaked and then boiled, or leaves boiled and eaten as a vegetable. Most rural households maintain a small crop of cassava throughout the year to be harvested as needed for reserve or supplemental food. It is often intercropped or planted in marginal areas, though large monoculture crops are found in some Districts. Cassava is typically harvested by farmers after approximately one year of growth.

2.3.1 Replicated cassava trials

Replicated trials for both 2011 and 2012 are reported here as the 2013 trials were harvested too late for inclusion in this report. Trials were conducted at Betano (Manufahi), Darasula (Baucau), Loes (Liquiça) and Kintal Portugal (Aileu) during both 2011 and 2012. The trials included the same set of clones as in previous years, allowing for a multi-year analysis.

Materials and methods

Each trial utilized a randomized complete block design with three replicates. This design was used on all four research centres. The trials were planted in December/January of their respective years and harvested from October to December the following year (Table 42).

Table 42. Cassava planting and harvest details, 2011-12.

Location	*Number of entries*	*Planting date*	*Harvest date*	*Mean yield (t/ha)*
Darasula	15	02/12/2011	03/10/2012	38.7
Loes	15	21/11/2011	07/11/2012	35.3
Betano	15	13/12/2011	Dec 2012	27.3
Aileu	15	09/11/2011	22/10/2012	17.0

Twelve to fifteen of the most promising clones were selected from the original germplasm import of 25 varieties. As in previous years, three of the best performing local varieties (Mantega, Merah, and Etu Hare) were included at all locations.

Plots at all sites were 5 m x 5 m with a walkway between each plot. Plant spacing was 1 m x 1 m resulting in 25 plants per plot. Yields were determined from 20 plants per plot with the remaining 5 plants used for field day observations and fresh stem production. At harvest, data was collected immediately on the fresh weight of tubers and their starch content. At some sites, HCN was also measured in the laboratory on a sample from each plot.

At most sites, field days were conducted in which farmers could inspect the remaining 5 plants and harvested tubers. Taste tests were also included in the field days during which both cooked and uncooked tubers could be sampled. In both instances, farmers were asked to choose which varieties they would be interested in planting on their own farms.

Analysis

Data collected from the trials were entered into an Excel spread sheet and then analysed with GenStat Discovery Edition 15 and GenStat 16 via one-way ANOVA in randomized blocks. For the multi-year analysis, a REML Linear Mixed Model in GenStat 15 was used. A principal component analysis (PCA) was used to describe the variation of variety yields across locations and years. PCA is one way to summarise variation in a large matrix of data (i.e. variety by experiment) into a smaller number of components. When the data is summarised into 2 components (PC1 and PC2) they can be displayed as an xy graph. However some of the variation is lost from the full matrix to just 2 components. The amount of variation retained from the full matrix in the 2 components depends on the data set. The principal component analysis was conducted using the GGE Biplot routine in Genstat 15.

Results

In the trials conducted in Darasula (Baucau) in 2012, there was significant difference in root yield, starch content and starch yield (Table 43).

Table 43. Cassava variety evaluation trial results, Darasula (Baucau) 2012

Code	*Variety name*	*Root yield (t/ha)*	*Starch content (%)*	*Starch yield t/ha*	*Plants/m²*	*Yield advantage over average of locals (%)*
Ca 015	Ai-luka 2	22.69	26.67	10.67	1	381
Ca 042	CMM 97-02-181	16.27	25.97	10.39	1	245
Ca 102	Rayong 1	16.16	26.57	10.63	1	242
Ca 109	KU 50	14.83	28.47	11.39	1	214
Ca 103	Rayong 2	13.64	21.27	8.51	1	189
Ca 016	*Mantega-Aileu*	12.67	26.57	10.63	1	168
Ca 036	CMM 97-02-36	12.43	25.47	10.19	1	163
L.M	*Local Manatuto*	11.87	23.77	9.51	1	151
Ca 013	CMM 96-25-25	11.07	20.73	8.29	1	135
Ca 026	Ai-luka 4	9.33	23.13	9.25	1	98
Ca 107	Rayong 72	8.16	25.50	10.20	1	73
Ca 101	Hanatee	8.13	13.77	5.51	1	72
Ca 106	Rayong 60	7.87	24.50	9.80	1	67
Ca 108	Rayong 90	3.76	27.83	11.13	1	-20
Ca 060	Local Etuhare	2.53	15.97	6.39	1	-46
F pr.		*0.056*	*0.009*	0.0036	<.001	
LSD		*10.468*	*7.298*	2.9192	0.148	
cv%		*54.8*	*18.4*	7.36	9.3	

In Loes, a significant difference in both yield and starch content was observed in 2012 (Table 44). Yields were among the highest ever observed in trials conducted by SoL with the variety Rayong 1 yielding 77.1 t/ha and improved varieties produced a large yield advantage over an average of the locals.

Table 44. Cassava variety evaluation trial results, Loes 2012

Code	*Variety name*	*Root yield (t/ha)*	*Starch content (%)*	*Starch yield t/ha (%)*	*Plant/m²*	*Yield advantage over average of locals (%)*
Ca 102	Rayong 1	77.1	31.73	12.71	1	355
Ca 109	KU 50	66.8	33.03	9.77	0	294
Ca 015	Ai-luka 2	58.5	30.23	12.09	1	245
Ca 013	CMM 96-25-25	58.3	27.43	10.97	1	244
Ca 042	CMM 97-02-181	54.5	31.77	4.57	0	222
Ca 026	Ai-luka 4	51.9	31.1	12.44	1	206
Ca 036	CMM 97-02-36	40.1	29.47	13.00	1	137
Ca 107	Rayong 72	40.1	33.57	12.69	1	137
Ca 108	Rayong 90	34.3	28.6	10.41	0	103
Ca 101	Hanatee	28.4	31.5	11.79	1	68
Ca 060	*Local Etuhare*	24.3	26.77	13.21	1	43
Ca 106	Rayong 60	19.7	24.43	12.60	1	16
Ca 103	Rayong 2	17.2	26.03	10.71	1	1.6
Ca 017	*Merah-Aileu*	16.9	11.43	11.44	0	-0.2
Ca 016	*Mantega-Aileu*	16.7	32.5	13.43	1	-1.4
F pr.		0.004	<.001	<.001	0.016	
LSD		32.18	4.422	1.769	0.2995	
cv%		47.7	9.2	9.2	30.7	

In the Betano 2012 trials, there was no significant difference in root yields; however there was significant different in starch content (Table 45). All improved varieties produced a wide margin of yield advantage over the locals.

Table 45. Cassava variety evaluation trial results, Betano 2012

Code	*Variety name*	*Root yield (t/ ha)*	*Starch content (%)*	*Starch yield (t/ha) (%)*	*Plant (m²)*	*Yield advantage over average of locals (%)*
Ca 013	CMM 96-25-25	43.9	28.50	11.40	0.35	276
Ca 015	Ai-luka 2	43.3	28.77	11.50	0.49	271
Ca 026	Ai-luka 4	42.4	28.03	11.21	1.00	263
Ca 109	KU 50	37.1	30.07	10.96	0.24	218
Ca 107	Rayong 72	36.8	26.33	11.30	0.21	215
Ca 042	CMM 97-02-181	30.9	28.93	7.35	0.12	165
Ca 016	Mantega-Aileu	26.9	29.53	10.53	0.52	131
Ca 036	CMM 97-02-36	26.3	23.27	11.81	0.16	125
Ca 106	Rayong 60	23.9	27.40	10.29	0.11	105
Ca 007	CMM 96-36-224	22.9	29.00	11.60	0.63	96
Ca 108	Rayong 90	21.9	28.77	10.83	0.23	88
Ca 060	Local Etuhare	17.5	25.73	12.03	0.40	50
Ca 102	Rayong 1	17.3	27.07	11.57	0.67	48
Ca 017	Merah-Aileu	9.6	18.38	11.51	0.21	-18
Ca 101	Hanatee	8.1	28.27	9.31	0.27	-31
F pr.		*0.443*	*0.014*	*0.0056*	*<.001*	
LSD		*ns*	*5.308*	*2.1232*	*0.2682*	
cv%		*72.4*	*11.6*	*4.64*	*43*	

In Aileu, a significant difference was found for both root yield and starch content (Table 46). Yield advantages were highest for Ca106; however Ai-Luka 2 also performed well.

Table 46. Cassava variety evaluation trial results, Aileu 2011-12

Code	*Variety name*	*Root yield (t/ ha)*	*Starch content (%)*	*Starch yield t/ha (%)*	*Plant (m2)*	*Yield advantage over average of locals (%)*
Ca 107	Rayong 72	34.3	34	12.39	1.00	178
Ca 015	Ai-luka 2	31.4	33	13.35	1.00	155
Ca 026	Ai-luka 4	30.5	28	11.16	1.00	147
Ca 036	CMM 97-02-36	30.1	33	10.15	0.99	144
Ca 042	CMM 97-02-181	29.2	29	11.03	1.00	137
Ca 013	CMM 96-25-25	28.8	24	9.40	1.00	134
Ca 109	KU 50	27.6	32	11.07	0.89	123
Ca 102	Rayong 1	21.4	31	11.72	0.96	73
Ca 103	Rayong 2	21.1	23	11.04	0.97	71
Ca 017	Merah-Aileu	20.7	28	13.47	0.95	68
Ca 101	Hanatee	18.6	27	13.29	0.96	50
Ca 016	Mantega-Aileu	16.0	25	13.19	0.99	30
Ca 108	Rayong 90	13.9	33	9.32	0.92	13
Ca 060	Local Etuhare	11.9	28	12.83	0.99	-4
Ca 106	Rayong 60	11.2	28	10.65	1.00	-9
f prop		*<.001*	*<.001*	*<.001*	*0.275*	
LSD		*8.9*	*4.2*	*1.3*	*0.1*	
cv %		*36.3*	*8.2*	*6.6*	*5.1*	

Starch production

There was considerable variation for starch production between varieties when tested at the 4 locations over 2 years. Yield advantages over the average local starch yields are presented in Table 47.

Table 47. Cassava multi-environment starch yield advantages (%) 2011-12

Variety	*Aileu 2011*	*Aileu 2012*	*Darasula 2011*	*Darasula 2012*	*Betano 2011*	*Betano 2012*	*Loes 2011*	*Loes 2012*	*Mean*
Ca 013	-18	-12	-28	-6	-2	16	-5	16	-5
Ai-Luka 2	0	24	0	21	0	17	20	28	14
Local Mantega	0	-6	2	20	14	20	42	38	16
Local Merah		3			3	-25	-50	-51	-24
Ai-Luka 4	32	4	-3	5	-5	14	26	32	13
Ca 036	14	24	2	15	-1	-5	22	25	12
Ca 042	-8	9	3	17	3	18	28	35	13
Local Etuhare		3	-2	-28	-17	5	8	14	-2
Ca 101	-3	-1	-6	-38	-1	15	-1	34	0
Ca 102	4	15	0	20	-2	10	38	35	15
Ca 103		-13	-47	-4			28	10	-5
Ca 106	6	3	6	11	-22	12	21	4	5
Ca 107	23	25	8	15	9	7	34	42	21
Ca 108	8	23	-100	26	0	17	46	21	5
Ca 109	29	19	10	29	7	23	36	40	24
Ca 007	-40				-33	18			-18
Local1	-6								-6
Local2	6								6
Local Manatuto				8					8

Figure 18 is a Biplot analysis of tuber yield of the tested varieties across the 8 test locations. The biplot shows the position of each variety in relation to the 8 test locations. The two components of the biplot (PC1 and PC2) account for 56.13% of the total variation in the original data set. Four of the test locations are near the center of graph. Only the two Loes experiments (Ba10 and Lo11) and Betano 2010 are quite some distance from the center and hence different from other locations.

Loes 2011 is positioned above and to the left of the center, and Betano 2010 is positioned below and to the right of center. This suggests that rank order of varieties in Loes 2011 is quite different to that of Betano 2010. In addition the test site Loes 2011 sits well to the right of the center, suggesting that there is no correlation between varieties yields in Loes across the 2 years (i.e. 2010 and 2011), and no correlation between Loes 2010 and Betano 2012. Flooding of the Loes 2011 trial may account for this effect.

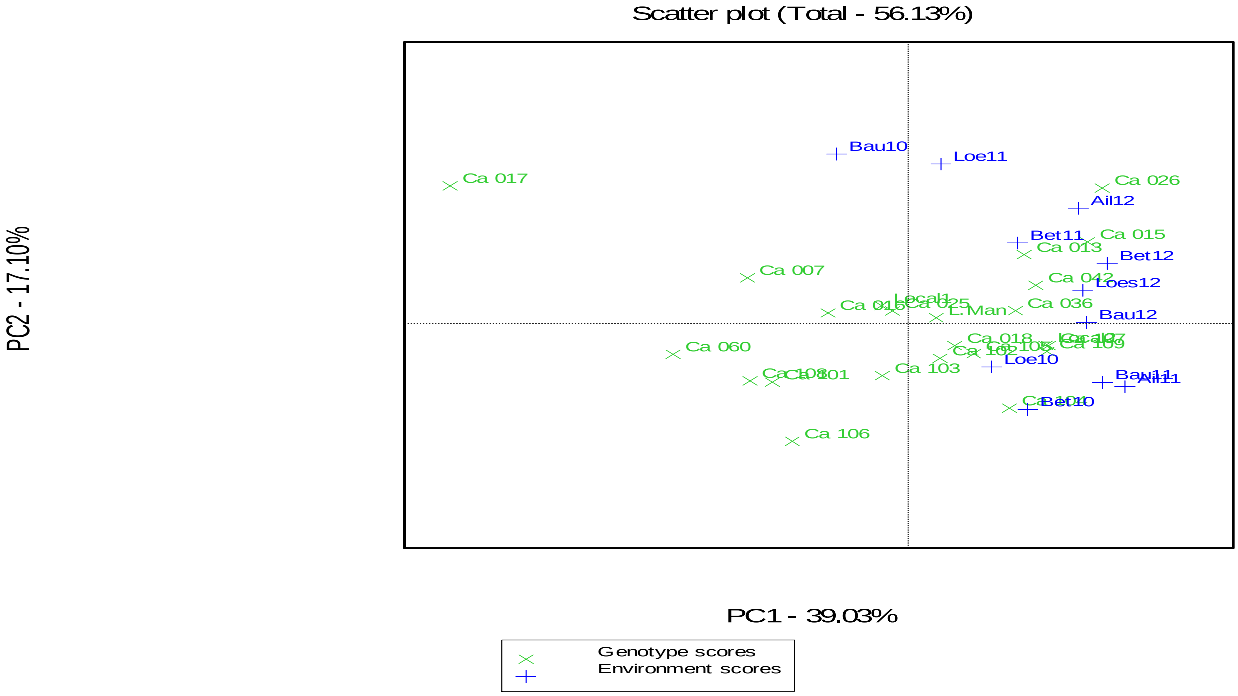


Figure 18. Biplot of multi-year cassava data 2008-2011.

2.3.2 Cassava performance across sites and years

A multiyear analysis was performed on all trials at the four sites for the years 2011 and 2012. The results of this analysis are presented in Table 48. Of the introduced varieties, Ai-Luka 2 and Ai-Luka 4 produced the highest average yield advantages over local varieties reaching 71.5% and 59.7% respectively. These varieties have been tested in 15 replicated trials since 2011 to 2012, and have consistently maintained a high yield advantage over local varieties. The overall average yield for cassava for all sites and years was 30.9 t/ha.

When analysed across all years, a significant difference in yield was observed for both variety and location. Among the test sites, Baucau proved to be the lowest producing and Loes the highest.

During the 2011 – 2012 testing period, the local variety Lokal Merah and Lokal Etuhare performed better than in previous testing years with a yield advantage of 2.4% and 7.4% respectively over the other local variety. This is worth noting as it is a very popular variety among Timorese farmers who value its yellow colour and good taste.

Table 48. Multi-year cassava replicated trial yields by variety and location, 2011-12

Variety	*Average yield by location 2010-2012 (t/ha)*				*Variety average yield, all locations (t/ha)*	*Yield advantage over average local (%)*
	Aileu	*Baucau*	*Betano*	*Loes*		
Local mantega	14.20	7.76	22.26	34.85	19.8	9.7
Local Merah	20.73	9.94	12.65	27.05	17.6	-2.4
Local Etuhare	11.89	4.34	23.28	27.25	16.7	-7.4
Ca 013	22.81	8.73	28.06	55.03	28.7	59.1
Ai-luka 2	24.66	12.13	30.28	47.99	28.8	59.7
Ca 036	25.80	9.75	29.87	48.97	28.6	58.7
Ca 042	22.46	10.89	30.39	44.48	27.1	50.2
Ai-luka 4	26.93	8.09	38.11	50.50	30.9	71.5
Ca 101	13.88	5.69	19.14	38.31	19.3	6.9
Ca 102	15.00	10.31	21.56	55.12	25.5	41.5
Ca 103	21.08	7.82	27.09	40.89	24.2	34.4
Ca 106	12.13	6.86	26.99	28.25	18.6	3.0
Ca 107	28.61	8.40	32.50	38.48	27.0	49.8
Ca 108	12.96	3.06	23.03	40.45	19.9	10.3
Ca 109	23.05	9.54	32.61	43.51	27.2	50.8
Location average	*19.75*	*8.22*	*26.52*	*41.41*	*24.0*	
F prob (Variety)					*F prob (Location)*	
0.878					*<.001*	

Starch content was also analysed across years with the results presented in Table 49. A significant difference was found for variety and the variety x location interaction, but not for location alone. The released varieties were on par with local varieties for starch content.

Table 49. Multiyear cassava replicated trial starch content by variety, 2011-12

Variety	*Variety average starch content, all locations (%)*	*Average starch production (t/ha)*	*Starch content advantage over average local (%)*
Ca 013	9.27	18.01	-10
Ai-luka 2	10.99	21.62	7
Local Mantega	10.12	22.49	-1
Local Merah	8.78	17.40	-14
Ai-luka 4	10.99	21.25	7
Ca 036	11.92	21.01	16
Ca 042	10.71	21.74	4
Local Etuhare	9.26	20.49	-10
Ca 101	9.61	19.49	-6
Ca 102	10.39	21.60	1
Ca 103	9.34	18.39	-9
Ca 104	6.49	25.22	-37
Ca 105	10.07	27.92	-2
Ca 106	9.45	20.84	-8
Ca 107	11.02	23.51	7
Ca 108	10.50	20.87	2
Ca 109	11.01	23.34	7
chi prob Variety	1.00		
chi prob Location	<.001		
chi prob Variety x Location	1.00		

Farmer field day results in Loes showed that many of the farmers selected local Mantega as their favourite eating variety due to its sweet taste (Table 50) Farmers also selected introduced varieties such as Ca102, when they were also sweet and had a good taste.

Table 50. Farmer field day result, taste test in Loes research station 2011-12

Variety	Sweet (%)	Bitter (%)	Dry (%)	Crumbly (%)	Soapy (%)	Wish to plant (%)
Mantega	83	4	96	22	9	48
Ca 102	48	39	61	13	30	39
Ca 013	65	0	61	39	22	26
Ca 042	70	0	52	70	13	22
Ca 109	43	26	74	17	13	17
Ai-luka 4	52	9	30	65	26	13
Ai-luka 2	57	0	78	22	13	9
Ca 060	78	13	48	43	9	9
Ca 036	57	22	39	61	4	4
Ca 107	65	13	57	35	43	4

At the farmer field day at Betano Research Centre most of the farmers selected the test variety Ca107 because it tasted sweet and was not sticky. Farmers also selected the MAF released variety Ai-luka 4 and the local Mantega (Table 51).

Table 51. Farmer field day result, taste test in Betano research station, 2011-12

Variety	Like (%)	Sweet (%)	Bitter (%)	Soapy (%)	Crumbly (%)	Soggy (%)	Wish to plant (%)
Ca107	57	50	7	46	14	7	68
Ai-luka4	57	57	4	18	64	11	36
Mantega	43	57	18	36	25	14	36
Ai-luka2	54	54	18	7	54	11	29
Ca017	50	39	14	32	21	11	29
Ca042	39	36	25	43	39	4	14
Ca060	43	61	4	32	32	7	14
Ca013	50	54	7	21	50	11	4
Ca109	21	32	18	29	32	11	0

Farmer field day results at the Darasula Research Centre showed many farmers selected the local variety from Manatuto because of its good taste. Variety Ca106 was also selected by many farmer due to the good taste. The MAF released variety, Ai-Luka 2 was also popular because it showed consistent yield (Table 52).

Table 52. Farmer field day result, taste test in Darasula research station, 2011-12

Variety	Like (%)	Good taste (%)	Soapy (%)	Dry (%)	Crumbly (%)	Sweet (%)	Bitter (%)	Wish to plant (%)
L.Man	43	62	17	17	19	55	14	74
Ca 106	64	45	21	21	21	45	12	43
Ai-Luka 4	40	52	19	12	21	55	14	36
Ca 060	43	55	14	14	14	50	12	29
Ca 107	24	33	40	12	2	31	38	26
Ca 042	26	38	29	14	14	26	36	19
Ca 013	24	19	40	5	2	19	40	14
Ai-Luka 2	40	29	33	17	2	29	21	14
Ca 016	52	0	0	0	0	60	2	12
Ca 109	12	12	29	12	10	17	45	5
Ca 103	29	0	0	0	0	40	24	5
Ca 102	10	10	24	19	5	19	40	2
Ca 036	33	0	0	0	0	40	31	2
Ca 101	55	0	0	2	0	62	5	0
Ca 108	45	0	0	0	0	55	14	0

Conclusions

The good performance of Ai-luka2 and Ai-luka 4 during 2011-2012 provide continued support for their choice as released varieties. These varieties have consistently maintained a high yield advantage since 2001 and have proven popular with Timorese farmers. In addition to the released varieties, a number of Timorese farmers also selected one or more local varieties to continue planting. The local variety of most merit is Mantega which proves to be highly popular at farmer field days, and is rated very highly for its buttery yellow colour. This suggests that improved varieties of a similar colour may prove to be popular.

The possibility of releasing Ca 109 as an industrial crop was raised during year. This variety yields well and has good starch content. Because it is bitter, this variety is less susceptible to rodent predation and is suitable for starch production only. The Cooperativa Café Timor (CCT) has distributed Ca 109 widely to farmers in a project which buys back planting material and dried chips for commercial starch production. The possibility of an industrial crop being released by MAF is set to be discussed by the variety release committee in 2014. Bitter cassava is grown in many areas by Timorese farmers, but whether it is suitable for MAF release is yet to be decided.

Farmer field days were conducted in three research centres - Betano, Darasula and Loes. The result showed that in Loes Research Centre many farmer select local variety Mantega code Ca016. In Betano Research Centre, many farmer selected variety Ca107; however, in Darasula Research Centre many farmer select local variety Manatuto. In short, farmer preferences varied widely from site to site.

2.4 Rice

2.4.1 Irrigated aromatic rice observational trials, 2013

Replicated rice trials established in 2013 will be reported in the 2014 report

2.4.2 Upland rice observational trials, 2013

Upland rice (*Oryza sativa* L.) has been cultivated in the island of Timor for hundreds of years. The botanist, Sir Joseph Banks, while with captain Bligh, took samples of upland rice from Kupang in 1789 which he shipped to England as a botanical specimen. Some seeds of this collection were cultivated by the then Secretary of State, Thomas Jefferson during 1790 in an effort to avoid the need for the American population to grow lowland rice in the southern swampy areas of the United States during which they often contracted malaria. Upland rice continues to be cultivated in Timor-Leste but in small areas. The SoL Baseline Survey indicated that ±14% of farmers in Baucau and Viqueque Districts grow upland rice.

Methods and materials

In 2010, 100 varieties of upland rice were imported from the International Rice Research Institute (IRRI) in the Philippines and compared as with 3 local varieties in an observational trials at Betano (Manufahi), Aileu (Aileu) and Baucau (Baucau). The results of this research were presented in the SoL 2011 Annual Research Report. In 2011-2012 60 of the best of these varieties were planted at Darasula, Baucau. The results of this trial are presented in the SoL 2012 Annual Research Report.

On 20 December, 2012, 49 varieties were again planted as an Observation Trial at Darasula (Baucau). The trial was harvested on 3 May 2013 after receiving 222 mm of rainfall.

Results

Seventeen varieties contracted brown spot disease and will be discarded from further research. In general, however, grain yields of the test entries were much higher in 2013 than they were in 2012 (Table 53). The yields were relatively consistent across years with R03, R21, R12, and R64 being in the highest yielding eight varieties in both years. On average, the highest yielding varieties were RO24, RO21 RO03 and RO48.

These varieties need further evaluation.

Table 53. Yield (t/ha) of 15 top yielding varieties evaluated in 2012 and 2013

Variety	2012	2013	Mean
RO24	0.79	3.40	2.10
RO21	1.14	2.95	2.05
RO03	1.58	2.24	1.91
RO48	0.67	2.75	1.71
RO12	1.55	1.59	1.57
RO64	1.08	1.87	1.48
RO69	0.77	1.97	1.37
RO50	1.20	1.41	1.31
RO43	0.98	1.59	1.29
RO52	0.88	1.66	1.27
RO41	0.87	1.54	1.21
RO10	0.65	1.74	1.20
RO99	0.64	1.69	1.17
RO46	1.31	0.94	1.13
RO102	1.16	1.07	1.12

2.4.3 Rice OFDTs, 2013

Rice On-Farm Demonstration Trials (OFDTs) were established in 5 districts and 5 sub-districts of Timor-Leste in the 2012-13 wet season. The trial objective was to determine whether a promising new rice variety identified in replicated trials performed well on farmers' fields under farmers' agronomic conditions. The test line, Matatag 2 was compared with the released variety, Nakroma, and the farmers' local variety.

Materials and methods

Forty six OFDTs were sown in three of the six agro ecological zones (AEZs) in Timor-Leste. These included the Sub-Districts of Aileu, Baucau, Liquiça, Maliana, and Hatolia. The trials were monitored by six researchers. Farmers received 5 kg bags of the released variety Nakroma and 300 g of Matatag. Farmers supplied their own seed to establish a plot of the local variety which was used as a check. Local checks included old Portuguese varieties (e.g. Nona Portu), Indonesian varieties (e.g. President, Membramo), and more recent releases from IRRI (e.g. IR64). Twenty four trials produced useable data.

Seed was usually first planted in a nursery to grow healthy seedlings before they were transplanted to a paddy field. As in previous years, the actual area planted to each variety (plot size) varied according to each farmer's bunded paddy area. In most cases the test varieties and the local were grown side by side in one paddy. The seedlings were 12-14 days old when transplanted during February or March, 2013. Where possible, a 5 m x 5 m area was used for each plot. However at some sites smaller sample sizes were taken. Much of the process establishing rice OFDTs was no different to that described in the maize chapter of this report.

Researchers visited the sites an average of 18 times between planting and harvest. At each visit they recorded different information about the OFDT. 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 fresch threshed grain was weighed. A sample of grain was also weighed, then dried and weighed again. The ratio of dry grain to fresh 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).

Analyses

Data from the 24 harvested trials were first entered into a MS Excel spread sheet database before being transferred for further analysis in Genstat Discovery Edition 16th. Rice yield data were analyzed by ANOVA (Unbalanced Linear Model) with variety and AEZ as constant factors in the model once the other locational factors had been tested.

Analyses were conducted for those trials where yield data were recorded. This allowed test varieties to be compared to both released and local varieties in a more balanced manner.

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

Rice OFDTs were conducted on a wide range of soil texture, pH, slope and elevation. Elevation of OFDT sites ranged from about sea level to almost 1,100 masl in Aileu Sub-District.

The average of soil pH across the OFDT test sites was 6.8, ranging from 6 to 8.0. A high proportion of sites was defined as neutral (pH 6-7).

Variety

There was no significant difference between the yields of either the two test varieties and the local despite the fact that the Nakroma appeared to yield lower (Table 54, Figure 19).

Table 54. Grain yields of OFDT rice varieties, 2013

Variety	*Yield (t/ha)*
Local	3.5
Matatag-2	3.5
Nakroma	3.2
LSD=(P<0.05)	ns

Figure 19 demonstrates graphically the yield relationships between the local and two test varieties. The difference in scale of the axes in the graph with Local and Matatag-2 demonstrate a slight yield reduction in several sites, but higher in others. This gives encouragement that a more comprehensive set of trials may show that Matatag-2 will be a competitor to the local variety.

A significant difference in rice yield between Sub-Districts was evident (F Pr. <.001). Most varieties yielded best in Hatolia Sub-District and worst in Aileu Villa Sub-District. In Table 55, the yield figures come from greater number of trials that contained a test variety and therefore are a more reliable estimate of the Sub-District effect. There was no significant interaction between variety and Sub-District.

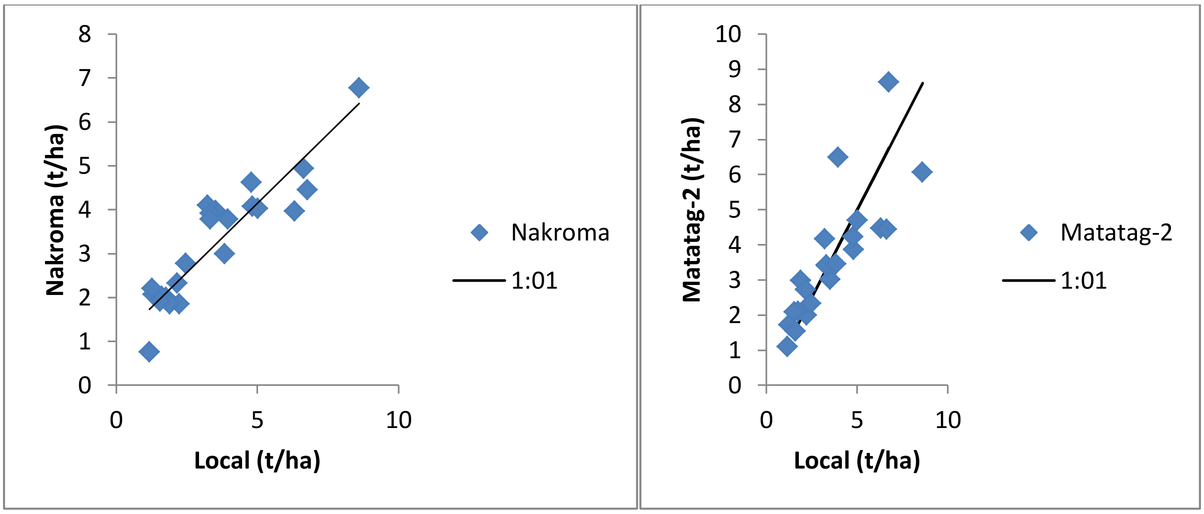


Figure 19. Comparison of 2 test rice varieties and local, 2012-2013

Table 55. Mean OFDT rice yields (t/ha), Sub-Districts, 2013

District	*Sub-District*	*Sub-District mean yield (t/ha)*	*Yield of local (t/ha)*	*Yield of Matatag 2 (t/ha)*	*Yield of Nakroma (t/ha)*
Aileu	Aileu Villa	1.6	1.4	1.7	1.7
Bobonaro	Maliana	3.0	3.0	2.9	3.1
Liquiça	Liquiça Villa	3.5	3.3	3.4	3.9
Ermera	Hatolia	4.9	5.3	5.2	4.3
Baucau	Baucau Villa	3.9	4.4	3.6	3.6
	LSD=(P<0.05)	*1.224*			
	F.Pr	*<.001*			
	CV %	*37.47*			

Agro Ecological Zones (AEZ) and yield

Yield results for each variety in each AEZ where tested are presented in Table 56. There was a significant effect (F.prob<.001) of AEZ on rice yield at different locations. There was no interaction between variety and AEZ with either data set. Yields were found to be lower at higher elevation sites.

Table 56. Mean yields (t/ha) of rice OFDTs by AEZ, 2012-2013

AEZ	*AEZ mean yield (t/ha)*	*Yield of local (t/ha)*	*Yield of Matatag 2 (t/ha)*	*Yield of Nakroma (t/ha)*
1 (0-100masl)	4.8	5.1	5.0	4.3
2 (100-500masl)	3.0	3.0	2.9	3.1
3 (>500masl)	2.1	2.1	2.2	2.1
LSD=(P<0.05)	*0.8*			
F.Pr	*<.001*			
CV (%)	*41.5*			

Agronomic factors affecting yield

The influence of a wide range of characters was tested for their effect on rice yield (Table 57). Half of the tested characters were found to have an influence on grain yield. These were Sub-District, AEZ, soil texture and elevation. No significant effect was measured for soil pH, soil colour, seedlings per hill of variety.

Table 57. Significance of Factors affecting rice yield, OFDTs 2012-2013.

Factor	*Significance(p=0.05)*
Variety	x
AEZ	✓
Sub-District	✓
Elevation	✓
Seedling	x
pH	x
Soil texture	✓
Soil colour	x

Soil texture

Soil texture had a significant effect on rice yield across the test sites. Fine clay yielded the highest followed by sandy loam (Table 5). Those soils classified as clay loam and heavy clay was the lowest yielding. No interaction of soil texture and variety was evident.

Table 58. Effect of soil texture of rice yield 2012-2013

Soil Texture	*% of OFDTs harvested*	*Yield (t/ha)*
Clay loam	20.3	3.5
Fine clay	33.3	1.7
Heavy clay	12.5	3.5
Silt Loam	33.3	4.8
F.prob	*<.001*	
LSD=(P<0.05)	*0.9*	
%CV	*38.0*	

Conclusions

Neither of the test varieties performed better than the local during the 2013 OFDTs. Further research across a larger number of sites is required to evaluate the performance of Matatag 2.

2.5 Peanuts

2.5.1 Replicated trials, 2012-2013

Peanut (*Arachis hypogaea* L.) lines tested by SoL were sourced from ICRISAT in India. The lines were originally selected for their adaptation to conditions similar to those found in Timor. Most of those included during the 2012-2013 season were also in previous years' trials. The characteristics of the varieties used in the trials are presented in Table 59.

Table 59. Replicated peanut variety trial line characteristics, 2012-2013

Code	*Name*	*Botanical type*	*Seed skin colour*
Utamua (PT 05)	ICGV 88438	Spanish bunch	Brown
PT 014*	ICGV 96165	Virginia	Red
PT 020**	ICGV 99017	Spanish bunch	Brown
PT 021*	Local mean	Timor	Red
PT 022*	Local large	Timor	Brown
PT 124*	ICGV 97120	Virginia	Brown
PT 131*	ICGV 97100	Virginia	Brown
PT 132*	ICGV 97131	Virginia	Brown
PT 133*	ICGV 97135	Virginia	Brown
PT 134*	ICGV 97137	Virginia	Brown
PT 136*	ICGV 98180	Virginia	Brown
PT 137*	ICGV 98184	Virginia	Brown
PT 138*	ICGV 98187	Virginia	Brown
PT 141*	ICGV 99171	Virginia	Brown
PT 142*	ICGV 99174	Virginia	Brown

* Medium-duration cycle ** Foliar disease resistant

Methodology

Yield, yield advantage and yield components

Trials were held in four research centers during the rainy season 2012-13 and at two centres in the dry season of 2013. Each trial comprised 15 entries including the recommended Utamua variety (PT 05) and two local varieties (Pt 021 and Pt 022) which acted as checks.

All sites contained three replicates of 25 m^2. The trial was designed as a randomized complete block. Planting hills (one seed per hill) were spaced at 40 cm x 20 cm. The trials were neither fertilized nor irrigated between planting (from December 2012 to June 2013) and harvest (from April – July 2013) (Table 60).

Table 60. Planting and harvest details of peanut varietal trials, 2012-2013.

Location	*No. of entries*	*No. of replicates*	*Planting date*	*Harvest date*	*Mean yield (t/ha)*
Aileu (rainy season)	15	3	11 Dec 2012	25 Apr 2013	0.70
Baucau (rainy season)	15	3	30 Jan 2013	08 Jul 2013	0.47
Betano (rainy season)	15	3	28 Dec 2012	03 May 2013	1.63
Loes (rainy season)	15	3	19 Dec 2012	14 May 2013	0.62
Betano (dry season)	15	3	06 May 2013	04 Sept 2013	0.71
Loes (dry season)	15	3	17 June 2013	08 Aug 2013	0.28

At harvest, all plants were dug, dried and weighed. The weight of fresh and then dry pods were measured. 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 Edition 16. No row effects were observed.

Results

Grain yield and yield components for the wet season trials are presented in Table 61 and Table 62. The results of the dry season trials are presented in Table 63. Grain yields were extremely low at three (Aileu, Baucau and Loes) of the four wet season sites and extremely variable. This was primarily due to crop establishment in the plot. Whereas the goal plant density was 12.5 plants/m^2 the maximum plant density was observed to be 9.5 plants/m^2 (Aileu), while at Loes the range was from 0.06 to 3.3. Mean grain yields ranged from 0.47 t/ha to 1.63 t/ha (Table 60).

Plant establishment at Loes during the dry season was reasonably even (Table 63) but yields were extremely low averaging 0.28t/ha. The plants were droughted towards the end of the growing season. Plant populations at Betano ranged from 2.1 to 8.0 per m^2 but yields were higher than at Loes (Table 63).

Table 61. Grain yield and yield components, Aileu and Baucau, 2012-13

Code	(Aileu 2013 (Rainy season) *Yield (t/ha)*	*Plants/m^2*	*100 pod weight (g)*	*Pods/plant*	*Seeds/pod*	Baucau 2013 (Rainy season) *Yield (t/ha)*	*Plant/m^2*	*100 Pod weight (g)*	*Pods/plant*	*Seed/pod*
Pt 014	0.79	8.59	32.1	54.7	1.70	0.37	6.20	58.2	6.2	1.50
Pt 020	0.24	1.67	28.0	50.0	1.77	0.41	3.04	50.4	23.3	1.44
Pt 021	0.96	7.25	25.2	59.2	2.38	0.54	6.17	58.9	8.9	1.59
Pt 022	0.85	7.65	31.4	61.4	1.96	0.42	1.47	53.0	42.3	1.67
Pt 124	0.14	1.40	36.8	63.7	1.77	0.24	2.44	57.4	12.9	1.32
Pt 131	0.45	7.03	29.9	52.8	1.76	0.22	5.59	39.3	6.6	1.63
Pt 132	0.73	7.17	39.3	70.5	1.82	0.46	3.52	44.6	15.3	1.74
Pt 133	0.72	7.13	36.0	65.7	1.81	0.45	3.60	50.2	14.6	1.86
Pt 134	0.96	9.53	40.8	73.7	1.82	0.42	3.09	57.9	13.9	1.63
Pt 136	0.63	6.92	43.1	71.9	1.67	0.84	4.73	53.1	20.6	1.52
Pt 137	0.80	5.24	36.0	55.8	1.55	0.77	4.80	39.0	28.4	1.51
Pt 138	0.90	7.71	36.4	60.3	1.67	0.32	3.37	56.0	12.3	1.43
Pt 141	0.34	4.91	40.0	57.6	1.51	0.41	2.56	27.2	17.8	1.00
Pt 142	1.06	6.07	32.4	55.0	1.69	0.62	7.20	57.8	13.6	1.35
Utamua	0.88	5.67	64.1	103.0	1.60	0.53	4.11	62.7	58.8	1.47
F.prob	0.18	0.03	0.02	0.06	<.001	0.59	0.02	<.001	0.52	0.02
LSD	0.66	4.24	16.9	ns	0.23	ns	2.88	10.9	ns	0.38
CV (<0.05)	56.4	40.2	27.3	25.5	7.9	68.8	41.7	12.7	127.9	15.0

Table 62. Yield and yield components, Betano and Loes, 2012-13

Code	Betano 2012-2013 (Rainy season)					Loes 2012-2013 (Rainy season)				
	Yield (t/ha)	Plant/m^2	100 Pod weight (g)	Pods/plant	Seeds/pod	Yield (t/ha)	Plants/m^2	100 Pod weight (g)	Pods/plant	Seeds/pod
Pt 014	2.02	9.03	77.7	20.8	2.16	0.94	1.49	43.7	35.6	1.64
Pt 020	1.09	5.31	78.0	20.8	1.79	0.14	0.88	40.5	15.2	1.69
Pt 021	2.21	7.61	105.0	23.0	2.55	0.18	0.38	55.9	24.0	2.43
Pt 022	2.41	8.31	78.7	27.2	1.94	0.56	3.32	39.9	14.8	1.96
Pt 124	1.87	6.03	66.7	31.8	1.84	0.10	0.06	74.1	91.6	1.31
Pt 131	1.52	2.40	72.0	62.2	1.82	0.24	0.87	37.0	27.7	1.98
Pt 132	2.15	6.80	74.0	33.2	1.75	0.35	1.20	48.4	20.5	1.89
Pt 133	2.22	5.47	87.0	32.6	1.81	0.87	1.80	49.7	37.1	1.95
Pt 134	1.51	3.69	76.3	38.4	1.87	0.94	1.29	53.3	41.4	1.99
Pt 136	0.77	2.59	79.0	26.4	1.87	1.47	1.35	58.5	58.8	1.93
Pt 137	1.43	3.72	71.7	34.0	1.76	*	0.19	40.8	0.0	1.79
Pt 138	1.22	2.59	70.3	45.7	1.83	0.62	1.17	44.4	30.9	1.73
Pt 141	0.77	1.48	73.3	50.4	1.83	0.08	0.07	41.8	119.8	2.08
Pt 142	2.13	5.19	67.3	41.7	1.87	1.73	3.65	46.4	43.6	1.63
Utamua	1.06	3.17	102.7	23.1	1.80	0.49	0.99	69.7	25.2	1.65
F.prob	*<.001*	*<.001*	*<.001*	*<.001*	*<.001*	*0.033*	*<.001*	*<.001*	*<.001*	*<.001*
LSD	*0.54*	*3.28*	*10.6*	*16.9*	*0.19*	*1.012*	*1.285*	*7.283*	*25.92*	*0.34*
CV (<0.05)	*19.8*	*40.1*	*8.1*	*29.6*	*5.9*	*100.7*	*61.6*	*8.60*	*39.5*	*10.9*

Table 63. Yield and yield components, Betano and Loes, dry season 2013

Code	Betano 2013 (Dry season)					Loes udan 2013 (Dry season)				
	Yield (t/ha)	Plant/m^2	100 pod weight (g)	Pods/plant	Seeds/pod	Yield (t/ha)	Plant/m^2	100 pod weight (g)	Pods/plant	Seeds/pod
Pt 014	0.53	4.92	48.0	11.0	2.10	0.22	3.37	38.7	4.83	1.53
Pt 020	0.85	5.57	59.9	14.1	1.68	0.40	4.52	57.3	5.68	1.54
Pt 021	1.41	7.32	63.5	16.5	1.90	0.32	3.09	68.3	5.43	1.61
Pt 022	1.61	8.01	56.3	17.9	1.79	0.25	4.05	66.7	3.88	1.72
Pt 124	0.74	6.40	42.1	14.8	2.40	0.56	4.43	67.7	7.11	1.82
Pt 131	0.31	2.35	41.3	16.0	2.47	0.24	2.48	65.7	5.78	1.64
Pt 132	0.22	2.08	51.6	15.4	2.02	0.38	4.07	76.0	5.80	1.74
Pt 133	0.25	3.24	56.9	6.2	1.76	0.26	3.83	74.7	3.79	1.83
Pt 134	0.51	5.03	55.5	10.7	1.81	0.18	4.09	50.0	2.80	1.62
Pt 136	0.97	4.49	67.4	19.3	1.55	0.19	2.89	50.3	4.78	1.61
Pt 137	0.45	3.88	48.9	13.5	2.09	0.13	2.68	39.3	3.05	1.47
Pt 138	0.44	4.17	53.0	8.3	1.90	0.31	4.27	46.0	4.36	1.50
Pt 141	0.48	5.19	42.3	12.9	2.39	0.47	3.49	59.3	7.69	1.75
Pt 142	0.92	4.65	42.5	14.9	2.35	0.13	2.81	50.7	3.44	1.48
Utamua	0.90	3.63	90.5	22.2	1.11	0.23	2.83	63.3	3.05	1.20
F.prob	<.001	<.001	<.001	0.327	0.002	0.009	0.37	0.57	0.24	0.68
LSD	0.33	1.31	26.81	ns	0.56	0.21	ns	ns	ns	ns
CV (<0.05)	28.2	16.6	15.3	45.6	17.1	45.0	31.9	37.6	46.4	19.9

Grain yields across locations, 2012-2013.

Peanut grain yields across six locations (4 wet season and 2 dry season) are summarized in Table 64. The highest yielding entry mean was the local PT 022 at 1.0 t/ha followed by PT 142 (0.96 t/ha). On average, all varieties underperformed this local variety and all but PT 142 performed worse than the other local (PT 021. At Betano, the local PT022 outperformed all other varieties both in the wet and dry season cultivations

Table 64. Peanut yields across locations 2012-2013

Code	*Aileu 2012-3 (Rainy)*	*Baucau 2012-3 (Rainy)*	*Betano 2012-3 (Rainy)*	*Loes 2012-3 (Rainy)*	*Betano 2013 (Dry)*	*Loes 2013 (Dry)*	*Mean all sites*
PT 022	0.79	0.42	2.41	0.56	1.61	0.25	1.01
PT 142	0.24	0.62	2.12	1.73	0.92	0.13	0.96
PT 021	0.96	0.54	2.21	0.12	1.41	0.32	0.93
PT 133	0.85	0.45	2.22	0.87	0.25	0.26	0.82
PT 014	0.14	0.37	2.02	0.63	0.53	0.22	0.65
PT 132	0.45	0.46	2.15	0.35	0.22	0.38	0.67
PT 124	0.73	0.24	1.90	0.03	0.74	0.56	0.70
PT 134	0.72	0.42	1.51	0.94	0.51	0.18	0.71
PT 136	0.96	0.84	0.77	1.47	0.97	0.19	0.87
Utamua	0.63	0.53	1.06	0.49	0.90	0.23	0.64
PT 137	0.80	0.77	1.43	0.00	0.45	0.13	0.60
PT 131	0.90	0.22	1.52	0.24	0.31	0.24	0.57
PT 020	0.34	0.41	1.09	0.14	0.85	0.40	0.54
PT 138	1.06	0.32	1.22	0.41	0.44	0.31	0.63
PT 141	0.88	0.41	0.77	0.08	0.48	0.47	0.52
Mean site	0.70	0.47	1.63	0.58	0.71	0.28	0.87
Mean locals	0.875	0.48	2.31	0.34	1.51	0.285	1.21

Farmer's consumption preferences

A field day held at Betano Research Centre at the end of the 2012-2013 wet season evaluated consumer preferences for peanut types. Thirty two persons participated in the testing and they were asked after their preferences for seed size, the grain oiliness, whether they thought it was nice tasting or bland and whether the shell type met their preferences. The group results were divided by gender to evaluate their preferences.

Most farmers preferred the local variety (84%) (Table 65). Males and females preferred different types. Men preferred the two local varieties (PT 021 and PT022) while the females preferred the local (PT021) and Utamua.

Table 65. Farmer preferences for peanuts varieties, Betano, 2012-13

Code	*Like (%)*	*Large seed (%)*	*Oily (%)*	*Bland (%)*	*Soft shell (%)*	*Male preference (%)*	*Female preference (%)*
PT 022	84	25	78	28	91	69	17
PT 021	81	53	78	25	75	69	83
PT 014	59	25	66	56	41	15	0
PT 020	31	31	53	38	38	8	0
PT 124	47	22	38	41	69	0	17
PT 131	53	25	50	38	47	4	17
PT 132	47	25	31	25	50	4	0
PT 133	53	59	53	38	59	12	0
PT 134	41	50	38	31	72	4	0
PT 136	34	50	41	56	41	0	0
PT 137	41	34	50	44	56	0	0
PT 138	56	38	44	38	56	8	0
PT 141	53	44	69	34	63	0	0
PT 142	62	47	53	31	63	0	0
Utamua	59	78	38	41	63	8	67
F.Prob	<.001	<.001	<.001	0.26	<.001	<.001	<.001
LSD	0.42	0.41	0.42	0.42	0.41	0.22	0.22
CV (<0.5%)	90.3	116.4	94.2	129.5	81.0	194.3	194.3

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

Ten successful peanut trials were implemented over the period from 2011 to 2013 at 4 different sites (Aileu, Baucau, Betano, and Loes, testing the performances of 15 varieties.

Cross-site analyses were conducted using ANOVA in order to evaluate the performance and consistency of the tested varieties across years and locations (genotype / environment).

Results

Mean site yield performances were similar from 0.17 t/ha to a maximum of 1.79 t/ha (Baucau 2011 and Loes 2011) with only three sites yielding over 1 t/ha (Table 5).

From the average yield there was no different between varieties, but the average yield was highest from varieties PT 142 and PT 133 (1.00-1.23 t/ha). The remaining varieties were below a mean of the two locals. By site, the average yield was greatest at Loes Research Center in 2011-2012 and at Betano in 2013 compared to other locations. Utamua maintained an average yield in each year on each site. In 2013 PT 022 obtained greater yield in most of the locations. In previous years the local PT 022 underperformed at most locations. The good result in 2013 may be due to a better source of seed.

Table 66. Variety yields across research stations between 2011 and 2013

CODE	*Aileu 2011 (Rainy)*	*Baucau 2011 (Rainy)*	*Betano 2011 (Rainy)*	*Loes 2011 (Rainy)*	*Betano 2012 (Rainy)*	*Loes 2012 (Rainy)*	*Aileu 2013 (Rainy)*	*Baucau 2013 (Rainy)*	*Betano 2013 (Rainy)*	*Loes 2013 (Rainy)*	*Betano 2013 (Dry season)*	*Loes 2013 (Dry season)*	*Mean site*	*Yield advantage*
PT 142	0.49	0.42	0.34	2.97	0.39	2.50	2.13	0.62	2.13	1.73	0.92	0.13	1.23	24
PT 133	0.28	0.11	0.87	1.48	1.19	1.80	2.22	0.45	2.22	0.87	0.25	0.26	1.00	1
PT 021	0.17		0.45	0.72	0.32	2.10	2.21	0.54	2.21	0.12	1.41	0.32	0.96	-3
PT 014	0.38	0.23	1.23	0.95	1.16	1.70	2.02	0.37	2.02	0.63	0.53	0.22	0.95	-3
PT 136	0.28		1.04	0.70	0.98	2.30	0.77	0.84	0.77	1.47	0.97	0.19	0.94	-5
Utamua	0.68	0.33	1.17	2.31	0.33	2.00	1.06	0.53	1.06	0.49	0.90	0.23	0.92	-6
PT 131	0.51	0.16	0.86	2.09	1.20	2.10	1.52	0.22	1.52	0.24	0.31	0.24	0.91	-8
PT 132	0.76	0.10	0.72	1.30	0.61	1.60	2.15	0.46	2.15	0.35	0.22	0.38	0.90	-9
PT 138	0.94	0.34	0.49	1.77	0.91	2.20	1.22	0.32	1.22	0.41	0.44	0.31	0.88	-11
PT 137	0.79	0.11	1.04	0.77	0.88	2.60	1.43	0.77	1.43	0.00	0.45	0.13	0.87	-12
PT 022	0.01	0.09	0.69	0.48	0.41	0.80	2.41	0.42	2.41	0.56	1.61	0.25	0.85	-14
PT 124	0.45	0.13	0.72	1.45	0.29	1.00	1.87	0.24	1.87	0.03	0.74	0.56	0.78	-21
PT 134	0.39	0.07	0.78	1.30	0.54	0.90	1.51	0.42	1.51	0.94	0.51	0.18	0.75	-24
PT 141	0.44	0.07	0.56	1.78	1.29	1.90	0.77	0.41	0.77	0.08	0.48	0.47	0.75	-24
PT 020	0.39	0.08	1.35	0.65	1.10	1.30	1.09	0.41	1.09	0.14	0.85	0.40	0.74	-25
Mean site	0.46	0.17	0.82	1.38	0.77	1.79	1.63	0.47	1.63	0.54	0.71	0.28	0.89	
Mean local	0.28	0.23	0.84	0.84	0.74	1.90	2.12	0.45	2.12	0.37	0.97	0.27	0.99	

The highest yield across sites were from the wet season trials at Loes Research Center (1.38 t/ha) in 2011 and 2012 (1.79 t/ha) and wet season trials at Betano in 2013 (1.63 t/ha) and Aileu (1.63 t/ha). The lowest yields at any site were in Baucau research center during 2011 (0.47 t/ha). Dry season trials were conducted at only two sites (Betano and Loes). Among these two location, Betano showed average yield of 0.71 t/ha and Loes research center, 0.28t/ha

The same fifteen entries were used in each of the ten trials. 50% of variability within this data was accounted for in the BiPlot. A BiPlot visualizing how varieties performed by environment (year/season and location) is represented in Figure 20. Data on this Biplot is partitioned by quadrant. The Biplot showed that higher yield sites were in Loes and Betano compared to other locations. There is no variety showed higher yield than other varieties in Loes 2011-12 and Betano 2013; however, PT 142 and PT 021 showed clear advantage in many years when compared to other varieties in Betano 2013. Utamua, PT 142, PT 137, PT 138 also performed well.

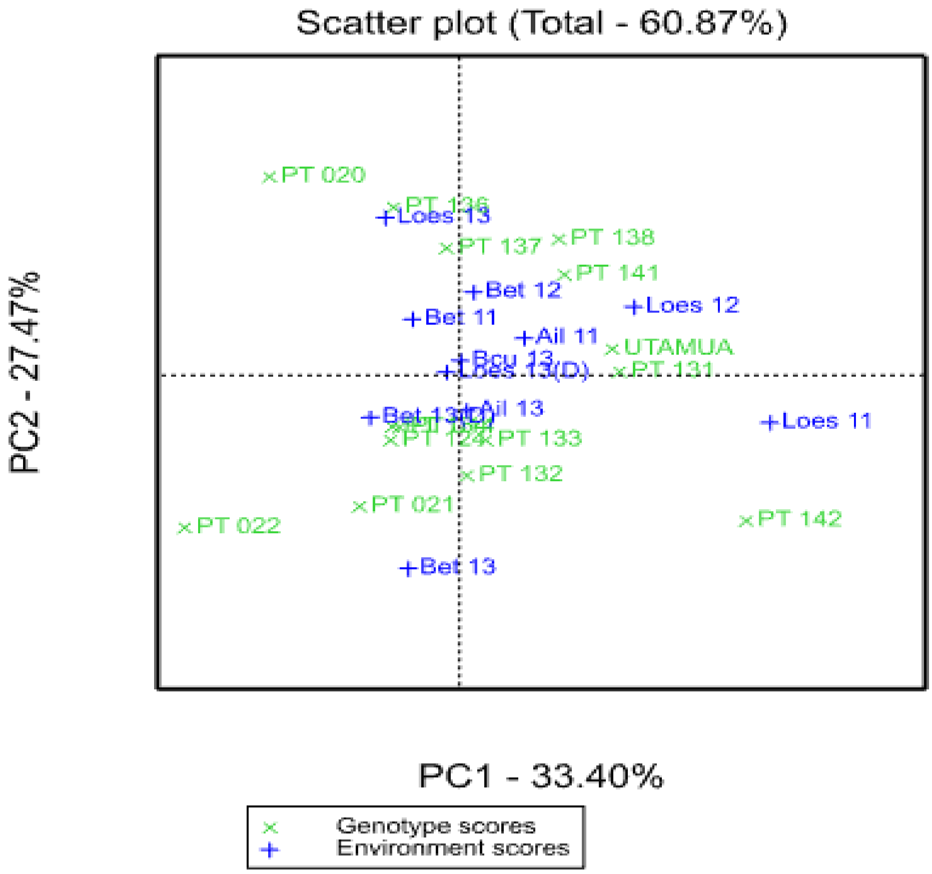


Figure 20. Biplot analysis (15 peanut varieties in 9 environments, 2011 - 2013)

Base on the multi-year and multi-location data analysis and farmer's preferences at the farmer's field day it can recommended that peanut varieties PT 142, PT 021, and PT 022 can advance to being evaluated on farmers fields' under the OFDT program.

2. Winged beans

2.6.1 Winged bean replicated trial, Loes 2012-2013

Winged beans (*Psophocarpus tetragonolobus* (L.) DC) are currently grown on a few farms in the Eastern Districts of Timor-Leste. However, they are extensively cultivated in other parts of Southeast Asia, the South Pacific and Africa as a source of nutritious food. This legume is known for its high protein content. All parts of the plant are edible including the young pods, leaves, young stems and tubers. In some countries, dry seeds are also pounded and eaten. There is considerable potential to improve food security and soil fertility in all parts of Timor-Leste if suitable high yielding varieties are made available to farmers. In the East of the country, winged beans are known as Duhaen, Wewe, Lari Lari or Duae.

Twelve improved winged bean varieties sourced from the Australian Tropical Crop and Forages Collection (ATCFC) were sown into observational plots in the Districts of Aileu, (sub-District of Aileu), Liquiça (Loes research station), Ainaro (Maubisse Sub District) and Dili (Comoro) during the wet season of 2010-2011. The seed originating from Indonesia, Nigeria, Papua New Guinea, and Thailand were assigned names of D = Duhaen (Tetun for winged bean) and Indo for Indonesia, N = Nigeria, PNG (Papua New Guinea) and T (Thailand). These varieties were compared with two local varieties – one from Luro in Los Palos District and the other from Laga in Baucau. The results of this observation trial were reported in the SoL Annual Research Report for 2011.

Six improved varieties were compared with two local varieties (D Luro and D Venilale) at Loes Research Station during the wet season of 2011-2012. All plants were grown on stakes. Of the six, one was from Indonesia (D Indo), one from Nigeria (D N6), three from PNG (DPNG10, 13, 31) and one from Thailand (D T4). Unfortunately, the site suffered flooding during the wet season, resulting in poor plant populations and poor yields. However, it was possible to harvest sufficient pods to compare pod and seed size as presented in SoL, 2012.

Replicated trials were repeated during the wet season of 2012-2013 at Betano and Loes research stations (Table 67).

Table 67. Winged bean trial planting and harvest dates, 2012-2013

Location	*Number of plants*	*Planting date*	*Harvest date*	*Mean yield (t/ha)*
Loes	8	21/12/2012	02/07/2013 - 07/10/2013	2.01
Betano	8	21/12/2012	25/07/2013	1.16

Results

Mean winged bean grain yields at Loes were just over 2 t/ha with all but one test variety out-yielding the locals (Table 68). The highest yielding variety was DT4 (2.58 t/ha), and the lowest a local variety selected from the sub-district of Venilale (0.72 t/ha). Plant populations were about one plant per square metre and there were between 11 and 15 seeds per pod.

Table 68. Wing bean yield and yield components, Loes, 2012-2013

Variety	*Grain yield (t/ha)*	*Plant pop'n/m²*	*Seed weight/ plot (kg)*	*Pod weight/plot (kg)*	*Seeds/pod*
D T4	2.58	0.6	6.46	15.6	14.3
D PNG13	2.38	0.6	5.94	15.0	11.3
D Indo	2.32	0.7	5.79	14.9	15.0
D N6	2.22	0.5	5.54	12.7	13.7
D PNG31	2.13	0.7	5.31	12.8	12.3
D PNG10	1.81	0.5	4.52	10.1	13.3
D Luro	1.93	0.8	4.83	11.1	13.0
D Venilale	0.72	0.7	1.80	3.8	12.7
Mean	2.01	0.64	5.02	11.98	13.21
F pr.	*0.004*	*0.2*	*0.00*	*0.0*	*0.8*
LSD	*0.77*	*0.2*	*1.92*	*6.8*	*5.0*
CV%	*21.8*	*17.8*	*21.8*	*32.4*	*21.6*

The same varieties planted at Loes were also planted at Betano Research Station however, grain yields were significantly lower (Table 69). The highest yielding variety at Betano was DN Indo (1.62 t/ha) and lowest yield was obtained by the local from Venilale (0.76 t/ha). Note that the plant populations were half those of Loes and the pod sizes (seeds per pod) were also slightly reduced compared with Loes. Seed size varied between 17.3g and 36.7g per 100 seeds.

Table 69. Wing bean yield and yield components Betano, 2012-2013

Variety	*Grain yield (t/ha)*	*Plant pop'n (/m²)*	*100 seed weight (g)*	*Seeds/pod*	*Pod length (cm)*
Local Luro	1.17	0.5	17.3	12	13.1
Local Venilale	0.76	0.7	36.7	12	14.9
DN Indo	1.62	0.4	30.7	12	14.7
DN PNG 31	1.42	0.4	29.3	12	16.6
DN PNG 10	0.82	0.6	28.7	12	12.6
DN PNG 13	1.15	0.5	27.0	12	15.6
DN TAI 4	1.21	0.4	27.7	12	15.1
DN N 6	1.11	0.4	24.3	12	16.7
Mean	*1.16*	*0.5*	*27.7*	*12*	*14.9*
F pr.	*0.065*	*<.001*	*0.661*	*0.103*	*0.049*
LSD	*0.1845*	*3.932*	*ns*	*ns*	*0.519*
cv%	*21.6*	*8.1*	*3.50*	*11.7*	*25.60*

Taste test

Forty two farmers (11 females and 31 males) visited Loes Research Station to personally evaluate the winged bean varieties during 2013. They were given the opportunity to observe the performance of each variety, the yields in 2013 and taste test the cooked product. Based on this evaluation (Table 70), the participants found that each variety had specific characteristics they liked. The local variety sourced from Venilale was the least preferred.

Table 70. Palatability approval rate (%) of cooked young winged bean pods, 2013

Variety	*Bitter*	*Sweet*	*Fragrant*	*Like*	*Not like*	*Choose*
D Indo	12	50	29	31	19	30
D Luro	19	60	26	43	14	32
D N6	12	52	36	38	21	31
D PNG10	29	45	14	36	26	31
D PNG13	10	55	26	29	21	26
D PNG31	10	60	17	33	24	27
D T4	5	62	31	29	19	26
D Venilale	14	31	14	17	33	25
LSD ($p<0.005$)	*0.1*	*0.2*	*0.2*	*0.2*	*0.2*	

Comparison across years and sites

Yield advantages of the eight test varieties at Loes for 2011 and 2013 and at Betano for 2013 were compared (Table 71). None of the test varieties performed consistently across sites and years but the three best (DN N6, DN Indo and DN PNG31) will be evaluated across extra sites in 2014. DN N6 has large, black coloured seed as has DN PNG 31 while DN Indo is large seeded and white coloured.

Table 71. Yield advantages (%) over local varieties at two sites and two years.

Variety	*Loes 2011*	*Loes 2013*	*Betano 2013*	*Mean*
DN Indo	162	95	33	96
DN PNG 31	319	79	17	138
DN PNG 10	12	74	-33	18
DN PNG 13	208	67	-6	90
DN TAI 4	-15	60	-1	15
DN N6	319	36	-9	115
Lokál Luro	81	46	-4	41
L. Venilale	-81	-46	-38	-55
Mean all site	*125*	*51*	*-5*	*57*

Winged bean local names and uses across Districts in Timor-Leste

Different winged bean varieties have been grown in Timor-Leste for a number of years and are known by different names at each site. For example, in Soibada Sub-District, Manatuto, winged beans are called Duhaen. Here, the crop is often intercropped with maize (Table 72). Local farmers cook the plant leaves or buds as a vegetable or boil them with maize, especially during the hungry season. Fresh pods can be cooked with maize or separately as a vegetable. None of the questioned farmers in this Sub District have ever dug the tubers for consumption. They do, however, recognize the legume attributes of winged bean because they notice that cereals grow vigorously when grown with or after the crop. Two types are grown - long pod (12 seeds/pod) and short pod varieties (6 seeds/pod); both white seeded. Seed is stored in a bucket or sack between seasons. Leaves of the plant cure abscesses by using them as a compress.

In Laga Sub-District, Baucau district winged beans are known as Lari-lari. In this Sub District, leaves or buds are cooked as vegetables, and pods can be boiled with maize or cooked as vegetables. Flowers are also cooked as vegetables and leaves fed to animals. As in Manatutu, winged beans are intercropped with maize. In Venilale the local name is Wewe. The bean is also cooked as a vegetable and boiled with maize and also to produce medicine for worms and other internal illnesses. The cultivation of winged bean in both Venilale and Laga has waned in recent years.

Table 72. Winged bean local names in Timor-Leste and other countries

Country	*District*	*Sub-district*	*Language*	*Local name*
Timor Leste	Lautem	Ili-Omara	Makalero	Fófan-Larin
Timor Leste	Lautem	Tutuala	Fataluku	Fófónu
Timor Leste	Lautem	Luro	Makasae	Lari-Lari/fófalari
Timor Leste	Baucau	Venilale	Kairui	Wewe
Timor Leste	Baucau	Laga	Makasae	Lari
Timor Leste	Viqueque	Watulari	Makasae	Wewe
Timor Leste	Viqueque	Osso	Makasae	Wewe
Timor Leste	Manatuto	Soibada	Tetun terik	Duhaen
Timor Leste	Manatuto	Natarbora	Tetun terik	Duhaen
Timor Leste	Bobonaro	Maliana	Bunak	Lumekase
Timor Leste	Bobonaro	Maliana	Kemak	Lumekase
Timor Leste	Covalima	Fatululik	Bunak	Upukoli
Timor Leste	Covalima	Fóhorem	Tetun Terik	Uas Coli
Timor Leste	Covalima	Fatumea	Tetun Terik	Uas Coli
Timor Leste	Covalima	Tilomar	Tetun terik	Uas Coli
Timor Leste	Covalima	Jumalai	Bunak	Upikoli
Indonesia	-	-	Indonesia	Kecipir
Papua New Guinea	-	-	English	Winged bean
Nigeria	-	-	English	Winged bean
Thailand	-	-	English	Winged bean

There are two types of winged bean in Watulari Sub-District, District of Viqueque – a small seeded variety is considered as being a local and a large seeded variety is thought to have originated from Indonesia during transmigration. One farmer from Viqueque stated that buds of both varieties are cooked as vegetables, leaves mixed and cooked with rice (tetum: sedok) and fresh pods boiled with maize. The leaves are also used to produce medicine, and feed to goats and buffaloes.

In the District of Lautem, the leaves and fresh pods are cooked as vegetables and with rice as in other districts. Dried winged bean (locally known as lari-lari) seeds in the Sub-District of Luro are pounded and cooked with rice (sedok) and also boiled with maize. The leaves are cooked with rice (sedok) and fed to animals (goats and buffaloes). Tubers are baked and boiled. Lari Lari has, for the past few years been left to grow in the wild but during the 1980s and 1990s was cultivated.

In Tutuala Sub-District, farmers call winged bean Fófónu. They only consume the fresh pods. They don't consume the leaves, buds or tubers as in other places because they didn't know how to cook them. Winged bean seeds in Tutuala were in short supply in 2013.

The local Makalero language name for winged bean in Ili-Omara is Fófan-Larin. In this sub district, buds are cooked as vegetables and leaves with rice (sedok). Fresh pods are boiled with maize, and seeds boiled with maize or with rice during food shortages. Tubers are baked and boiled. Farmers in Ili-Omara consider winged bean to be a multi-functional crop and will continue to grow it, particularly if crop yields can be increased.

Winged bean has not been grown in Covalima district for many years. It was known as Upukoli in the Sub District of Fatululik and farmers ate the fresh pods cooked with maize and as a vegetable. Some farmers from Tilomar sub-district commented that Upukoli can be used to cure the illness called Upugo (swelling in the throat). The treatment process is for the leaves to be crushed and placed in the throat.

The local name for winged beans in Bobonaro is Lumekase.

2.7 Mungbean and black gram

2.7.1 Replicated trials 2012-2013

Mung beans (*Vigna radiata* L.) have a high protein content (23%) and possess significant levels of other nutrients. They are particularly high in vitamins C, B1 and B2. These attributes make mung bean an ideal supplement to the high starch based maize and rice diet of Timorese. Its ability as a legume to fix atmospheric nitrogen is also valuable in an environment where chemical fertilizers are not available to small-scale subsistence farmers.

Mung bean is already a highly prized short duration crop in the Indian sub-continent where it can be grown between rice and wheat crops or as a relay crop. It can be planted separately after rice in the low lands and can be intercropped with maize in the upland areas. Mung bean should fit into the low-input agricultural system of Timor Leste. However, mung beans prefer fertile soils with pH close to neutral and do not tolerate high levels of soil aluminum. The plant is more suited to clay soils which can be found in upland areas of Timor especially between sea level to approximately 700 masl.

Mung beans can be dried after harvest or just left on the plant until dry. Grain yields average between 0.8-1.2 t/ha but can be much higher. Stored grain may suffer from weevil damage after 3-4 months if this pest is not controlled. Usually mungbean seed is eaten after boiling or can be used to make cakes.

In 1997 national mumg bean production was more than 4000 tons but this had reduced to approximately 1,300 tons in 2006 (MAF, 2008). Seventy five percent of this production was from the districts of Covalima, Viqueque and Bobonaro (Estimation from National Directorate of Horticulture/MAF). However the country could produce substantially higher amounts for both consumption in Timor-Leste and export. There is a possibility to export mung bean to west Timor and other parts of Indonesia which is a major importer of this commodity. Generally, seed uniformity will affect export sales. The trials presented below describes an evaluation of imported test material in an effort to identify good quality high yielding varieties suitable for cultivation in Timor-Leste.

Methods and materials

Twelve mung bean varieties were evaluated from 2010 through to 2013 in two research centres (Loes and Betano). Three varieties were sourced from Indonesia (ILETRI), four were considered to be locals having been cultivated in Timor-Leste for a number of years (one was a black gram variety) and five were sourced from the Queensland Department of Primary Industries in Australia.

The trials were designed as a randomised complete block with three replicates. Plot sizes were 5.5 m x 2.5 m with 25 between rows and 15 cm between plants. Mung beans usually take up to 40 days before flowering and another 30 days on average before producing seeds. Details of the trial design are presented in Table 73.

Table 73. Planting and harvest details of mung bean varietal trials, 2012-2013

Location	*Number of entries*	*Number of replicates*	*Planting date*	*Harvest date*	*Mean yield yield (t/ha)*	*In-season rain (mm)*
Loes 2012	12	3	19/06/2012	10/09/2012	2.32	Not available
Betano 2013	12	3	7/05/2013	25/08/2013	1.5	341

A number of parameters were recorded during plant growth, starting with emergence and ended with harvest. Grain yield was collected from the whole plot, and the numbers of plants in each plot at harvest were used to calculate plant density. Plant height was measured on 10 random plants, and the pods from these were used to measure pod length and seeds per pod.

After all the data being collected then entered into Excel for analysis using Genstat Discovery.

Table 74. Mung bean population details, Betano and Loes, 2012 and 2013

Name	*Origin*	*Seed size**	*Seed colour*	*Seed type*	*Other charateristics**
Celera	Australia**	Small	Green	Bright	Good resistance to cracking and weather damage. Prone to lodging
Delta	Australia	Large	Green	Bright	Low resistance to powdery mildew. Prone to shattering
Diamond	Australia	Small	Green	Dull	Tolerant to brown spot. Tolerant to dry conditions
Metan	Timor Leste	Med-lar	Green	Dull	Good resistance to shattering and tolerant to rainy season.
Satin	Australia	Small	Green	Dull	Good resistance to shattering and tolerant to dry conditions
Sirity	Indonesia	Small	Green	Bright	Resistance to dry condition, prone to brown spot.
Murai	Indonesia	Large	Green	Dull	Resistance to brown spot and tolerant to dry conditions
Merpati	Indonesia	Large	Green	Bright	Resistance to brown spot
Besikama	Timor	Large	Green	Dull	Resistance to shattering and low yields in heavy rain, Low resistance to powdery mildew
Berken	Australia	Med-lar	Green	Bright	Prone to powdery mildew and brown spot
Balibo	Timor Leste	Small	Green	Dull	Low resistance to powdery mildew.
Suai	Timor ***	Small	Green	Dull	Low resistance to heavy rain fall, good resistance to dry conditions.

* small: <4 g/100 seeds; sufficient:5 g/100 seeds; large:>6 g/100 seeds
** source: *Queensland Primary Industries and Fisheries* - www.dpi.qld.gov.au
**** source from Vietnamese Jesuit priest in Suai (Probably an introduction from Vietnam).*

Results

Grain yields in the mung bean trial at Loes in 2012 were generally quite high compared with 2010 and 2011. There was a significant difference between entry yields. The three highest yielding varieties were Local Balibo, Local Besikama and Diamond (Table 75). The poorest yielders in this trial were Sarity and a local variety from Suai. Some of this difference may have been due to the different plant densities found in the plots. Plant height, and pod size were also significantly different among entries.

Table 75. Yield (t/ha) and yield components, mungbean, Loes, 2012

Variety	*Yield (t/ha)*	*Plant density (/m^2)*	*Plant height (cm)*	*Pod length (cm)*	*Seeds per pod*
Local Balibo	2.7	10.0	53.8	8.6	14.4
Local Besikama	2.6	10.0	60.9	12.0	12.4
Diamond	2.6	10.8	71.0	10.2	12.0
Satin	2.5	7.4	50.6	7.8	13.1
Berken	2.5	11.4	50.2	6.8	11.7
Delta	2.5	10.2	46.2	9.4	10.7
Selera	2.4	11.1	72.7	12.1	11.4
Local black	2.3	7.5	62.9	9.6	12.0
Merpati	2.1	8.0	50.2	9.6	11.6
Murai	1.9	8.1	51.1	9.1	11.6
Sarity	1.9	7.1	48.2	8.8	9.7
Local Suai	1.8	6.6	58.8	10.7	10.4
F.pro	0.01	0.03	0.054	<.001	0.002
LSD	0.52	3.16	17.43	0.98	1.79
%CV	13.30	20.70	18.3	6.00	9.00

A field day held at Loes Research Centre requested farmers to evaluate physical and eating qualities of the varieties. Seed grain was viewed for its appearance as some consumers preferred dull grain while others preferred bright seed. Yield was taken into consideration. Colour was also a character. The beans were then cooked and tasted. A few varieties were chosen by each farmer and ratings added. Percentage ratings exceeded 100% overall. Most of the farmers would have chosen the variety Diamond based on yield, its appearance and taste. The farmers preferred cooked seed that can be considered to be oily but still tasty.

Table 76. Farmer appreciation (%) of mung bean, Loes, 2012

Variety	*Choose*	*Oily*	*Tasty*
Balibo	40	60	70
Besikama	60	70	50
Diamond	70	60	70
Satin	40	70	60
Berken	40	70	50
Delta	50	50	30
Selera	30	60	60
Local black	30	20	40
Merpati	50	50	70
Murai	40	20	70
Sarita	40	50	60
Suai	30	40	50
F.pro	20	0.0	20
LSD	ns	0.28	ns
%CV	115.0	94.5	85.2

The twelve varieties evaluated in Loes during 2012 were again evaluated at Betano in 2013. At this site, there was good plant establishment and plant densities were similar (Table 77). However, there was heavy rain at flowering which may have affected yield. Grain yields were significantly different from each other with Merpati yielding slightly above Satin. Balibo and Sarity did not yield well in this trial.

All imported varieties (both from Australia and Indonesia) matured a week earlier than local varieties.

Table 77. Yield (t/ha) and yield components, Betano, 2013

Variety	*Yield (t/ha)*	*Plant height (cm)*	*Pod length (cm)*	*100 seed weight (g)*	*Seeds per pod*	*Plant density (/m²)*
Merpati	2.4	47.3	9.2	64.3	9.3	25.3
Satin	2.2	46.0	8.9	41.7	10.1	24.5
Delta	1.7	51.8	9.5	59.7	9.7	22.7
Berken	1.6	41.5	8.5	53.0	10.2	24.9
Murai	1.6	40.1	9.8	59.0	10.7	23.4
F.Metan	1.6	53.3	9.8	57.3	11.4	24.2
Suai	1.4	49.5	10.1	68.3	10.3	23.8
Celera	1.3	65.9	10.0	68.0	10.0	20.9
Diamond	1.3	54.4	9.6	61.0	10.7	23.8
Besikama	1.1	68.7	10.5	50.3	10.5	22.9
Sarity	1.1	54.4	9.2	48.7	10.1	24.0
Balibo	1.0	48.5	7.7	63.3	10.7	24.3
F pr.	0.003	0.05	0.14	0.27	0.86	0.57
LSD.	0.63	16.9	ns	ns	ns	ns
%CV	24.5	19.2	11.1	21	12.3	9.1

Grain yields were correlated with plant density (Figure 21).

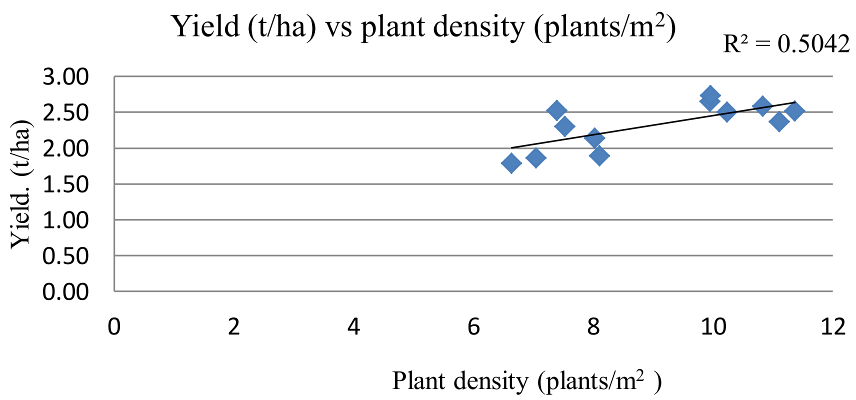


Figure 21. Impact of plant density on yield (t/ha)

Mung bean multi-year and mulit-location analysis

Mung bean variety trials were conducted at Betano Research Centre, Manufahi District from 2008 through to 2013. Trials with the same 12 varieties were also conducted at Loes Research Centre in 2010 and 2012. The mean yields of varieties included in these trials are presented in Table 78. Merpati, Satin, Delta and Berken performed well across years.

Multi-location analysis showed there was difference in yield (t/ha) between Betano and Loes research centres (Figure 22). The Balibo and Besikama varieties were high yielding in Loes and low in Betano. Merpati and Delta appeared to be less variable than other varieties.

Two large-seeded, bright-seeded varieties were chosen to be carried forward to on-farm testing. These are Merpati and Delta.

Table 78   Yield (t/ha) of 12 mung bean varieties, Betano and Loes, 2008-13

Variety	*Betano 2013*	*Betano 2012*	*Betano 2011*	*Betano 2010*	*Betano 2009*	*Betano 2008*	*Loes 2012*	*Loes 2010*	*Mean yield*
Merpati	2.44	1.40	2.26	1.15	0.87	1.38	2.58	1.14	1.65
Satin	2.16	1.20	1.91	0.68	1.04		2.53	1.03	1.51
Delta	1.57	1.70	1.36	0.81	1.09		2.74	1.15	1.49
Berken	1.74	1.30	2.10	0.55	0.84		2.50	1.13	1.45
Murai	1.57	1.12	1.69	0.59	0.97	1.55	2.14	1.13	1.34
F.Metan	1.45	0.91	1.25	0.70	0.79	1.39	1.89	1.21	1.20
Suai	1.06	1.12	1.86	0.55	0.44	1.00	2.52	1.02	1.19
Celera	1.01	1.34	1.76	0.53	0.91		1.79	0.79	1.16
Diamond	1.62	1.05	0.48	0.83	0.99		2.30	0.83	1.16
Besikama	1.11	1.12	0.81	0.48	0.54	1.01	2.65	1.46	1.15
Sirity	1.28	0.85	0.78	0.64	0.95	1.73	1.86	0.90	1.12
Balibo	1.32	1.19	0.68	0.58	0.49	0.82	2.37	1.26	1.09
F pr.	0.003	0.002	<.001	0.005	<.001	<.001	0.01	ns	
LSD	0.63	0.33	0.47	0.28	0.21	0.41	0.52	0.45	
%CV	24.5	16.3	19.8	24.7	15.2	23	13.3	24.7	
Mean local	1.24	1.08	1.15	0.58	0.56	1.05	2.36	1.24	
Overall local	1.16								

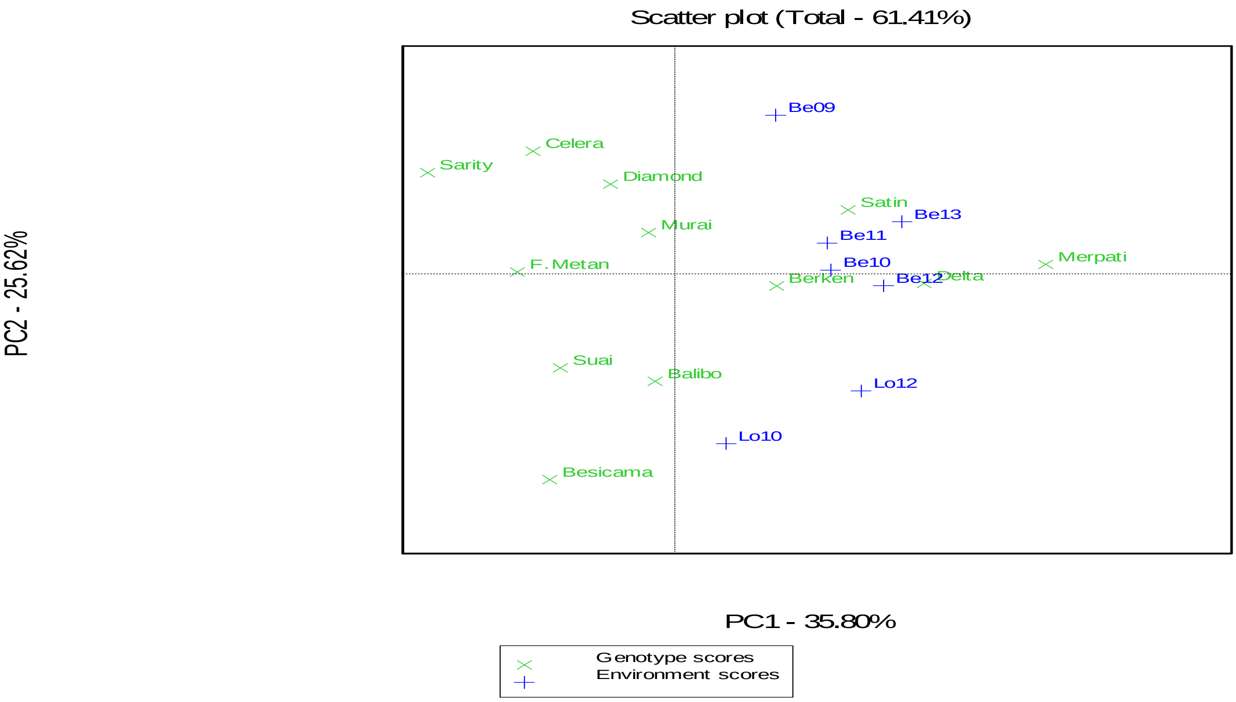


Figure 22.   Scatter plot for location and mungbean variety on yield.

2.8 Climbing beans

2.8.1 Climbing bean replicated trials, 2012-2013

Red beans (*Phaseolus vulgaris* L.) are commonly grown in Timor at medium to high elevations. There are two forms of this species. The first is the bunch type, which is planted in maize fields and harvested before the maize flowers. The second type is a climbing bean that is grown over tall plants or bean poles. Red beans contribute to a significant proportion of protein in the diet of subsistence farmers with red bean soup being a classic Timorese side dish. Surplus beans are also sold in local markets and can provide a valuable source of income.

Materials and methods

A set of 16 new varieties originating from Rwanda and imported during 2009 were evaluated on stations during that year and from 2010 through to 2012. In 2013 the number of lines was reduced to 10 varieties - 8 introduced and 2 from local sources. The remaining 8 varieties are not well adapted and discarded from the experiment. Four trials were installed during the 2012-2013 wet season at elevations ranging from 800 – 1545 masl (Table 79). These were located at Urulefa (Ainaro), Aituto (Ainaro), Venelali (Baucau) and Ossu (Viqueque). At Urulefa, Aituto and Ossu a tripod frame with legs of 1.5-2.0 m was used for the vines to grow up while at Venilale a horizontal wooden trellis was erected on the research plots. Two seeds were planted per hill and there was no thinning or rogueing. The plots were not fertilized or irrigated.

Table 79. Climbing bean trial details, wet season 2012-2013

Location	*Elevation (masl)*	*Planting date*	*Days to maturity*	*Mean yield (t/ha)*
Urulefa 2013 Wet	*1350*	*11/2/2012*	*150*	*0.14*
Venilale 2013 Wet	*800*	*12/2/2013*	*117*	*0.39*
Ossu 2013 Wet	*941*	*18/03/2013*	*97*	*0.21*
Aituto 2013 Wet	*1545*	*25/10/2012*	*147*	*1.56*

The pods were harvested up to three times to account for different maturation dates. The number and weight of 100 fresh and dry pods and seeds were recorded. Other data collected included the total weight of dry seed, number of seeds per pod and the weight of 100 seeds.

Trial data were analysed using General Analysis of Variance in GenStat 16th Edition in order to determine varietal effects.

The existence and degree of correlation between yield and other yield components were then identified using Simple Linear Regressions for each location. The percentage of variability accounted for was then equivalent to an adjusted R^2.

Results

Wet season, Urulefa 2013

Dry bean seed yield was low at Urulefa compared with 2012. In 2012 the average yield was 2.5 t/ha while in 2013 it was only 0.14 t/ha (Table 80). The low yields may have been due to the trial being replanted because of poor initial emergence and this was done very late in February. The trial was also repeated on the same site as the previous year after the soil had been ploughed with a hand tractor.

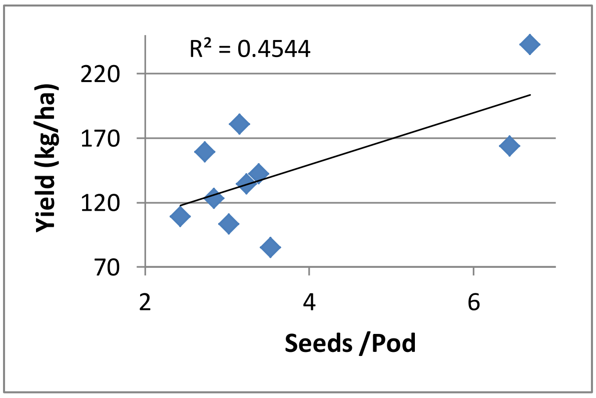
Despite the low yields, yield variation was significant. One of the introduced varieties (RWV 1348) had the highest yield, and was significantly higher yielding than the controls (Table 80). RWV 1348 is also distinctive in having more seeds per pod (7 compared with the average 4) and one of the smallest seed sizes (25g/100 compared to an average of 33g/100 seeds). Most yield components were significantly different. RWV 1348 produced pods for an extra 33 days compared to the local variety from Maubisse.

Table 80. Yield and yield components climbing bean varieties, Maubisse 2013 wet season.

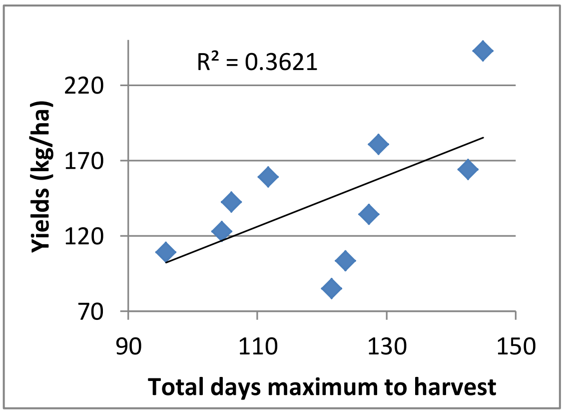
Variety	*Yield (kg/ha)*	*Plants / m^2*	*Pods/ plant*	*Seeds/ pod*	*100 seed wt (g)*	*Days to maturity*	*Yield advantage over mean of locals (%)*
RWV 1348	243	2.1	6.7	6.7	25	145	81
Mwirasi	181	3.0	4.5	3.2	39	129	35
Umubano	164	2.2	5.0	6.4	26	143	22
Local Maubisse	159	1.6	3.2	2.7	30	112	19
Gasilidia	142	1.8	1.9	3.4	27	106	6
RWV 2409	134	3.1	3.7	3.2	46	127	0
Yol X	123	2.8	2.2	2.8	30	105	-8
Lokál Urulefa	109	1.7	2.8	2.4	27	96	-19
MAC 28	103	3.2	3.3	3.0	49	124	-23
Decelaya	85	2.3	2.3	3.5	36	122	-37
Average	144	2.4	3.5	3.7	33	121	8
F Prov	*<.001*	*0.011*	*0.087*	*<.001*	*0.001*	*0.134*	
L.S.D	*82.23*	*1.04*	*ns*	*1.50*	*12.49*	*ns*	
%CV	*48.1*	*37.4*	*75.2*	*34.3*	*32.2*	*25.7*	

Variety RWV 1348 continued to provide high yields at Urulefa compared with other varieties even though the yields were low in 2013. None of the varieties showed disease symptoms as in 2009.

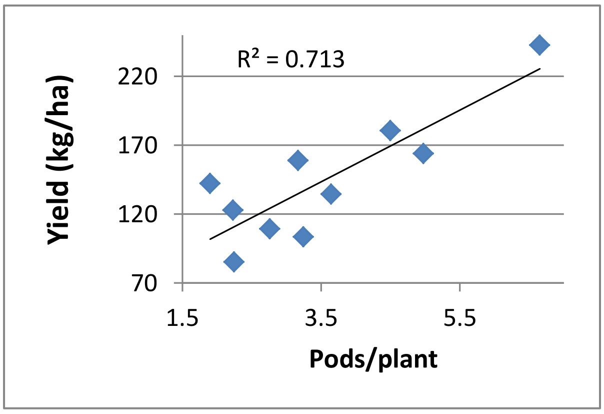
Grain yield was correlation with number of pods per plant, seeds per pod and plant maturation period (Figure 23).



Yield vs seeds/pod



Yield vs maturation age



Yield vs pods/plant

Figure 23. Correlation between yield and yield components, 2013.

Venilale 2013 wet season

Grain yields at Venelale showed significant variation and all yield components were significantly different (Table 81).

Both Mwirasi and RWV 1348 performed well at Venelali as they did in previous years. Mwirasi had double the yield of the best local. Their plants possessed nearly double the number of pods compared to RWV 1348 and the local Maubisse but the seed weight was greatly reduced. The 100 seed weight results in this location were different compared to previous years. Usually Mwirasi is categorized as a large seeded variety and RWV 1348 is considered as a variety with a small number of seeds. In 2013 in Venilale, RWV 1348 seed was largest among the varieties and Mwirasi seed was smaller. There was no clear reason for the different weight of seed between this year and previous years.

Local varieties do not generally perform well in trials conducted in Maubisse. However, when planted in Venilale, local varieties from Maubisse gave good yields. This factor and the poor soil issue will be examined during future trials.

Table 81. Yield and yield components climbing bean varieties, Venilale 2013 wet season

Variety	*Yield (kg/ha)*	*Pods/ plant*	*Seeds/ plant*	*Seed weight (g/100)*	*Days to maturity*	*Yield advantage over mean of locals (%)*
Mwirasi	904	29.6	2.1	15	105	134
RWV 1348	435	16.3	0.6	67	115	12
Local Maubisse	420	18.1	1.6	14	117	9
Yol X	386	20.4	0.9	22	117	0
Local Urulefa	354	17.1	1.0	32	109	-9
Gasilidia	343	20.3	0.7	37	121	-11
RWV 2409	319	13.9	1.4	17	105	-18
MAC 28	271	17.0	0.4	41	111	-30
Umubano	270	16.7	1.2	17	117	-30
Decelaya	228	12.1	1.2	23	115	-41
Average	393	18.2	1.1	28	113.2	2
F Prov	*<.001*	*<.001*	*<.001*	*0.034*	*0.001*	
L.S.D	*198.1*	*5.785*	*198.1*	*29.85*	*6.947*	
%CV	*29.4*	*18.6*	*29.4*	*61.2*	*3.6*	

There was a correlation between yield and number of pods per plant and seeds per pod (Figure 24).

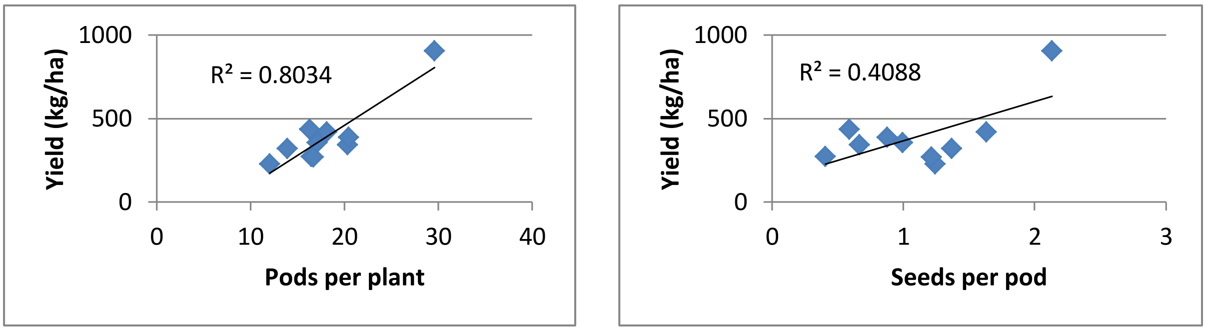


Figure 24. Correlation between yield, pods per plant and seeds per pod, 2013

Ossu 2013 wet season

Climbing bean yields in Ossu during 2013 averaged approximately 208 kg/ha (Table 82). The variability was extremely high due to poor germination and neither the yield nor yield components were significantly different. Despite the lack of statistical difference, the Mwirasi variety was double the yield of an average local yield. Umubano also performed well.

Table 82. Yield and yield components, climbing bean varieties, Ossu 2012 wet season

Variety	*Yield (kg/ha)*	*Plants/ m^2*	*Pods / plant*	*Seeds / Pod*	*100 seed weight (g)*	*Days to maturity*	*Yield advantage over mean of locals (%)*
Mwirasi	572	3.5	9.4	4.8	35.3	97	111
Umubano	408	0.8	11.8	3.9	50.7	65	51
Local Maubisse	301	1.3	11.4	3.3	16.8	65	11
Local Urulefa	241	1.8	10.0	1.9	35.3	97	-11
RWV 1348	140	1.7	9.1	11.8	14.6	97	-48
Decelaya	138	2.0	5.0	3.0	57.4	97	-49
Gasilidia	120	2.0	3.4	4.5	48.9	97	-56
Yol X	83	2.5	2.0	3.0	28.2	97	-69
MAC 28	41	2.3	1.1	1.5	15.0	97	-85
RWV 2409	33	0.8	1.3	1.1	18.8	65	-88
Average	207.7	3.2	6.5	3.9	32.1	87	-23
F Prov	*0.06*	*0.50*	*0.32*	*0.10*	*0.64*	*0.70*	
L.S.D	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	
%CV	*94.6*	*241.7*	*103.4*	*95.1*	*98.4*	*37*	

Aituto 2013 wet season

A new site for bean research was selected at Aituto during 2013. This site is at a higher elevation than other trial sites used since 2009. Grain yields at Aituto were the highest of all sites in 2013. Umubano was the highest yielding variety (Table 83). Decalaya and RWV 1348 also performed well.

Table 83. Yield and yield components, climbing bean varieties, Aituto 2013 wet season

Variety	*Yield (t/ha)*	*Plants/ m^2*	*Pods /plant*	*Seeds/ pod*	*100 seed weight (g)*	*Yield advantage over mean of locals (%)*
Umubano	2.5	6.0	12.4	7.5	46	208
Decelaya	2.3	5.3	9.7	5.8	78	184
RWV 1348	2.0	4.8	10.3	9.4	47	155
Yol X	2.0	5.8	8.7	6.0	69	149
Mac 28	1.6	5.3	10.9	6.5	44	106
Gasilidia	1.4	5.7	8.7	5.5	52	72
Mwirasi	1.1	4.9	6.5	7.1	66	42
RWV 2409	1.1	5.1	6.5	6.4	66	40
Lokál Urulefa	1.0	5.4	5.1	4.8	74	22
Lokál Maubisse	0.6	4.7	3.3	5.7	74	-22
Average	1.6	5.3	8.2	6.5	62	96
F Prov	*0.01*	*0.44*	*0.15*	*0.04*	*0.25*	
L.S.D	*0.98*	*ns*	*ns*	*2.34*	*ns*	
%CV	*36.6*	*14*	*45.2*	*21.1*	*31.2*	

There is no correlation between yield and plant density nor with the number of seeds per pod. However, there was good correlation between the number of pods per plant and yield (Figure 25).

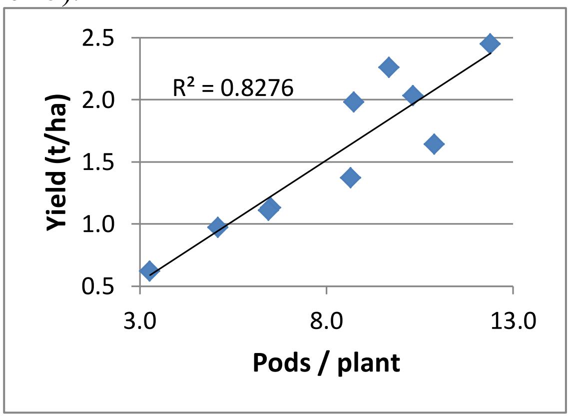


Figure 25. Correlation between yield and pods per plant in Aituto 2013

Conclusions

RWV 1348, Mwirasi and Umabano all performed well across the four test sites in 2013. Further analysis is provided below to examine the performance of the test varieties across sites and years.

2.8.2 Climbing bean, multi-year and location analysis

Materials and methods

Successful climbing bean variety trials (including 3 dry season trials) were implemented by SoL between 2009 and 2013 at 7 different sites. The performance of 10 climbing bean varieties (including 2 locals) were compared.

The entire dataset comprised 160 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). At each site a performance was calculated. The sites were at Maubisse (Maub), Turiscai (Tur), Venilale (Ven), Aileu (Ail), Lisalara (Lis), Holarua (Hol), Ossu (Oss), Urulefa (Ulu) and Aituto (Ait).

Cross-site analyses were conducted using biplots (GGE Plot procedure in Genstat 16) in order to evaluate the performances and consistency of the tested varieties across years and locations (genotype/environment).

Results

The average yield of the entire dataset (16 environments, 148 data points) was 0.82 t/ha against 0.84 t/ha for the local checks (8 environments, 20 data points). Yield averages from trial to trial varied from a very low 26 kg/ha to a maximum of 2.5 t/ha (Lisalara 2010 and Maubisse 2012 respectively).

Table 84. Climbing bean yields for 9 varieties from 11 trials, 2009-2011

Variety	*Maub. 2009*	*Tur. 2009*	*Ven. 2009*	*Ail. 2010*	*Lis. 2010*	*Maub. 2010w*	*Hol. 2010*	*Oss. 2010*	*Ven. 2010*	*Maub. 2010*	*Maub. 2011*
RWV 1348	0.12	0.14	0.91	0.21		4.28	0.47	0.48	0.6	0.43	0.14
Mwirasi	0.34	0.24	0.51	0.33	0.01	3.63	0.32	0.13	0.44	0.85	0.29
Decelaya	0.28	0.08	0.43	1.12	0.04	2.68	0.37	0.53	0.29	0.6	0.04
MAC 28	0.44	0.22	0.63	0	0	3.65	0.16	0.11	0.35	0.7	0.11
YOL X	0.14	0.18	1.07	0.23	0.03	2.96	0.1	0.29	0.59	0.39	0.14
Umubano	0.08	0.02	0.36	0.28	0	1.91	0.32	1.1	0.22	0.27	0.13
Gasilidia	0.08	0.17	0.38	0.24	0.02	2.2	0.18	0.14	0.25	0.99	0.05
RWV 2409	0.36	0.2	0.41	0.18	0.11	2	0.15	0.05	0.29	0.7	0.05
Local Maubisse	0.3	0.14	*	0	0.01	1.17	0.31	0.09	0.35	0.39	0.04

Table 85. Climbing bean yields for 10 varieties from 5 trials, 2012-2013

Variety	Ulu. 2012	Ulu. 2013	Ven. 2013	Oss. 2013	Aitt. 2013
RWV 1348	4.6	0.24	0.44	0.14	2.03
Local Urulefa	2.7	0.11	0.35	0.24	0.97
Mwirasi	2.9	0.18	0.90	0.57	1.13
Decelaya	2.1	0.09	0.23	0.14	2.26
MAC 28	2.7	0.10	0.27	0.04	1.64
YOL X	1.6	0.12	0.39	0.08	1.98
Umubano	2.2	0.16	0.27	0.41	2.45
Gasilidia	2.7	0.14	0.34	0.12	1.37
RWV 2409	1.9	0.13	0.32	0.03	1.11
Local Maubisse	2	0.16	0.42	0.30	0.62

Table 86. Mean climbing bean yields, multi-locations, 2009 to 2013 and 2012-2013

Variety	*Mean yield (t/ha) 16 locations (2009-13)*	*Mean yield (t/ha) 5 locations (2012-13)*
RWV 1348	1.02	1.41
Mwirasi	0.80	1.08
Umubano	0.64	1.02
Decelaya	0.70	0.92
MAC 28	0.70	0.91
Gasilidia	0.59	0.88
Local Urulefa		0.87
YOL X	0.64	0.80
RWV 2409	0.50	0.67
Local Maubisse	0.42	0.65

All new varieties showed higher yield than locals (compared with local Maubisse only). Most of the new varieties showed higher yield than the average of two local varieties (local Maubisse and local Urulefa). RWV 1348 and Mwirasi were better yielding than all varieties when compared with local in 16 locations and also with 5 locations that included local Urulefa.

Figure **26** presents the biplot resulting from the analysis of 10 varieties in all 16 environments. The two components combined explain 58% of the variation in the table of yield of 10 varieties across the 16 sites.

Of the biplots, there does not appear to be any grouping of locations based on the same year or the same site, but varieties further to the right of the line perform better. Umbano showed high yields in some places like Ossu and Aituto but showed low yields when planted in other places and years. There is no suggestion that different varieties should be recommended for different locations. Two varieties RWV 1348 and Mwirasi showed high consistent yields for most places and years.

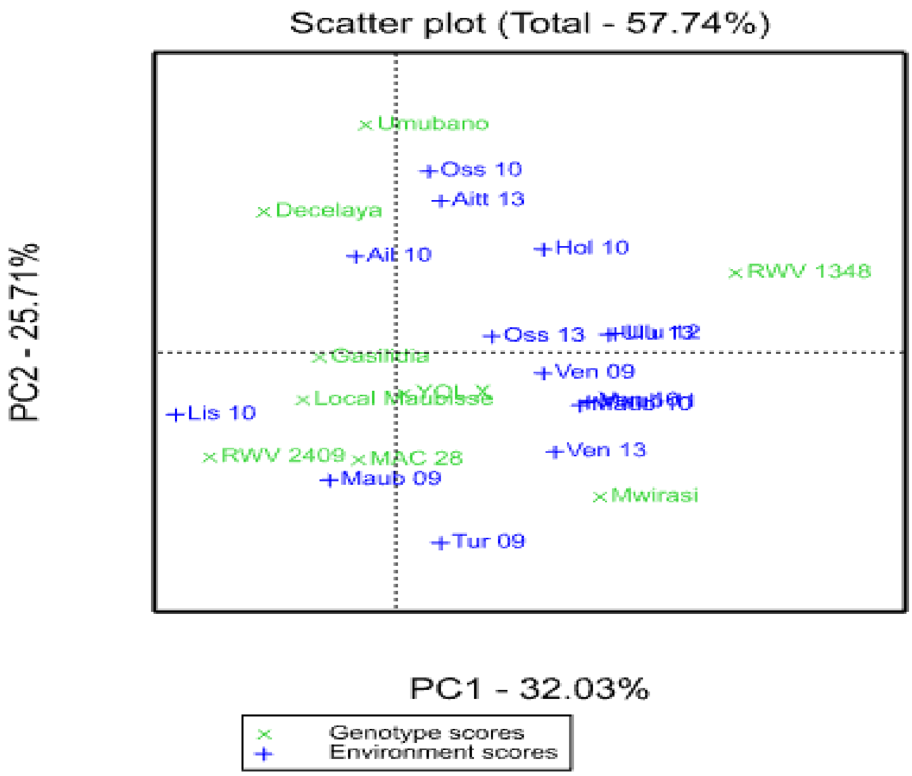


Figure 26. Ranking BiPlot of 9 climbing bean varieties in 16 environments, 2009-2013

Turning specifically to 2012-2013, the two components combined explain 75% of the variation in the table of yield of 10 varieties across the 5 sites. (Figure 27).

Of the biplots, as in 2009-2013, there does not appear to be any grouping of locations based on the same year or the same site, but varieties further to the right of the line performed better. Two varieties RWV 1348 and Mwirasi showed high consistent yields when planted in many places and years.

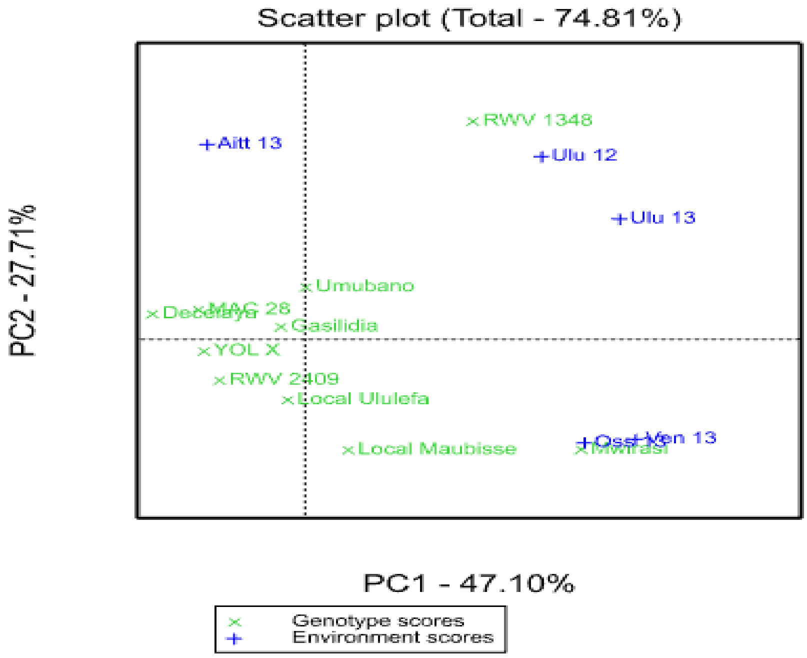


Figure 27. Ranking BiPlot of 10 climbing bean varieties in 5 environments, 2012-2013

In all sites, the level of production was different. However there is correlation between yield and pods per plant (Figure 28).

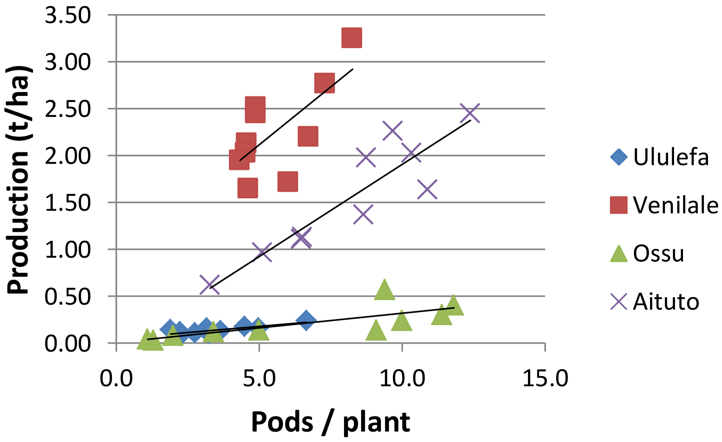


Figure 28. Comparison between pods per plant and yield (t/ha) in 4 sites, 2013

Conclusions

After a series of 16 test locations with 10 varieties, a number of introduced varieties seem to be generally superior to the local checks. The varieties which performed the best presenting yield advantages of more than 50% over locals were RWV 1348, Mwirasi and Umbano. RWV 1348 and Mwirasi always showed a high yield in each year and each location. Sometimes one variety yielded higher than the other and vice versa, but in general the two varieties usually performed well. These varieties need to be evaluated on farmers' fields under different agro-ecological zones in Timor Leste. The grain of each also needs to be tested for suitability for cooking, eating and weevil resistance prior to consideration for release.

3. Foundation and certified seed production and distribution

Introduction

The National Seed Policy (NSP) and the National Seed System of Released Varieties (NSSRV) of Timor Leste classifies seed quality as being either breeder seed, foundation seed, certified seed, truthfully labeled/Commercial seed and community seed.

The Association of Official Seed Certifying Agencies (AOSCA) system has four seed classes of breeder, foundation, stock, and certified seed. The three classes in Timor-Leste are breeder, foundation, and certified seed. Seed for grain production is in Timor-Leste is named commercial seed (truthfully-labeled seed).

Maintaining high quality is this source seed receives high priority from the MAF and close cooperation remains between research and seed production to ensure the seed system runs smoothly. The MAF National Directorate for Research and Special Services (NDRSS) produces breeder and foundation seed and the National Directorate of Agriculture and Horticulture (NDAH) produces certified seed (purple label). The former seed is produced on research centres by pure seed officers while certified seed is produced by contract seed growers under close supervision of District seed officers.

The Department of Seed Production and Certification, under DNAH, is the responsible agency for seed quality control in the country. Field inspection and seed testing in the seed laboratory is conducted by staff of this Department. Seed testing results are displayed in the seed label/certificate which is attached in every seed bag.

To conduct their duty, seed officers (pure seed officer, district seed officer, seed analyst) have been trained well on basic seed production, processing and storage, seed technology, seed testing for seed certification, field inspection for seed certification and seed health testing.

Six seed warehouse have been established to process and store seed produced by contract growers. Basic drying and cleaning facilities and silos to store seed have been installed in those seed warehouses.

The first National seed laboratory, located at the MAF compound in Comoro was inauguration by the Minister of Agriculture on May 2013.

Institutions received planting material of the released SOL's varieties during 2012/2013 were: MAF-IFAD program, USC Canada, JICA, CARE, RDP4, WVI-Aileu, Mercy Corp, Share, Hivos-Fraterna Lautem, Hivos-Prospect Lautem, CRS-Baucau, Hivos-prospect Baucau, WVI-Aileu, Hiam, WVI-Baucau, CRS-Viqueque, and Hivos Fraterna-Viqueque.

3.1 Seed Production (Sept 2012 – August 2013)

Contract growers multiplied certified seed in the 7 districts of Aileu, Baucau, Bobonaro, Manufahi, Liquiça, Viqueque and Manatuto during 2012/2013. Areas cultivated to seed were 57 ha of maize, 32 ha of rice and 15 ha of peanut. All fields were inspected by seed officers. However, not all the harvested seed was purchased by MAF/SoL. The program purchased sufficient certified seed to fill the target of 25 ton of maize, 25 ton of rice and 10 ton of peanut (Table 87).

Table 87. Certified seed target (t), area (ha) and number of contract growers 2012-2013

	Certified seed production target (t)				*Cultivated seed crop (ha)*				*Number of contracted seed grower**			
District	Nakroma	Sele	Noi Mutin	Utamua	Nakroma	Sele	Noi Mutin	Utamua	Nakroma	Sele	Noi Mutin	Utamua
Aileu	4	0	1	0	6.5	0	3	0	5	0	2	0
Baucau	9	2	0	5	16	4.5	3	7.5	6	4	1	6
Bobonaro	0	5	0	3	0	16	0	5.5	0	4	0	5
Liquiça	1	5	0	0	0	6.8	0	0	0	5	0	0
Manufahi	1	7	3	1	0	19	3	1	0	5	1	1
Viqueque	10	0	2	1	10	0	2	1	22	0	3	1
Total	25	19	6	10	32.5	46.3	11	15	33	18	7	13

Note: * Contract seed growers can be either in a group or be individuals

In summary, there was about 26.6 tons of Rice-Nakroma, 42 tons of maize (32 t Sele plus 10 t Noi Mutin) and 8 tons of Peanut-Utamua seed produced in 2012/2013 (Table 88). Production of maize seed (42 t) was 68 % higher that target (25 t) because seed was provided to the IFAD funded maize storage program. The maize seed for IFAD is excess seed produced by contracted seed growers. Certified seed produced in 2012-2013 will be distributed for 2013-2014 season

Table 88. Clean seed production (kg) of Nakroma, Sele and Utamua, 2012-2013

District	*Rice (Nakroma)*	*Maize (Sele)*	*Maize (Noi Mutin)*	*Peanut (Utamua)*
Aileu	4,000	0	1,480	0
Baucau	15,515	4,198.8	2,456	5,286
Bobonaro	0	4,337.0	0	2,066.4
Liquiça	0	3,697.7	0	0
Manufahi	0	20,175.0	3,243	700
Viqueque	7,100	0	2,500	0
Total	26,615	32,408.5	9,679	8,052.4
Betano research station		467*		
Loes research station			200**; 1,270*	

Note: * = Foundation Seed; ** = Breeder Seed

3.2 Seed distribution (Sept 2012 – August 2013)

Seed harvested from the crops grown in 2011/2012 was distributed to support the MAF-SoL program (Research, On-Farm Demonstration Trials (OFDTs), certified seed production, and for community seed), as well as MAF, and NGOs for the 2012-2013 planting season. About 15.5 t of Nakroma, 4.0 t of Utamua and 32.0 t of maize (29.5 t Sele and 2.5 t Noi Mutin) seed were distributed within the period from Sept 2012 – August 2013.

Most of the seed was distributed through the MAF (73.3%). The remainder was provided for certified seed production (9.8 %), community seed production (7.3%), for OFDTs (5.3%), NGOs (2.3%) and to NGO-CSPGs (1.59%).

3.3 Production and distribution of sweet potato and cassava

Stem cuttings of Hohrae 1, Hohrae 2, and Hohrae 3 sweet potato varieties were multiplied in Manufahi, Aileu, Liquiça, Bobonaro and Baucau during the year. Cuttings of these varieties were planted at a distance of 25 cm x 50 cm. It was assumed that 2 month old plants provided 4 cuttings/plant. Each square metre of field, should be able to produce 32 stem cuttings. Based on that estimation, it is possible to harvest about 186,000 cutting every two months or 371,000 cuttings from three harvests off the total 0.58 ha of land at the five sites. That number will be sufficient to cover about 9.6 ha of sweet potato fields (spaced at 0.5 m x 0.5 m) for consumption or commercial purposes.

During 2012-2013, about 368,000 sweet potato cuttings were distributed (Table 89). This was more than twice as many distributed the year earlier and sixteen times higher than the year prior to that.. Most of the cuttings (about 40%) were distributed to farmer through the MAF District office.

Cassava fields to multiply stem cutting were established at Loes-Liquiça (1 ha), Corluli-Bobonaro (1 ha), Betano-Manufahi (1 ha) and in a farmer field at Viqueque (2 ha). Cassava planting distance was 100 cm x 100 cm. To stimulate more stem /plant, the plant was pruned when they were about 40 cm high resulting in approximately 3-branches/plant.

A single cassava stem can be cut into 4 to 5 pieces of 25 cm cuttings. A one ha field, therefore, can produce 120,000–150,000 cuttings. In 2012-2013, approximately 136,000 cuttings were distributed (Table 89). Most of these went directly to farmers via MAF (55.4 %).

Table 89. Distribution of sweet potato and cassava cuttings 2012-2013.

Commodity	*NGO (no.)*	*MAF District (no.)*	*Agric. school& UNTL (no.)*	*MAF-SOL-Comp 2 (no.)*	*MAF-SOL-Comp 3 (no.)*	*NGO-CSPG (no.)*	*OFDT (no.)*	*Total (no.)*
Sweet potato	85,465	145,080	400	6,900	58,800	46,250	25,093	367,988
	(23.2%)	(39.4%)	(0.1%)	(1.9%)	(16%)	(12.6%)	(6.8%)	(100%)
Cassava	29,505	75,300	0	22,440	2,300	6,500	60	135,905
	(21.7%)	(55.4%)	(0.0%)	(16.5%)	(1.7%)	(4.6%)	(0.0%)	(100%)

3.4 Seed warehouse and national seed laboratory

Seed processing during the year was done by seed officers using seed processing units located at seed warehouses. It was considered too early/risky to ask less experience contracted seed growers to process their source seed. In time it is planned that contract seed growers will grow, process, store, bag and distribute their seed. At that stage, the SEO and seed officer's roles will be to provide advice. When this happens, the term "seed grower" can be changed to "seed producer".

There are two steps to quality assessment under most seed certification schemes. The first assessment is during the growing period and before seed processing. The second assessment is done after seed processing by taking seed samples for seed quality testing in a seed laboratory.

Field assessments are done by field seed inspectors (seed officers assigned as field inspectors). Seed sampling is conducted by authorized seed officers and seed laboratory tests are done by a seed analyst (seed officer assigned as seed analyst).

Seed processing units and seed warehouses established in the six districts played an important in 2012-2013. Good seed processing improved the percent of pure live seed because it reduced the number of impurities, empty, and cracked and diseased seed. Equipment available in the seed warehouses included silos, air screen cleaners, batch driers, maize and rice threshers, rice cleaners, baggers and sealers, moisture meters, germinators, seed dividers, purity tables, compressors and generators.

The first National Seed laboratory has been established in Dili in May, 2013. Two technicians work in the laboratory under supervision of the Seed Department head and the national quality control coordinator. Seed samples submitted to the laboratory were coded to reduce bias and evaluated for seed moisture content, physical purity and germination rates. The seed testing methods used in the laboratory were based on ISTA rules or modified ISTA rules. Results of the tests were written on the seed label which were later attached to certified seed bags. Reliable seed testing and labeling provides important information for seed users, seed producers and seed officers.

4. Community based seed production

Introduction:

Community Seed Production in Timor-Leste is the decentralized production, storage and marketing of seeds by organized groups of farmers operating close to their homes as community groups or as farmer associations. Groups normally have 10-20 members and produce seed to meet the needs of its members. If there is any surplus production by the group, they sell, barter or share it with neighbors within the Suco. Associations are larger in size ranging from 25-100 members and produce seed, primarily for commercial purposes. They often have their own brand and place labels on every seed packet. During the early stages of forming community seed production, groups and associations receive considerable training on seed production, storage and marketing from extension staff of MAF/SoL. As groups and associations develop experience, they continued seed production activities on their own with little or no extension support. The groups and associations follow basic seed production procedures and produce a quality seed. Community seed production is a community owned and community managed approach to local quality seed production and storage.

MAF released food crop varieties possess yield advantages ranging from 30% to 131% over local crop varieties (see Section 2). But prior to 2011, the potential of these varieties was not being realized due to insufficient availability of quality improved seed and planting material. Poor access to seed was recognized as being a constraint and MAF/SoL initiated a five year community seed production program in February 2011 to address this issue. By mid-2013, MAF SoL program had expanded from 7 districts to 11 districts covering 45 sub-districts. This report covers the progress from September 2012 to August 2013 covering the 2012-2013 cropping season.

There has been impressive progress on seed production at the community level over the past two seasons. In 2012-2013, MAF/SoL implemented community seed production activities by supporting 680 groups (CSPGs) in 11 of 13 districts, 45 of 65 districts and 135 of 442 Sucos growing one or more of the five major food crops: maize, paddy rice, peanuts, sweet potato and cassava. This means that the program was being implemented in 85% of all the districts, 69% of all the sub-districts and 31% of all the Sucos by August 2013. Between 2011-2012 and 2012-13, coverage of Suco increased nearly two fold from 70 to 135 Sucos and the number of MAF-SoL CSPGs involved in seed production has also sharply increased from 280 to 680.

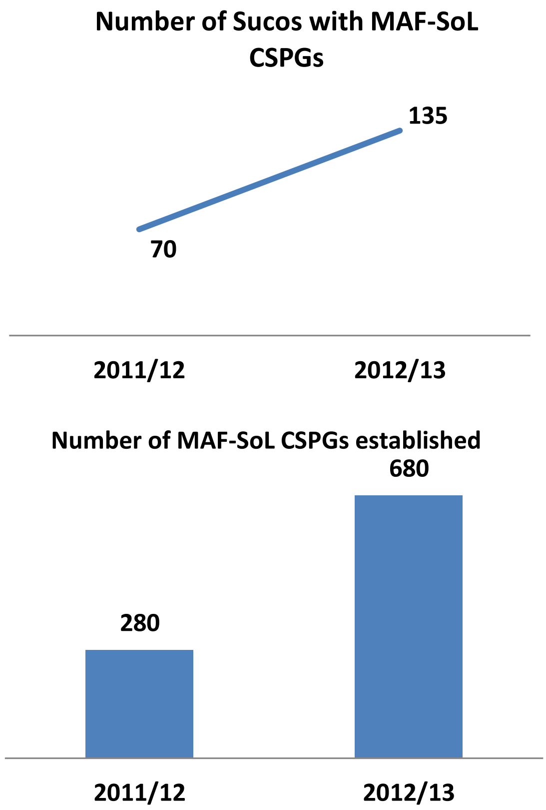


Figure 29. Number of CSPGs and sucos in MAF/SoL program 2012-2013

4.1 Community Seed Production Groups (CSPGs) 2012-2013

Nine MAF released varieties were included in the 2012-2013 community seed production program. These include, 'Sele' and 'Noi Mutin' varieties of maize, 'Nakroma' for paddy rice, 'Utamua' for peanut, 'Hohrae 1', 'Hohrae 2', 'Hohrae 3' for sweet potato and 'Ailuka 2' and 'Ailuka 4' for cassava. During the wet season of 2012-13, 55 tons of maize seed, 68 tons of paddy seed and 7 tons of peanut seed totaling 130 tons of improved seeds were produced. These are presented by District below.

4.1.1 Maize seed production

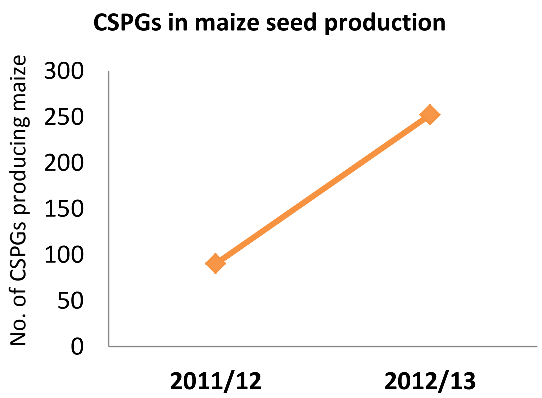
A total of 253 community groups were involved in seed production of 'Sele' or 'Noi Mutin' varieties of maize. Of the total, 252 were successful in harvesting seed (Table 90).

Table 90. Maize seed production by District in 2012-2013

	District	*# of CSPGs planted*	*# of CSPGs harvested*	*Total result (kg)*	*Total seed (kg)*	*Seed (kg)/CSPG*
1	Aileu	32	32	10,553	5,438	170
2	Ainaro	27	27	10,640	7,335	272
6	Baucau	23	23	23,850	9,524	414
3	Bobonaro	29	29	13,168	8,103	279
4	Ermera	14	14	5,003	3,076	220
5	Liquiça	36	36	8,547	5,805	161
7	Lautem	9	9	3,345	2,292	255
8	Manatuto	4	4	1,200	900	225
9	Manufahi	25	25	8,270	5,464	219
10	Oecusse	23	22	2,505	873	40
11	Viqueque	31	31	9,293	6,206	200
	Total	*253*	*252*	*96,374*	*55,016*	
	Mean (kg)			*382*	*218*	*218*

Each group received 5 kg seeds from SoL at planting time and cultivated 'Sele' or 'Noi Mutin' variety in one single plot (normally 0.2 ha) maintaining sufficient isolation distance with other maize varieties. Basic seed production' training was provided to all concerned MAF Suco Extension Officers (SEOs) about one month before planting time. Follow-up training was provided on 'post-harvest operations and quality control' one month before harvest. The SEOs then provided coaching and mentoring support to these CSPGs on production, processing and storage through their regular visits with CSPGs following a coaching and mentoring approach.

The number of maize CSPGs increased from 90 in 2011-12 to 252 in 2012-13. Similarly, there is nearly a four-fold increase in maize seed production from 15 t in 2011-12 to 55 t in 2012-13 (Figure 30).



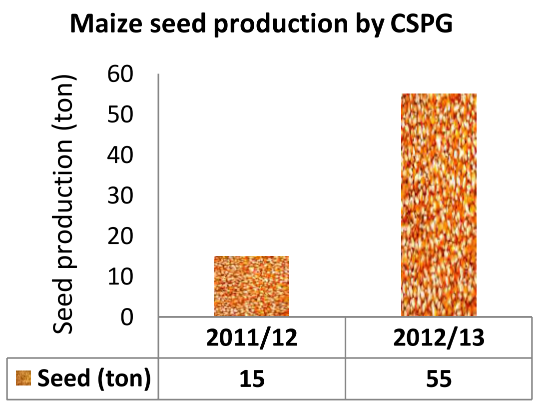
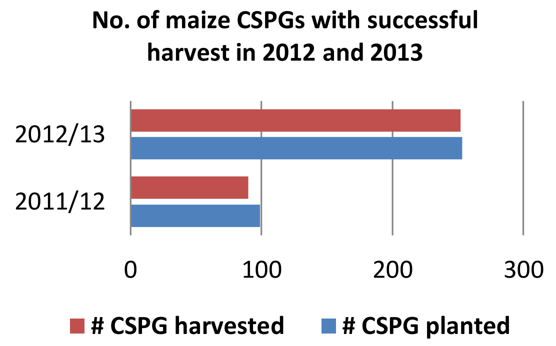


Figure 30. Number of CSPGs and production of maize CSPGs 2012-2013

Average seed produced by a group was 218 kg which is 31% higher than the previous year. From the total harvest, 57% was selected by CSPG members for seed and the remainder was used as either food for family members or as animal feed.



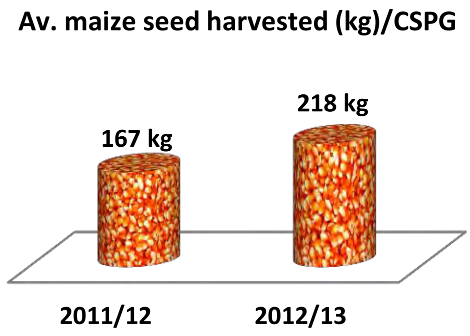


Figure 31. Maize CSPG success rate and seed production by CSPG

Almost all (99%) CSPGs in 2012-13 were able to harvest maize seed - an increase of 8% over the previous year when there were some crop failures due to animal damage and from flash floods. In 2012, extra care was taken by SEOs to select seed plots that were properly fenced and less prone to flash floods.

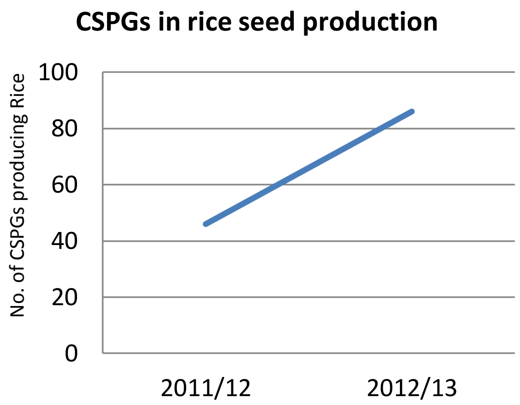
4.1.2 Rice seed production

A total of 112 community groups were involved in 'Nakroma' seed production. Of the total, 86 were successfully harvested. Failures in Aileu, Ainaro, Viqueque and Baucau were due to drought. The seed production guidelines in Liquiça were not followed, leading to the crop being rejected as seed. Each group received 5kg of seed at planting time and planted a single plot (normally 0.25 ha) maintaining sufficient isolation distance from other varieties. In most cases, CSPGs adopted either ICM (integrated crop management) or SRI (System Rice Intensification) cultivation techniques. Basic seed production' training was provided to all SEOs about one month before planting and one month before harvest further training on 'post-harvest operations and quality control'. The SEOs also provided coaching and mentoring support to the CSPG members on production, processing and storage during their regular visits and meetings. A summary of rice seed production during 2012-13 is presented in Table 91.

Table 91. Rice seed production by District in 2012-2013

SN	*District*	*# CSPGs planted*	*# CSPGs harvested*	*Total harvest (kg)*	*Total seed (kg)*	*Seed (kg)/CSPG*
1	Aileu	6	4	3,208	2,099	525
2	Ainaro	6	2	2,500	1,300	650
6	Baucau	38	25	38,060	31,717	1,269
3	Bobonaro	18	18	16,600	10,950	608
4	Ermera	7	7	3,495	2,802	400
5	Liquiça	3	-	-	-	-
7	Lautem	6	6	4,005	3,753	626
8	Manatuto	13	12	3,800	2,542	212
9	Manufahi	1	-	-	-	-
10	Oecusse	-	-	-	-	-
11	Viqueque	15	12	13,750	12,680	1,057
	Total	*113*	*86*	*85,418*	*67,843*	
	%		*77*		*79*	
	Average (kg)			*993*	*789*	

There was increase in number of MAF-SoL CSPGs successfully growing rice which increased from 46 in 2011-12 to 86 in 2012-2013 (Figure 32). Similarly, there is almost three-fold increase in rice seed production from 24 tons in 2011-2012 to 68 tons in 2012-2013 by MAF-SoL CSPGs.



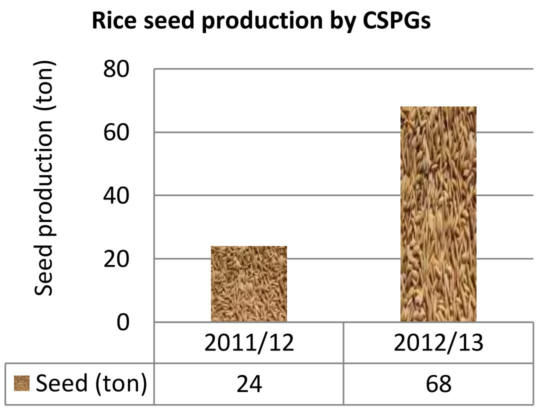
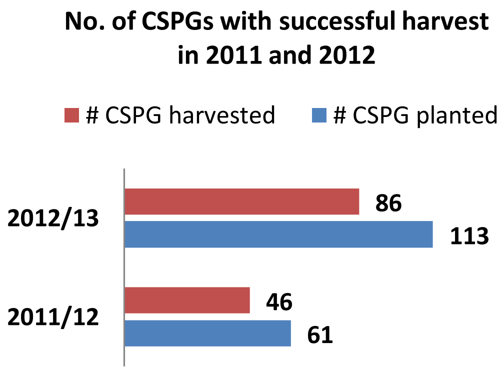


Figure 32. Rice CSPG success rate and seed production by CSPG

Average seed produced by a rice CSPG was 789 kg which is 49% higher than the previous year (Figure 33). From the total harvest, 79% was selected by CSPGs as a seed and 21% was used as food-grain.



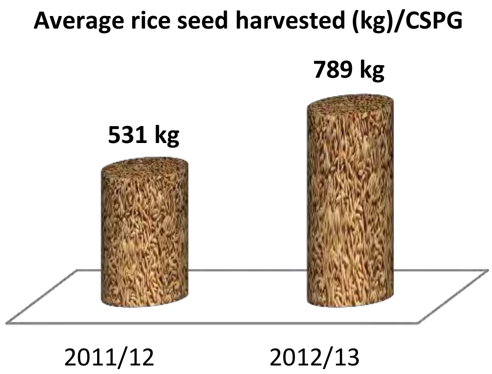


Figure 33. Rice CSPG success rate and seed production by CSPG

A majority (76%) of CSPGs in 2012/13 were able to harvest rice seed (75% in previous year). In both years 25% of failures were due to drought towards the end of the season. Extra care will be taken to select production areas with reliable access to water in future.

4.1.3 Peanut seed production

One hundred and sixty two community groups were involved in ‘Utamua’ peanut seed production in 2012-2013 (Table 92). Of the total, 132 were successful in harvesting seed. Thirty groups (19%) suffered a crop failure due to bad land preparation or damage by animals. The successful harvests averaged 53 kg per seed plot. Each group had received 10 kg seeds from SoL at planting time. Each of the seed plot was grown by a group in a single plot with a size of 0.065 ha with sufficient isolation distance from other peanut varieties.

About one month before planting time, basic seed production training was provided to all SEOs followed by 'post-harvest operations and quality control' training before harvest. The SEOs also provided coaching and mentoring support to these CSPGs on production and storage of peanuts during their regular visits.

Table 92. Peanut seed production by District in 2012-2013

SN	*District*	*CSPGs Planted*	*CSPGs Harvested*	*Total Result (kg)*	*Total Seed (kg)*	*Av. Seed (kg)/CSPG*
1	Aileu	35	26	1,995	1,069	41
2	Ainaro	20	18	1,838	1,138	63
3	Bobonaro	14	9	580	370	41
4	Ermera	3	3	310	237	79
5	Liquiça	17	8	628	413	52
6	Baucau	14	14	1,691	842	60
7	Lautem	9	9	950	688	76
8	Manatuto	4	4	515	250	63
9	Manufahi	15	14	682	450	32
10	Oecusse	15	15	1,125	729	49
11	Viqueque	16	12	1,387	748	62
	Total	*162*	*132*	*11,701*	*6,934*	
	%		*81*		*59*	
	Average (kg)			*89*	*53*	*53*

There was increase in number of MAF-SoL CSPGs successfully growing peanuts which increased from 47 in 2011-12 to 132 in 2012-13 (Figure 34). Similarly, there is more than four-fold increase in peanut seed production from 1.7 tons in 2011-12 to 6.9 tons in 2012-13.

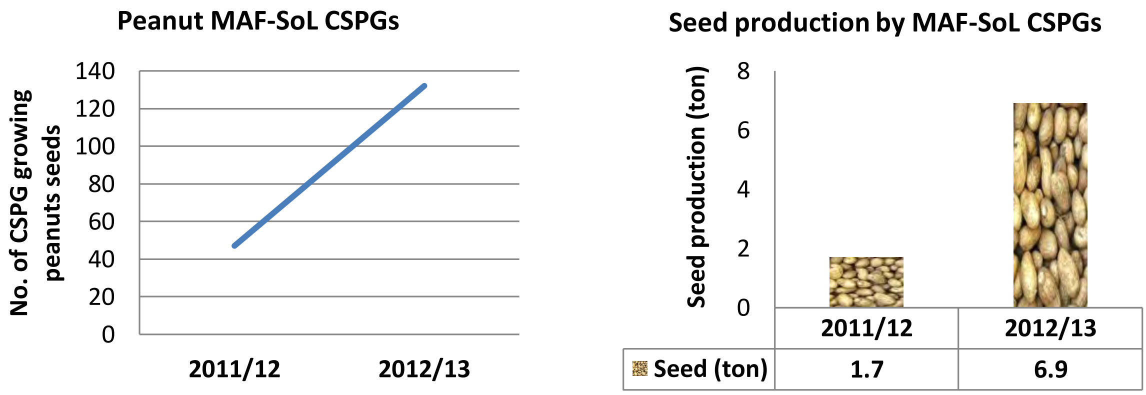


Figure 34. No of CSPGs and production of peanut CSPGs in 2012-2013

Average seed produced by a Peanut CSPG was 53 kg from a 0.065 ha plot, which is 49% higher than the previous year (Figure 35). From the total harvest, 59% was selected as a seed and the remainder shared among group members. An expansion in the area under production in 2012-2013 led to the use of marginal land where weed problems and labour constraints reduced the percentage of successful harvests. Closer attention will be paid to these factors in 2013-2014.

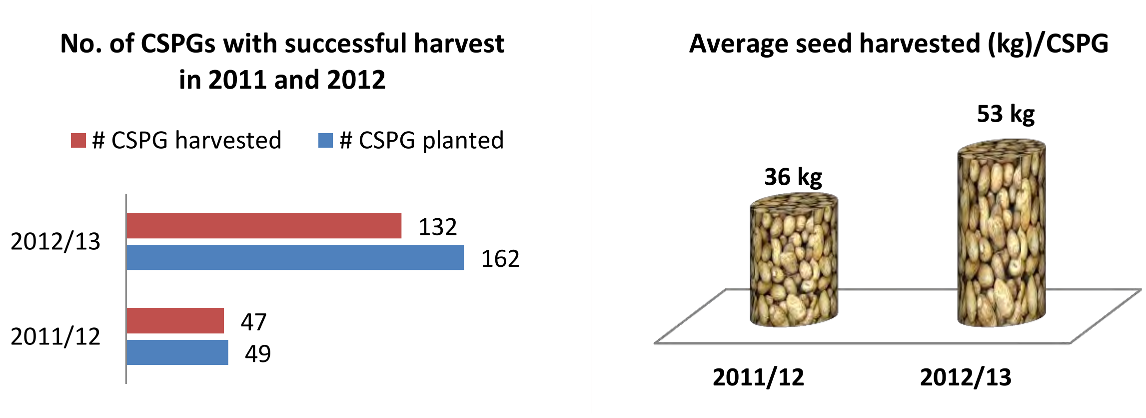


Figure 35. Peanut CSPG success rate and seed production by CSPG

4.1.4 Sweet potato cutting production

One of the major lessons learned from sweet potato cultivation in 2011-12 was that the survival rate is low when perishable cuttings are transported long distances. In order to minimize the mortality rate, it was decided not to transport the cuttings from research stations in 2012-2013 but to establish sweet potato cutting production centres in each sub-district close to production areas. In 2012-2013, such centres were established in nearly half (20 of 45) of the sub-districts. Each centre consisted of at least 0.02 ha in which 2000 cuttings were planted. These centres have the capacity to produce 30-40,000 cuttings in a year. A few of these centres sold cuttings to MAF and NGOs for their own multiplication. Four CSPGs in Maumeta Suco, Liquiça District producing the sweet potato cuttings for commercial purposes sold more than 50,000 cuttings to neighbors, NGOs, MAF and SoL during the year. In 2013-14, additional centres will be established to cover the remaining 25 sub-districts.

4.1.5 Cassava cutting production

After two years of community seed production experience in the districts it is evident that cassava cutting production is not effectively done by CSPGs. The main reason mentioned by CSPG members is that they want to see benefits accrue quickly. Cassava cuttings take 1-2 years to mature and the group approach is not practical. Alternative ways to produce cuttings are being investigated.

4.2 Registration of commercial seed producers

Following the national seed system for released varieties (NSSRV), all commercial seed producers must obtain registration certificates from the MAF Seed Department to market commercial seed. In July 2013, three Farmers Associations (FA), one from Liquiça and two from Baucau, were formally registered as commercial seed producers. The guidelines of the NSSRV require registered seed producers to register their crop, varieties and the area to be cultivated annually. During production, MAF District Seed Officers check the fields and seed standard. After clearance by the District Seed Officers, the seed can be sold with the commercial seed producers own brand and truthful label on the seed packets. MAF-SoL targets the establishment of 3-5 FAs as a commercial seed producers in every district by the end of 2016. This will result in the existence of 40-50 FAs in the country.

4.3 Access to seed for vulnerable households

Providing vulnerable households (VH) access to seed is a challenge in Timor-Leste where seed distribution is traditionally biased towards farmer groups and easily accessible farmers. VHs are normally not part of a group, live in relatively remote areas and have poor contact with extension officers. These relatively poorer people in the community (often widows and/or women headed households) may also lack the information on who to contact and where to get improved seeds. In February, 2012, a mechanism was developed to strengthen the linkage between seed users and seed producers. The mechanism involves the SEO and Aldeia Chiefs jointly selecting vulnerable households based on pre-agreed criteria. These criteria are:

1) poorer households who are not members of existing MAF group in the Aldeia,
2) poor widows or women-headed households, and
3) poor households possessing small areas of land and are interested in growing improved varieties.

Once the list of VHs possessing approximately 30 household per Aldeia, is approved by Chief of the Suco, the vulnerable households are informed by either the Aldeia Chief or the SEO that they can collect seeds or cuttings of MAF released varieties from the CSPGs nearest to their farm. The CSPGs check the names against the approved list and provide an agreed quantity of seed (normally 2 kg maize or paddy) or sweet potato cuttings (200 cuttings of sweet potato/VH). The seeds and cuttings are distributed approximately one month before planting time. After the seeds or cuttings are distributed, the CSPGs submit the invoice with the signed list of recipients for payment. MAF-SoL through District community seed coordinator makes the payment to the CSPGs. In 2012, this concept was piloted in Maumeta Suco where 120 VHs from 4 Aldeias received 24,000 cuttings of sweet potato (200 cuttings/VH). In second half of 2013, seed distribution to VHs is planned in 30 Sucos and 99 Aldeias. Lessons learned from the piloting of improved seed access mechanism to VH will be documented and shared with MAF extension officers and NGOs. A self-explanatory schematic framework of improved seed access mechanism for vulnerable households is presented below (Figure 36).

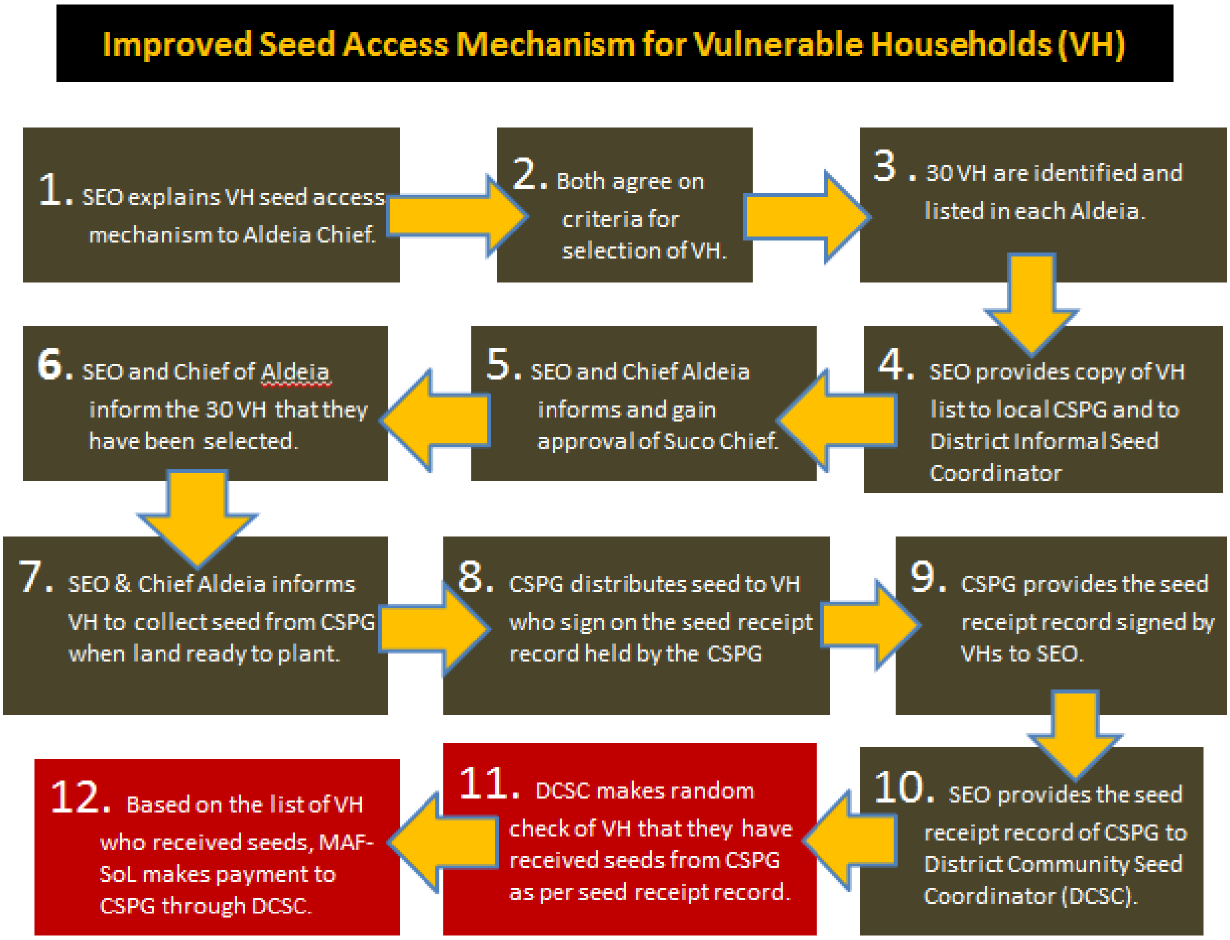


Figure 36. Schematic for providing improved seed to vulnerable households

5. Farming systems research

5.1 Maize and velvet bean systems

Introduction

This trial continues the work described in the journal article titled “Maize-mucuna (*Mucuna pruriens* (L.) DC) relay intercropping in the lowlands of Timor-Leste” published in Field Crops Research (Correia *et al*, 2014). The trial is designed to improve the productivity of cropping systems in rainfed maize based farming environments where inorganic fertilizer use is minimal. After five rotational cycles, the percentage of maize yield advantage of cropping with mucuna v. sole cropping was 132%, lifting maize yields from a very low base. A wild variety of velvet bean known locally as *Karalele* (itchy velvet bean) grows in many isolated parts of the island of Timor but is considered to be unsuitable for widespread cultivation. The introduction of the *utilis* variety has renewed farmers interest of cultivating the plant which, if sown in a timely manner, both smothers weeds and improves soil nutrition through leaf fall and the nitrogen fixing properties of its leguminous root system. Mucuna seed is also edible if processed properly prior to consumption.

The Food and Agriculture Organization (FAO) is acknowledged for supporting the following work.

Methods and materials

The trial was conducted at Betano research station, Manufahi District during the wet season of 2012-2013 and then repeated in the dry season of 2013 (Table 93). During the growing period, the research station recorded 719 mm of rainfall during the wet season and 341 mm in the dry season.

Table 93. Planting and harvest details of velvet bean experiments, 2012-2013.

Location	Season	Number of replicates	Planting date	Harvest date	Days to maturity	Rainfall (mm)*	Mean yield (t/ha)
Betano	Wet	3	28 Dec 2012	8 March 2013	106	719	2.28
Betano	Dry	3	07 May 2013	10 Aug 2013	105	341	1.08

* Total rainfall from 1 week prior to planting to one week prior to harvest.

The trials were laid out in a randomized complete block design with three replicates of 40 m x 20 m plots. The five treatments compared mechanical ploughing with the farmers' practice of no tillage, with or without Round-Up and velvet bean (Table 94). The maize was planted with two seeds per hill at a distance of 75×50 cm (i.e. 2.6 plants/m^2). Velvet bean treatments were sown with velvet bean seed 30 days after the maize crop at a density of 1 plant/m^2.

Table 94. Treatments for velvet bean/maize trials, Betano 2012-2013.

No.	*Treatment/Factor*				*Treatment*
	Tractor	*Round-Up*	*Hand prep.*	*Velvet bean*	
1.	X				Tillage (mechanical)
2.		X			Round-up
3.	X			X	Combination tillage/Velvet bean
4.		X		X	Combination round Up/ Velvet bean
5.			X	X	Combination hand preparation/ Velvet bean

The plots without velvet bean were weeded twice as farmers commonly practice. Weed and 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, and dry seed weight measured.

Results were analysed in GenStat Discovery 4 using ANOVA (Unbalanced ANOVA) for the factors analysis and One-Way ANOVA in a Complete Randomized Block for the overall cropping system treatment).

Results

Maize plots planted without velvet bean in the trial established during the 2012-2013 wet season produced much lower dry maize grain yields (mean of two treatments at 1.69 t/ha) than those cultivated with velvet bean (mean maize yields of three treatments at 2.67 t/ha) (Table 95). Larger cob size and an increase in the number of cobs per plant accounted for the increased yields in the plots planted with velvet bean.

Table 95. Maize-velvet bean replicated trial results, wet season Betano 2013

Treatment	*Yield (t/ha)*	*Plant density (/m^2)*	*100 Seed weight (g)*	*No. Cobs/plant*	*Velvet bean weight (kg)*	*Weed weight (kg)*	*Cob weight (g)*
Tillage	1.65	4.47	26.67	0.81	0.26	0.69	87.6
Tillage and velvet bean	2.56	4.76	27.33	0.99	0.42	0.70	90.7
No tillage & Velvet bean	2.64	4.56	31	1.07	0.34	0.57	103.4
No tillage & Velvet bean + round-up	2.82	4.45	30.33	0.98	0.17	0.45	119.6
No tillage & round-up	1.72	4.19	30.67	0.91	0.48	0.91	99.2
F pr.	0.16	0.091	0.363	0.36	0.16	0.01	0.017
LSD ($P<0.5$)	0.65	0.391	ns	ns	ns	0.21	17.03
% CV	24.6	4.6	10.8	16	43.0	16.90	9.0

Grain yields were much lower in the dry season trial which received less than 350 mm of rainfall during the growing season. There was also heavy rainfall at flowering and stagnant water in the plots for a few days that may have affected yields. The average maize grain yield for plots with velvet bean was 1.23 t/ha while plots without velvet bean yielded 0.87 t/ha (Table 96).

Table 96. Maize yield with and without velvet bean from dry season trial in Betano 2013.

Treatment	*Yield (t/ha)*	*Plant density (/m^2)*	*100 seed weight (g)*	*Cobs /plant*	*Velvet bean weight (kg)*	*Weed weight (kg)*	*Cob weight (g)*
Tillage & no velvet bean	0.86	2.14	45.1	0.93	0.00	1.78	108.8
Tillage & velvet bean	1.29	1.88	40.5	1.24	2.70	0.81	97.2
No tillage & velvet bean	1.23	2.02	42.7	0.97	2.32	0.71	89.7
No tillage & velvet bean + round-up	1.18	2.14	43.9	0.80	2.87	1.00	93.8
No tillage & round-up	0.90	1.94	39.8	0.94	0.00	1.66	95.9
F pr.	0.011	0.62	0.774	0.023	<.001	0.018	0.341
LSD	0.253	ns	ns	0.23	0.62	0.68	ns
%CV	12.3	12.5	13.8	12.5	21.2	30.20	11.1

Table 97 outlines the maize yields of all maize-velvet bean trials conducted between 2009 and 2013 and measures the maize yield advantages achieved by including velvet bean as a relay crop in the treatment. In some years, the yield advantage by using velvet bean as a cover crop was higher than others but remained, on average, at 104% over the seven measured seasons. Based on this information it is possible to inform the farmers with confidence about the benefits of using velvet bean in the farming system.

Table 97. Maize yields in maize/velvet bean rotational trial, Betano, 2009-2013.

Treatment	*Maize yield (t/ha)*							
	Wet season 2009-10	*Wet season 2010-11*	*Dry season 2011*	*Wet season 2011-12*	*Dry season 2012*	*Wet season 2013*	*Dry season 2013*	*Mean yield (t/ha).*
+ Velvet bean	0.5	2.3	3.5	3.0	1.64	2.67	1.23	2.12
- Velvet bean	0.26	1.3	1.05	1.5	0.61	1.69	0.87	1.04
Yield advantage	83%	77%	233%	100%	169%	57%	41%	104%
F prob.	0.043	0.001	<0.001	<0.001	<0.001	0.007	<0.007	
LSD (p<0.05)	0.20	0.48	1.10	0.36	0.12	0.651	0.14	
%CV	43	21.7	37	13	8.7	24.6	11.3	
Velvet bean dry weight at harvest (t/ha)	9.0	10.1	0.4	10.0	1.0	0.33	1.58	
Rainfall from planting to harvest (mm)	400	500	301	424	156	719	341	

Conclusions

The velvet bean rotation trial at Betano continued to show the positive effects of cultivating velvet bean with maize. After seven rotations, the mean yield advantage of maize growing with velvet bean was 104% over treatments with no velvet bean. The long term effects on soil organic matter may also become apparent and will be measured in the future.

5.2 Weeding and plant spacing on maize yields

Introduction

Weed infestation is a major constraint to maize production in Timor-Leste. Farmers often weed two to three times each growing season to reduce the competition effects of weeds on their crops. Nut grass (*Cyperus rotundus* sp) and siam weed (*Chromolaena odorata*) are particularly prevalent in the Loes area of North West Timor-Leste. This report describes a trial conducted at Loes Research Station to investigate the control of both nut grass and siam weed in maize by changing the spacing of the crop rows plus plant spacing and by varying the number of weeding events. The objective of the research was to reduce weeding costs and increase crop yields.

Nut grass is a serious weed for a range of crops and in Loes, dramatically reduces maize yields unless properly controlled. Farmers in this environment weed their crops two to four times a season in an effort to reduce competition with their crops for sunlight nutrition, water and root space.

Siam weed is also a problem in the area and quickly takes over uncultivated areas. Crops grown into freshly prepared fields may often suffer from the weed growing in the crop.

Methods and materials

This research was conducted in Loes Research Station, Maubara Sub-District, Liquiça District from April – August 2013. The trial was designed as a Randomised Block Design with two factors - planting distance and number of weeding activities. The first factor included is planting distances (D) of; D1 (30 x70 cm), D2 (40 x70 cm), D3 (50 x 70 cm) and D4 (60 x 70 cm). Weeding (H) of siam weed were H0 (No weeding), H1 (one time weeding), H2 (two weeding times) and H3 (three weeding times). There were three replicates of each treatment composed of 48, 5 m x 5 m plots with a distance between plots of 0.5 m and 1 m between blocks.

Results

Weeding the maize crop more than twice resulted in increased grain yields (Table 98). The unweeded crop tended to be shorter, although plant height was variable and statistically non-significant. The cobs in the weeded plots were significantly larger than in those in the unweeded plots both in cob length and cob diameter. Dry weed weights measured at the end of the trial were significantly higher in unweeded plots and in those weeded only once.

In this trial, there was no interaction effect on maize grain yields of crops planted at the range of row widths and plant spacings mentioned above. This result suggests that plant spacing had no effect on siam weed populations. The trial will be repeated in future years to re-examine this this effect.

Table 98. Maize yield from number of weeding activities

Number of weeding activities	*Plant height (cm)*	*Cob length (cm)*	*Cob diameter (cm)*	*Yield (t/ha)*	*Dry weight of weeds (g)*	*1000 seed weight (g)*
No weeding	184a	11 a	3.52 a	1.56 a	9.70 c	230.6 a
1 weeding	282b	14 b	4.05 b	1.95 a	7.90 b	235.7 a
2 weeding	211 a	15 b	4.20 b	2.62 b	1.87 a	241.2 a
3 weeding	204 a	15 b	4.19 b	2.48 b	1.08 a	236.3 a
LSD 5%	27.6	1.0		0.67	1.5	22.8 (ns)

Note, value with the same letter as in line (row) or column showed no significant different in LSD 5%. (ns) No interaction between factors.

5.3 Effect of inorganic fertilizers on rice production

Introduction

Rice (*Oryza sativa L.*) yields in Timor-Leste are, in general, low compared to other parts of the world (SoL, 2010). One of the reasons for poor productivity is the low rates of fertilizers applied to the nation's paddy fields. Farmers are not in the practice of purchasing and applying inorganic fertilizers to their paddy fields resulting in potentially low levels of soil N, P and other elements. This presentation describes a trial where different rates of fertilizer were applied to a crop grown on Raimaten research station, Maliana Sub District, Bobonaro District. The objective of the trial was to determine the effects of nitrogen, phosphorus and micronutrients on the rice variety Nakroma.

Methods and materials

These trials used a split plot design with the main plots being applied with treatments of a) micronutrients alone, b) Phosphorus alone, c) Micronutrients and phosphorus together and d) the control (Table 99). Each trial had three replications. The fertilizer treatments were applied either 10 or 40 days after transplanting (DAT) or at panicle initiation. Rates and application timings were based on IRRI recommendations of starting at 30 kg N/ha (i.e. "moderate levels"). Rates of Micronutrients are based on ManTech trace elements.

Table 99. Details of fertilizer rates and timing on rice trial, Maliana

	Key		*Rates**	*Application times*[+]
Main plot factors	M	Micronutrients	3kg/ha	100%, 10 DAT
	P	Phosphorus (TSP)	20 kg/ha	100%, 10 DAT
	M + P	Micronutrients and Phosphorus	M- 3kg/ha P- 20kg/ha	100%, 10 DAT Simultaneously
	Control	No treatment		
Sub plot factors	N_0	N level 0	0 kg/ha	
	N_1	N level 1	30 kg/ha	30%, 10 DAT 40%, 40 DAT 30%, at panicle initiation
	N_2	N level 2	60 kg/ha	30%, 10 DAT 40%, 40 DAT 30%, at panicle initiation
	N_3	N level 3	120 kg/ha	30%, 10 DAT 40%, 40 DAT 30%, at panicle initiation

The trial was initially planted during the dry season of 2012 and harvested in 2013 (Table 100). The experiment was repeated during the wet season using the same treatments and rates.

Table 100. Planting and harvest details of rice fertilizer trial, Maliana, 2012-2013.

Season	*Planting date*	*Harvest date*	*Maturity (days)*	*Mean yield (t/ha)*
Dry season	12/9/2012	4/1/2013	113	4.21
Rainy season	27/2/2013	13/6/2013	105	3.98

Results

Neither the application of micronutrients, phosphorus nor the two treatments combined affected the grain yield or seed weights in either trial (Table 101). Although the application of phosphorus did appear to increase the tiller number and panicle number during the dry season trial this effect was not repeated during in the rainy season.

Table 101. Effect of P and micronutrients on rice production, Maliana Research Station

Fertilizer	*(Dry season)* Yield (t/ha)	Seed weight 100g	Tillers/ hill	Panicles/ hill	*(Rainy season)* Yield (t/ha)	Seed weight 100g	Tillers/ hill	Panicles/ hill
Control	4.32	2.48	28	104b	3.95	2.36	26	36.9
Micronutrients	4.32	2.54	27.4	97a	3.67	2.38	23.8	32.4
Micronutrients + Phosphorus	4.01	2.51	34.0	117c	3.95	2.35	25.2	34.8
Phosphorus	4.17	2.51	34.2	125d	4.34	2.39	23.3	32.3
F prob	*0.48*	*0.72*	*<.001*	*<.001*	*0.67*	*0.94*	*0.79*	*0.58*
LSD	*ns*	*ns*	*0.46*	*7.63*	*ns*	*ns*	*ns*	*ns*
% CV	*6.5*	*2.4*	*0.7*	*3.4*	*16.4*	*3.8*	*14.8*	*13*

Applying nitrogen at 30kg/ha or more did not affect grain yields or seed weights during the dry season trial (Table 102). However, grain yields significantly increased with increasing rates of nitrogen during the wet season trial despite the fact that neither the seed weight, nor tiller numbers and panicle numbers per hill increased. The number of seeds per panicle must have increased to reflect the grain yield increase. These trials will be repeated in 2013-2014.

Table 102. Effect of N on rice yields, Maliana, 2012-2013.

Nitrogen rate	*(Dry season)* Yield (t/ha)	Seed weight (100g)	Tillers/ hill	Panicles/ hill	*(Rainy season)* Yield (t/ha)	Seed weight (100g)	Tillers/ hill	Panicles/ hill
0 kg N/ha	3.95	2.48	29.8	103	2.93	2.34	22.2	31.5
30 kg N/ha	4.22	2.52	30.1	110	3.46	2.41	24	33.5
60 kg N/ha	4.34	2.51	33.9	116	4.54	2.36	25.4	34.8
120 kg N/ha	4.32	2.53	29.9	114	5.00	2.38	26.7	36.7
F prob	*0.77*	*0.63*	*<.001*	*<.001*	*<.001*	*0.56*	*0.021*	*0.04*
LSD	*ns*	*ns*	*0.57*	*5.10*	*0.50*	*ns*	*ns*	*ns*
%CV	*24*	*3.9*	*2.2*	*5.4*	*15*	*5.1*	*13.8*	*12.3*

5.4 Effect of macro and micro nutrients on maize

Introduction

During the dry season of 2012, a fertilizer experiment was carried out using an irrigated Sele seed producing maize plot on Betano Research Centre. The objective of the trial was to determine whether maize yields at Betano are limited by either or both macronutrients and micronutrients.

Betano soils are known to be very low in some essential elements, and this leads to severe yellowing of leaves of major crops such as cassava and peanuts. It is unknown if the low micronutrient level also impacts on maize yields. The trial was located in an irrigated area commonly used for multiplying seed. When producing pure maize seed, urea is generally applied twice at a rate of approximately 100 kg per hectare. It is unknown if the addition of extra nutrients will increase yields further, and increase the response of maize to the urea application.

Methods and materials

The treatments applied as a factorial combination of micro nutrients and macronutrients with 8 treatments and 3 replicates (24 plots). Each plot comprised 6 rows of maize spaced 0.75 m apart and 5.0 m in length. The size of each plot was 22.5 m^2. There were 2 levels of micronutrient applications, and 4 levels of macro nutrients. Nitrogen (100kg/ha) was applied as urea or NPK (15:15:15) with half of the N applied 2 weeks after germination and 6 weeks after germination. All the P, K and S (50kg/ha) was applied 2 weeks after germination. P was applied as superphosphate or 15:15:15, K as 15:15:15 and S as superphosphate. The Manutec trace element formulation was applied at 110 kg per hectare 2 weeks after germination.

Results

Results were analyzed through GenStat Discovery 4 using two way ANOVA. As shown in Table 103, yield was increased by the application of any fertilizer although which one was most influential is not clear. The experiment needs to be repeated at another site.

Table 103. Effect of macro and micro nutrient applications on maize, Betano, 2012

	Plants/ m^2	*Cobs/ plant*	*Seeds/ cob*	*100 grain weight (g)*	*Yield/ (t/ha)*
Treatments					
NPS+micro elements	1.33	1.83	279.4	27.0	1.77
N+micro elements	1.24	2.35	361.6	23.3	2.45
NPK+micro elements	1.41	1.63	324.3	24.0	1.59
Micro elements only	1.57	1.61	329.0	25.7	2.00
Control	1.63	1.48	299.9	24.0	1.53
NPS	1.48	1.98	343.5	24.0	2.32
NPK	1.51	2.18	267.4	26.7	2.17
N	1.57	1.71	335.0	25.7	2.30
Mean	*1.47*	*1.85*	*317.5*	*25.04*	*2.02*
F prob.	*0.52*	*0.02*	*0.88*	*0.98*	*0.05*
LSD (0.05)	*0.47*	*0.41*	*169.7*	*9.0*	*0.62*
CV (%)	*16.1*	*14.6*	*30.7*	*20.5*	*17.1*

5.5 Effect of herbicides and cultivation on nutgrass

This trial was undertaken with the aim of developing a system for controlling nutgrass (*Cyperus rotundus)* using both herbicides and cultivation techniques.

C. rotundus has been described as the world's worst weed due to its extensive distribution and ability to compete vigorously in all crops, resulting in large losses of yield (Holm *et al*. 1977; Santos *et al*. 1997) in (A. Rahman, 1998). The structure and physiology of the plant and the fact that it reproduces via underground tubers, enhances its ability to evade conventional weed suppression techniques. "A dense nutgrass infestation can contain up to 14,000 tubers/m^2, but will have only about 2200 shoots/m^2. This means that a high proportion of tubers may not be directly connected to a live shoot" (G.Charles, 2002).

The climate and topography at Loes provides perfect conditions for nutgrass growth. During the wet season, soils in the area are in excess of field capacity for long periods and lack of control measures have allowed a substantial build-up of tubers. Recent international research trials have demonstrated that in "ideal growing conditions a single tuber can produce a further 100 tubers in 90 days" (Munro & Aitken, 2011). Tubers become dormant in cold winters or during dry conditions and thus can survive for years in the soil, re-shooting when conditions become favourable to the plant.

Nutgrass when left uncontrolled has a large effect on crop yields by a combination of allelopathic affects and competition for water and nutrients. Trials undertaken between 2007 and 2010 in NSW, Australia showed sugar cane yield losses of around 30% in both plant and ratoon cane where nutgrass was allowed to grow without any control (Munro & Aitken, 2011).

Figure 37: Weed burden at Loes Research Station

With soils in Timor-Leste often in nutrient decline, the addition of weeds in the cropping system act to further lock up critical plant available nutrients. Munroe and Aitken in a trial on sugar cane found that "in moderate to heavy infestations nutgrass can take up around 25 to 45 kg N/ha that would otherwise be available to the cane crop. Similarly nutgrass above ground shoots can take up around 45 to 50 kg K/ha (equivalent to the K applied in many planting mixes). Further to this "a thick sward of nutgrass can remove the equivalent of 11 to12 mm rain from the plough layer in 4 to 8 days" (Munro & Aitken, 2011). This is critical in dry season cropping in Timor-Leste where moisture is scarce especially later in the season.

Control of Nutgrass

A variety of techniques have been developed for the control of nutgrass including cultural, biological and herbicide. In the context of trials for the control of nutgrass in Timor Leste options available include; Chemical- Round-Up (Glyphosate) and Sempra (halosulfuron-methyl) and Cultural-mechanical or hand cultivation.

Cultivation-Due to their vegetative plant structures tubers cannot survive without water. "Tubers are rapidly killed if they are exposed to very dry soil or are exposed at the soil surface after their roots are cut (G.Charles, 2002). Tubers without roots will die within a few hours when exposed at the soil surface in high, dry temperatures.

Hand Weeding- Current hand weeding or chipping techniques undertaken on farm fail to control nutgrass infestations as tubers are left in place or moved around the site.

As little data existed on *C. rotundus* control methods in Timor-Leste, the experiment was established with the objective of determining if Sempra would give more residual control of *C. rotundus* than Round-up. Cultivation was also tested in combination with the herbicide treatments to establish if this gave added *C. rotundus* control.

Figure 38. Nutgrass control using Round-up along fence line at Loes

Materials and methods

All experimentation was undertaken at Loes Research Station in Timor Leste; Longitude 8°44'09"S Latitude 125°08'24"E. The level of weed infestation was established via a site transect, establishing percentages of overall weeds and separately for *C. rotundus*.

The treatments below were combined with a factorial combination of + or – cultivation, plus three herbicide options.

The trial assessed the response of C. rotundus to Glyphosate (Round-up©) and Halosulfuron-Methyl(Sempra) using 3 treatments;

1.Round-up (360 g/L Glyphosate present as the isopropylamine salt)
2. Sempra©(750 g/kg halosulfuron-methyl) and Round-up© in a tank mix
3. Sempra followed by Round-up©

As glyphosate has been sprayed for control of *C. rotundus* at LRS, it was used as a check against the new chemical mode of action used in Sempra. Roundup was applied at a rate of 100 ml in 10 L of water plus 10 ml of wetting agent (370 g/L *Nonyl Phenol Ethylene oxide)*. Sempra was applied at 1.3 g in 10 L of water over 100 m^2+ 10 ml of wetting agent.

Each plot was 10 m x 5 m in size, with each treatment having 4 replicates in a randomised block formation (Figure 39).

S > RU	**RU + S**	**RU + S**	**RU**	**RU + S**	**S > RU**
RU + S	S > RU	RU	RU + S	RU	RU
RU	S > RU	RU + S	S > RU	RU	RU
S > RU	RU + S	RU + S	S > RU	RU	S > RU

RU = Round –up (Glyphosate)
RU + S = Round-up + Sempra (Halosulfuron-methyl) in tank mix
S > RU = Sempra then delayed application of Round-up

Cultivation
No Cultivation

Figure 39. Experimental design layout of plots.

Prior to the trial the site was left to grow without intervention, the site contained heavy infestation of *C. rotundus*, couch grass and other broad leaf weeds up to 1m in height.

Transects of the plot was conducted on a weekly basis measuring the percentage of; a) total weed kill as percentage, b) total *C. rotundus* kill as percentage, c) total nutgrass re-growth as percentage and d) number of *C. rotundus* plant re-growth per 10 x 10cm sample area.

The treatments included two separate sprays and cultivation over half the plots. A three way Anova was undertaken Using GenStat© 15 Edition SP1, analysing interactions between treatment, cultivation and date.

Results

The results from the experiment showed that significant differences occurred between herbicide treatments. Both herbicides tested were shown to control total weeds and total *C. rotundus* populations effectively, but differed in their ability to control *C. rotundus* re-growth.

Total weed kill

There was significant effect ($p<0.05$) of Date, Cultivation and Treatment on Total Weed Kill. Significant interactions occurred between Date and Cultivation, and Cultivation and Treatment.

All herbicide treatments showed very effective kill rates over all weeds of 95%. Cultivation plots was shown to significantly ($p<0.05$) improve total weed kill.

Total *C. rotundus* kill

Date, cultivation, and treatment all had a significant effect ($p<0.05$) on total *C. Rotundus* kill. Interactions of Date x Cultivation and Date ,Cultivation, and Treatment occurred in this measurement.

The kill rate of *C. rotundus* was also over 95 % for all herbicides used. Cultivation resulted in a slightly better *C. rotundus* kill rate than non-cultivation (approx. 1%).

***C. rotundus* re-growth**

% Regrowth

There was significant effect ($p<0.05$) of Date, Cultivation, and Treatment on % *C. rotundus* Re-growth. Interactions of Date/Treatment, Cultivation/Treatment and 3 way interaction between Date/Cultivation/Treatment occurred.

Results from the % re-growth of *C. rotundus* show the 2 treatments containing Sempra, significantly ($p<0.05$) increased the control of re-growth of *C. rotundus*. Round-up had approximately 9% re-growth of *C. rotundus* compared to the Sempra treatments with approximately 3%. This trend was also seen in the *C. rotundus* plant re-growth result with Round-up having double the plant re-growth as the Sempra treatments (Figure 40).

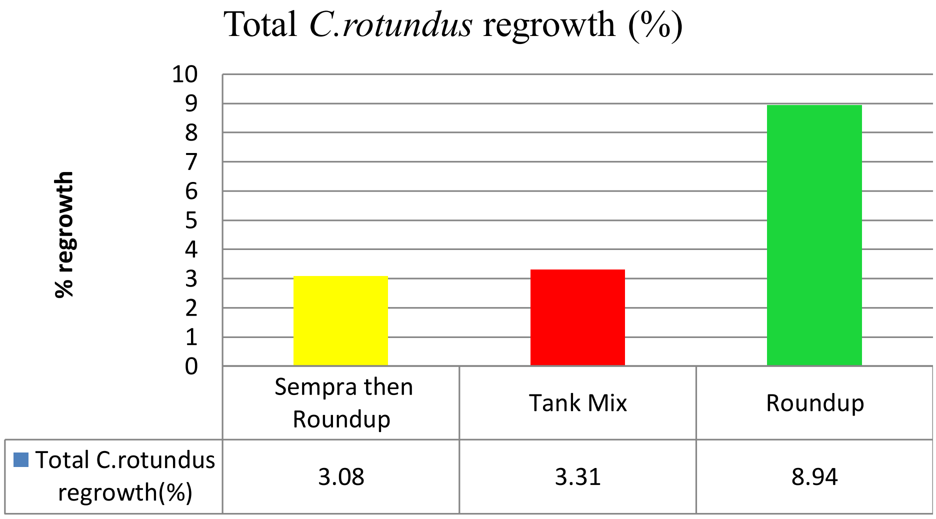


Figure 40. Total *C. rotundus* re-growth (%) during trial.

The effect of cultivation on both herbicide effectiveness and *C. rotundus* re-growth increased effectiveness of herbicides and reduced the *C. rotundus* re-growth across all herbicide modes of action. Re-growth percentage was half that under cultivation compared to no cultivation (3.6% re-growth compared to 6.6 % re-growth). The *C. rotundus* plant re-growth also showed this trend although the results were not significant.

C. rotundus percentage re-growth after an application of Sempra both in tank mix and followed by Roundup reduces the amount of nutgrass that re-grows after treatment when compared to Roundup (Figure 41).

The three way interaction of Date/Cultivation/Treatment in % *C. rotundus* re-growth are shown in Figure 42 and Figure 43 below. The percentage re-growth after spray events 12/6 and 1/8 show cultivation reduces % re-growth (Figure 42). Cultivation also reduced the differences between herbicide treatments compared with no cultivation (Figure 41). No cultivation shows Round-up treatments with 30-35% re growth 3-4 weeks after spray compared to Round-up plus Sempra tank mix below 13% re-growth.

Spray event

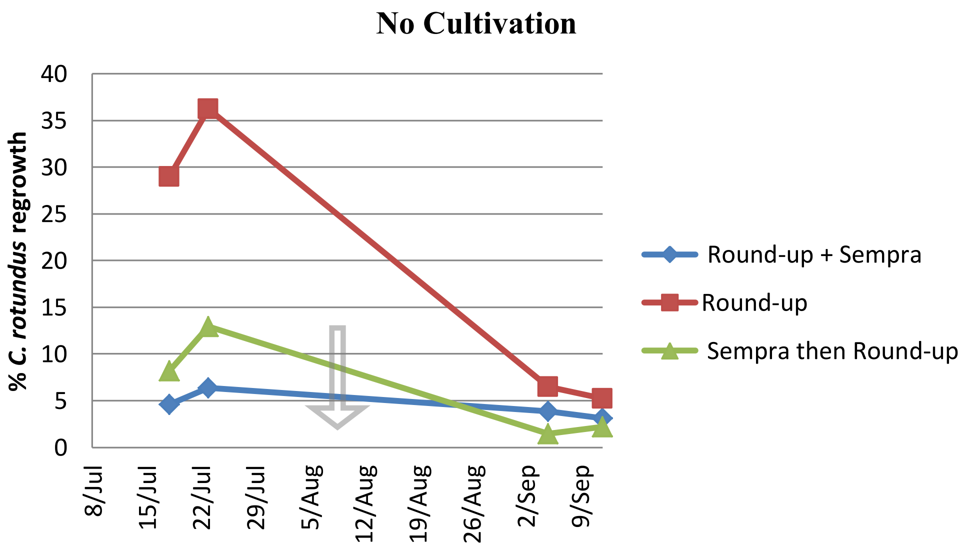


Figure 41. Percentage *C. rotundus* re-growth with no cultivation

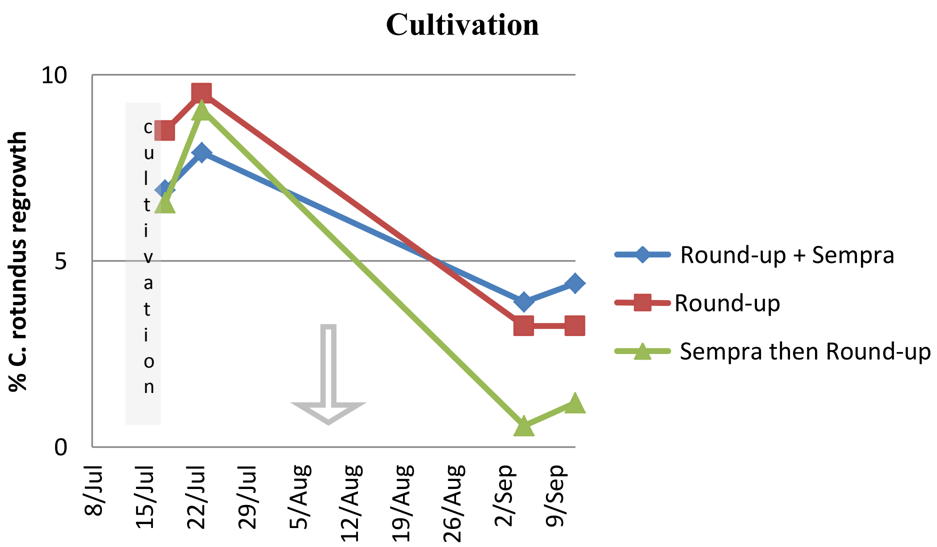


Figure 42. Percentage *C. rotundus* re-growth with cultivation

Number of plant re-growth.

There was significant effect ($p<0.05$) of Date and Treatment on Number of plant re-growth.

Interactions occurred between Cultivation and treatment. Figure 43 below shows Round-up had clear and significant effect on Number of plant re-growth, approximately doubling the plant re- growth with no cultivation from 1 plant/100cm^2 to 2 plants/100cm^2.

Cultivation in both measurement of re-growth (% re-growth and number of plant re-growth) was shown to have mixed impacts upon Sempra treatments. Cultivation was shown to either increase or decrease *C. rotundus* re-growth dependent upon the treatment and the result measure (Figure 43).

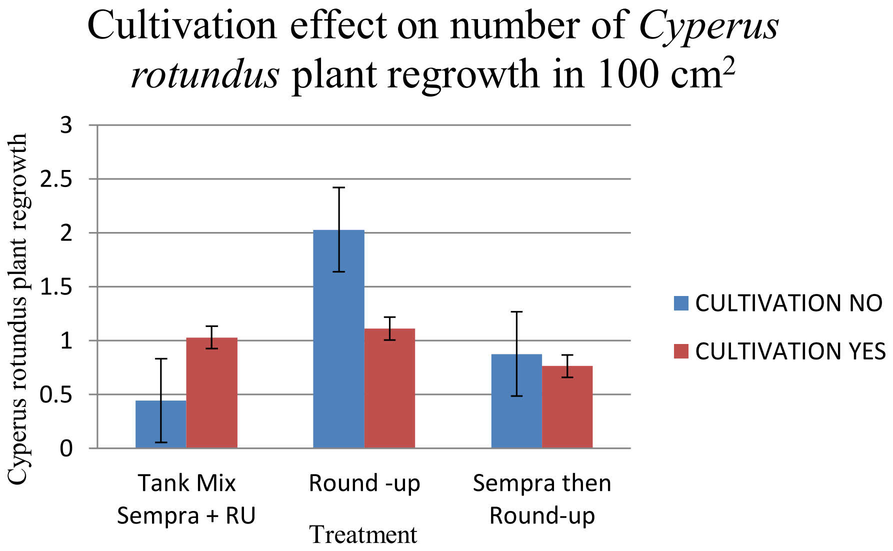


Figure 43. Number of *C. rotundus* plant re-growth measured after cultivation.

Discussion

All herbicide treatments used had good initial effectiveness against *C. rotundus*, this demonstrated that glyphosate (Round-up) and/or Halosulfuron (Sempra) used with Round-up can be an important knockdown option in cropping systems at Loes and more broadly in Timor-Leste. Roundup has the added benefit of no residual effect and reduced plant-back times over those of Sempra. Round-up worked more effectively on actively growing weeds and will be beneficial after cultivation and before planting due to its short plant back restraints.

Importantly in long-term control of *C. rotundus*, it was demonstrated that glyphosate was less effective in terms or the amount of *C. rotundus* that re-grows after herbicide treatment. The tank mix of Sempra and Round-up and the Sempra followed by Round-up treatments were shown to have the lowest re-growth of C. rotundus. The combination of knockdown glyphosate with halosulfuron-methyl which gives longer control of *C. rotundus* will be an important tool in land management. This tank mix will be most important in preparation for maize planting as follow-up Sempra treatment can be over maize in crop (Nufarm, 2005). This tank mix will also be useful to prepare ground for fallow, by spraying large areas of heavy infestation of *C. rotundus* before cover crops are planted.

Cultivation of trial areas reduced re-growth of *C. rotundus* in the Roundup and the Sempra Roundup tank mix treatments, this was partly due to herbicide activity upon actively growing weeds, younger plants allowed herbicide to perform better. As the dry season continued the soil dried out quicker in the cultivation plots and caused some soil surface tubers to dry out.

Non cultivated plots demonstrated high levels of mulch cover, increasing soil moisture and could have increased weed germination and improved *C. rotundus* tuber viability especially late in the dry season.

Recommendations for *C. rotundus* control need to fit within a farm-wide weed management strategy across the farm. C. rotundus can only be managed using a long-term, integrated weed approach (G.Charles, 2002). Most infestations are caused by tubers being spread from field to field and farm to farm by machinery (G.Charles, 2002). It is therefore essential that nutgrass infestations are managed not just in-field, but also on roadways, channels and on tractors and implements between use (G.Charles, 2002).

Conclusions

The results show that the use of Sempra combined with Round-up either in a tank mix or delayed spraying significantly reduced the re-growth of C. rotundus at Loes Research Station. Both the Sempra treatments will be effective whenever determined eradication is undertaken, fallow or cover crops are to be used. Sempra also fits in well with maize production.

The use of targeted and timely Roundup usage will be very important in C. rotundus control especially directly before cropping and in crop where appropriate. Glyphosate is important chemical option in total weed management due to its ease of use and short plant-back period and low cost. Timing will be important in herbicide application, regardless.

Developed from the information analysed in this trial has been used to produce a technical sheet on control of C. rotundus both in fallow and in-crop during maize cropping. Further work was also conducted on-station to test plant back times for; cassava, mung bean, peanut, sweet potato and maize.

Further consideration of cost per hectare and availability of herbicides for control measures of C. rotundus needs to be considered in the context of weed control in Timor-Leste. Testing of herbicides in the wet season will be required to test the control methods in the main cropping season when the conditions for will be conducive for C. rotundus tuber multiplication.

6. Social science research

6.1 OFDT Farmers baseline data (*Buka Dadus Los*)

During the 2012-2013 growing season, 143 households participated in 143 OFDTs in eight districts (Ainaro, Aileu, Baucau, Bobonaro, Ermera, Liquiça, Manufahi and Viqueque). This number was smaller than the number of OFDTs in 2011-2012 (225), 2010-2011 (277) and in 2009-2010 (480).

Household farmers were surveyed and interviewed to collect information on their household conditions and agricultural practices. This survey is called *Buku Dadus Los* (BDL) which means ‘looking for reliable data’ in Tetun. The BDL survey provides information about the number of people in the household, the gender of the head of the household, housing condition, household food security, success or failure of harvests, and measurement of household wealth. For 2012-2013, BDL data is available for 143 farmers, but the data are not always complete for each household.

Farmer households and gender participation

Agriculture in Timor-Leste is a collective activity in which most household members participate. For example, young men tend animals and old-age family members perform light tasks such as milling grain. In 2012-2013, most farmer households that took part in OFDTs had three to nine members to share their workload; on average there were 6.8 members in a household (Table 104). A larger household with more than ten members is considered an extended family that lives in the same house. Such an extended family usually includes grand parents, parents and children.

Table 104. Number of members of OFDT households, by District

Members per household	*District*								*Total*	
	Aileu	*Ainaro*	*Baucau*	*Bobonaro*	*Ermera*	*Liquiça*	*Manufahi*	*Viqueque*	*No.*	*%*
2		1	1					2	4	3
3	4		1	2					7	5
4		1	3	4			1	4	13	9
5			3	4	2	2	1	2	14	10
6	3		2	1		1	2	9	18	13
7	2	2	2	2	1	3	4	6	22	15
8	1	1	5	1	2	3	1	2	16	11
9			2	3		1		1	7	5
10		1	1	3					5	3
11		1					2		3	2
12		1		1					2	1
13		1	1		1				3	2
No data	*12*		*1*	*2*	*2*	*1*		*11*	*29*	*20*
Total	*22*	*9*	*22*	*23*	*8*	*11*	*11*	*37*	*143*	*100*

Although farmer households operate as production units, the head of the household is considered as the senior person in the household. Most head of the households are men, but regularly women take on such responsibilities within the household. During the 2012-2013 season, 24% of the surveyed households were headed by women and 76% by men (Table 105). There was no change in gender participation in OFDTs in 2012-2013 compared to 2011-2012.

Table 105. Gender participation as heads of households, 2012-2013

		Number			*Percentage*	
District	*Sub district*	Women	Men	*Total*	Women	Men
Aileu	Aileu villa	9	8	17	53	47
	Laulara	1	1	2	50	50
	Remexio	2	1	3	67	33
Ainaro	Maubisse	3	6	9	33	67
Baucau	Baucau villa	2	14	16	13	88
	Vemasse	1	5	6	17	83
Bobonaro	Balibo		8	8		100
	Bobonaro	3	6	9	33	67
	Maliana	2	4	6	33	67
Ermera	Hatolia	1	7	8	13	88
Liquiça	Liquiça Villa	3	8	11	27	73
Manufahi	Alas	2	9	11	18	82
Viqueque	Ossu	3	16	19	16	84
	Viqueque Villa	2	16	18	20	80
	Total	*34*	*109*	*143*	*24*	*76*

Food crops

Farmers in Timor-Leste grow a wide range of crops to reduce the risk of harvest failure of one or two commodities. The list of crops grown by 139 of the 2012-2013 OFDT farmers is given in Table 106.

Table 106. Food crops planted in house gardens or bush gardens (N=139)

Crops planted			Total	
English	Tetun	Latin	Number	Percentage
Long season maize	Batar Bot	*Zea mays L.*	115	83
Cassava	Aifarina	*Manihot esculenta Cranz*	104	75
Pumpkin	Lakeru	*Cucurbita spp*	100	72
Sweet potatoes	Fehuk midar	*Ipomea batatas L.*	91	65
Short season maize	Batar Lais	*Zea mays L.*	73	53
Taro	Talas	*Colocasia esculenta*	72	52
Irrigated rice	Hare irigasaun	*Oryza sativa L.*	51	37
Cucumber	Pipinho	*Cucumis sativus*	51	37
Cowpea	Foretalin	*Vigna unguiculata subsp. sesquipedalis*	48	35
Wild yam	Kumbili	*Dioscorea spp.*	46	33
Arrow root	Kontas	*Maranta arundinacea*	46	33
Sorghum	Batar hun a'as	*Sorghum bicolor L*	43	31
Upland rice	Hare rai maran	*Oryza sativa L.*	38	27
Irish potatoes	Fehuk ropa	*Solanum tubersosum L.*	32	23
Red beans	Koto mean	*Phaseolus vulgaris*	32	23
Elephant foot's yam	Maek	*Amorphophallus paeoniifolius*	28	20
Peanuts	Forerai	*Arachis hypogaea L.*	24	17
Yam bean	Singkumas	*Pachyrhyzus erosus L.*	11	8
Mung bean	Foremuunggu	*Vigna radiata*	10	7
Banana	Hudi	*Musa spp*	6	4
Watermelon	Pateka	*Citrullus lanatus*	5	4
Other maize	Batar seluk	*Zea mays L.*	2	1
Pineapple	Ainanas	*Ananas comosus*	2	1
Eggplant	Brinjela	*Solanum melongena L.*	2	1
Bitter bean	Kotomoruk	*Phaseolus lunatus L.*	1	1
Papaya	Aidila	*Carica papaya L.*	1	1

Risk of harvest failure is also reduced by intercropping practices and by growing a wide range of crops on the farm. The principal crops that farmers grow are: maize, cassava and pumpkin. Consumption of such home-grown food is complemented with beans, peanuts and other traditional crops. Irrigated rice was cultivated by 36% of the OFDT households and dry land rice was cultivated by 27% of them. These are 7% and 24% increases respectively for the same commodities compared to 2011-2012.

Beside growing food crops, a small number of OFDT farmers (1-4%) also grew fruit crops (such as banana, watermelon, pineapple and papaya) and horticulture crops (e.g. eggplant) in their home gardens (a plot next to the house) and bush gardens. Wild food such as elephant foot's yam and bitter beans also grown by farmers, 20% and 1% respectively.

The distribution of the number of crops grown by OFDTs farmers (Figure 44) indicates that, if possible farmers prefer to cultivate many crops to reduce the risk of lack of food or income loss because of harvest failure. Around 65% of farmers cultivated 4-11 food crops.

Table 106 also shows that tuber crops are important food crops for farmer households. These crops (e.g. cassava and sweet potatoes) can be harvested at any time to supplement maize and rice during the hungry seasons. Tuber food can be kept in the ground and farmers can harvest it anytime whenever they need it, as with wild food gathered from surrounding forests.

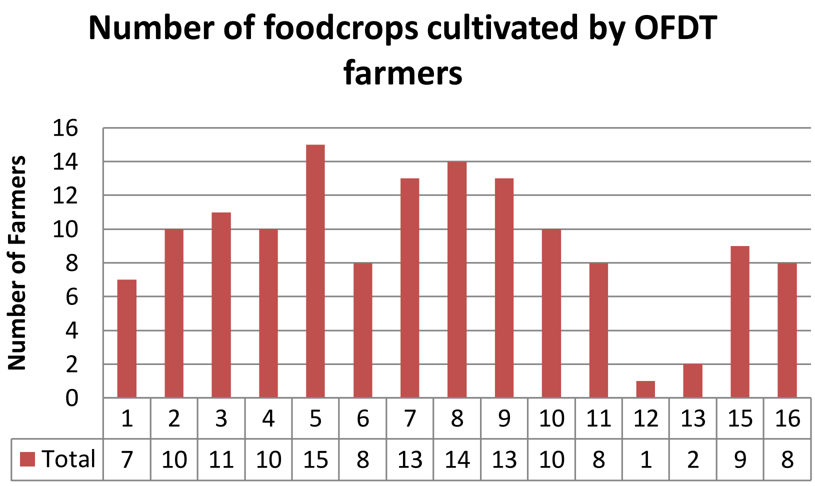


Figure 44. Number of crops cultivated by OFDT farmers (N= 139)

Food security

Data from the survey provide information on maize adequacy for domestic consumption of the OFDT farmers (see Table 107). The respondents were asked if their last harvest of maize was sufficient for their household need during the year or not, or if they had a surplus.

The data on food security indicates that farmers who reported that their maize harvest in 2012-2013 was not enough to meet their food need over the year amounted to 35%. The percentage of women who reported that their maize was not enough for their yearly consumption was higher than the percentage of male headed OFDT households.

Comparing the 2012-2013 figure with those of previous years (Table 108)., the percentage of farmers with insufficient food stocks was smaller this year than in 2011-2012, but still high in comparison for the six years. The data indicates that all farmers in Ainaro (100%) reported that their maize was insufficient for consumption over the year, whereas in 2011-2012 that figure stood at 42%; it was the smallest one among the six districts in that year. In contrast, the percentage of farmers who reported that they had surplus grain was higher this year (17%) than in 2011-2012, when it was only 8%.

Table 107. Respondent measures of food sufficiency (maize)

	Insufficient		*Surplus*		*Sufficient*		
District	*Number*	*%*	*Number*	*%*	*Number*	*%*	*Total*
Aileu	6	30	7	35	7	35	20
Ainaro	9	100					9
Baucau	2	9	4	18	16	73	22
Bobonaro					6	100	6
Ermera	6	75			2	25	8
Liquiça	2	20	3	30	5	50	10
Maliana			2	12	15	88	17
Manufahi	1	33			2	67	3
Viqueque	18	56	6	19	8	25	32
Women	*12*	*40*	*7*	*23*	*11*	*37*	*30*
Men	*32*	*33*	*15*	*15*	*50*	*52*	*97*
Total	*44*	*35*	*22*	*17*	*61*	*48*	*127*

N=127

Table 108. Respondent food security over years (maize)

Year	*Insufficient* %	*Sufficient* %	*Surplus* %	*Number of respondents*
2007-2008	38	47	15	502
2008-2009	29	54	17	262
2009-2010	16	73	11	354
2010-2011	21	72	7	232
2011-2012	47	45	8	114
2012-2013	35	48	17	127

The survey also asked the respondents who had insufficient maize reserves when they ran out of stock. Figure 45 shows when this happened in 2012-2013. Based on the response of six OFDT farmers (from the 44 who reported they had insufficient maize), four of the six respondents run out of stock in June.

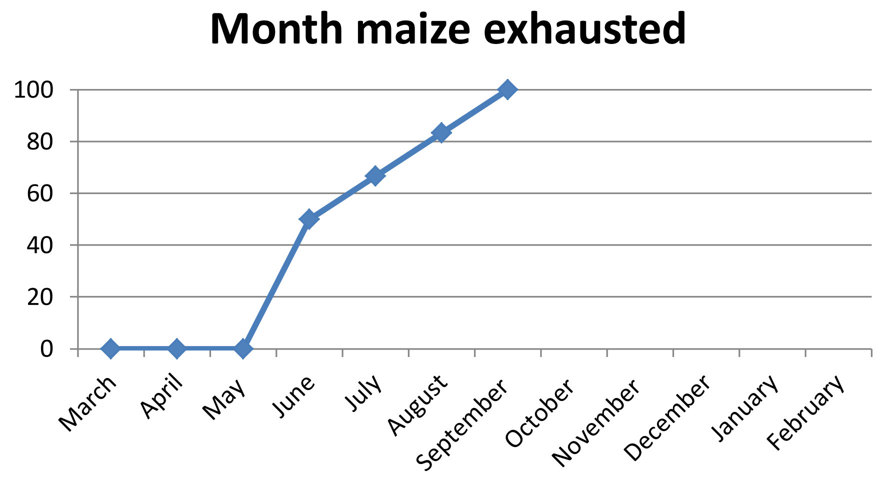


Figure 45. Maize sufficiency in farm households (2012-2013)

Comparing the data on food sufficiency of self-grown maize over the last five years, the data in Table 108 and Figure 45 indicate that farmers had much less maize in 2010-2012 an then in 2012-2013. As reported in the SoL Annual Report 2012, there were heavy rains during the planting period in the second half of 2011, which was longer than usual and, because of this, crop production was lower which caused farmers to run out of maize quicker in 2011-2012 than in previous years.

The BDL survey also records data on causes of harvest failure. In 2012-2013, late rain was the most often reported cause of harvest failure (Table 109). Nine and one respondents reported that their harvest failed due to late rains and lack of rain respectively, and one respondent reported that his maize was damaged because of rats. Only 11 respondents reported on causes of crop damages which only accounted for 8% of the total respondents surveyed in 2012-2013.

Table 109. Farmer's perceptions of factors reducing harvest yields by district

District	*Lack of rain*	*Rats*	*Late rains*
Aileu		1	
Ainaro			9
Ermera	1		
Total	1	1	9
% causes	9%	9%	82%
% farmers reporting damages	7%	7%	60%

Common practices of storage of maize seed and seed from other food crops are presented in Table 110. The most common method of seed storage practiced by farmers in the eight districts was above the fire place (41%). The other methods commonly used by farmers to store seeds was in a tree and in a drum (16% and 15% respectively). Storing/hanging in trees can reduce the risk of seeds being eaten by animals. Storage in a drum is a modern technology used by farmers to store seeds. The use of drums by farmer in 2012-2013 was higher than in 2011-2012 (15% vs. 4%). The use of airtight drums reduces the level of oxygen in the drums, and the weevils cannot survive. To a lesser extent, some farmers used two storage methods (see Table 110)

Table 110. Storage methods for maize seed (and other crops)

	District								Ave
	Aileu	*Ainaro*	*Baucau*	*Bobonaro*	*Ermera*	*Liquiça*	*Manufahi*	*Viqueque*	
Method	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Above the fire	21	56	32	27	88	44	100	48	41
In a tree	42		9	18				17	16
Drum	16	11	18	23	13	33			15
Inside the house								35	7
Bamboo platform			32						6
Tree & Jerry can	21		9	5					6
Sack		33							3
Above fire & drum				18					3
Jerry can				5		22			3
Above fire & silo				5					1
Total # respondents	19	9	22	22	8	9	3	23	115

Economic status

To assess the socio-economic condition of the households that participate in OFDTs, two measurements are used: the condition of the house, and ownership of a range of household assets. The materials used for the house construction is considered a key indicator of the financial capacity of the farm household. This can be seen from the three components: roof structure, wall structure and floor structure. The housing condition of the OFDT households is presented in Table 111.

Table 111. Housing conditions of OFDT farmers across the eight Districts

District	*Aileu*	*Ainaro*	*Baucau*	*Bobonaro*	*Ermera*	*Liquiça*	*Manufahi*	*Viqueque*	*Average*
Number	*19*	*9*	*20*	*23*	*8*	*10*	*8*	*32*	*129*
	%	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Corrugated iron roof	86	100	100	30	25	87	60	63	68
Corr. iron & other roof				17				19	8
Bamboo	5							3	2
Palm leaves & thatch	5			52	75	19	48	16	23
Full block wall	32		5		25	29		9	12
Concrete/brick	32		5		25	10		9	10
Rock						19			2
Half block wall	27		20	35		10		3	15
Non-brick walls	42	93	74	65	75	68	84	87	72
Bamboo	27		39			10		50	23
Earth		81	5	17					9
Palm trunk	5		25	48	75	48	84	25	33
Timber	5		5			10		6	4
Zinc	5	12						6	3
Cement & ceramic floor	59	46	20	74	25	39	12	13	36
Non-cement floor	43	58	79	26	75	48	96	87	64
Soil	43	58	79	26	75	48	96	84	63
Wood								3	1

The majority of households (76%) that participated in the 2012-2013 OFDTs had roofs of corrugated iron, or corrugated iron combined with other roof materials. This is an increase by 8% over the figure of 2011-2012. In 2012-2013, the percentage of OFDT farmers whose house had the same type of roofing accounted for 62% (see Table 113). The majority of OFDT farmers had walls and floors structures of non-brick (72%) and non-cement materials (64%) respectively. This was smaller than the figure in 2011-2012.

The housing condition and the ownership of household goods of the households that participated in OFDTs indicates that the OFDT households of 2012-2013 were wealthier than the OFDT households from 2011-2012 (Table 112 and Table 113).

Table 112. Ownership of household goods, 2012-2013

	District								*Average*
	Aileu	*Ainaro*	*Baucau*	*Bobonaro*	*Ermera*	*Liquiça*	*Manufahi*	*Viqueque*	
Item held	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*	*%*
Chairs	77	100	82	87	25	82	88	79	79
Telephone	77	100	82	65	25	45	75	76	71
Radio	77	100	82	39	25	55	25	52	59
Drum	27	33	27	57	25	73		33	36
Television	50	44	23	26		27		9	24
Bicycle	9	33	23				63	12	14
Motorcycle	18	33	23	9		9	13	3	13
Rice mill			5	4		18		3	4
Refrigerator	18					9	13		4
Car	9								1
Boat								3	1
Generator	5							3	1
Total # respondent	22	9	22	23	8	11	8	33	136

Table 113. Wealth measures across years

Description	*2006-07*	*2007-08*	*2008-09*	*2009-10*	*2010-11*	*2011-12*	*2012-13*
	%	*%*	*%*	*%*	*%*	*%*	*%*
Tin/board roof	n/a	76	69	79	70	62	76
Full block wall	n/a	19	17	24	24	13	12
Half block wall	n/a	22	10	13	13	12	15
Cement / floor tiles	n/a	34	22	35	30	19	36
Mobile phone	3	10	6	43	65	35	71
Motorbike	5	5	3	11	22	10	13
Car	2	3	1	2	4	0.9	9
Diesel generator	3	3	2	3	9	1.4	1
Total # respondent	340	502	362	354	237	156	136

Conclusion

The information obtained from the BDL data indicates that farmers who were involved in OFDTs in 2012-2013 were subsistence farmers cultivating a wide range of crops to reduce the risk of insufficient food. Thirty five per cent of the farmers involved in the 2012-2013 OFDTs ran out of maize before the end of the growing season, and most stocks were exhausted during the period June-August, which would force the farmers to switch to tuber crops and to forage for wild food to meet their household food demands.

6.2 Impact of imported rice on agriculture in Timor-Leste

Introduction.

The "Impact of Imported Rice" study evaluated the cost effectiveness of importing rice into Timor-Leste compared with local production. Multiple analyses were required to complete the study. These included (i) calculating the domestic demand for and supply of rice; (ii) reconciling rice imports by the private and public sectors; (iii) reconciling rice distribution by the public sector; (iv) preparing a rice supply and demand "balance sheet" and; (v) the use of rice production cost models based on the construction of new irrigation schemes, the rehabilitation of currently damaged and inoperable schemes, and low cost ground water schemes.

Results and discussion

Inconsistent data sets from the various sectors limited the accuracy of the results. However, very strong relationships emerged from the study with the key conclusion being that it is far more expensive for Timor-Leste to grow rather than to import rice, at least in the current agriculture environment in which sectorial investment is heavily skewed in favour of irrigation infrastructure. Rice imports in 2012 cost about $53 million per year ($660/Mt for 80,000 Mt) whereas it would cost $188 million per year ($2,350/Mt) to grow the equivalent tonnage under the current rice production systems. If a more efficient and cheaper irrigation system was feasible (perhaps based on tube-wells and small pumps, and more intensive use of production inputs and improved market support) the economic cost of growing rice in Timor-Leste would be less than the cost of importing rice; about $410/Mt compared with $660/Mt. The construction costs of seven proposed irrigations schemes would be about $9,000 per ha over 9,920 ha for rehabilitation and about $860 per ha per year to operate and support. These figures are very high by international standards and range from about $1,975 to $15,545/ha depending on crop yields, crop prices and cropping intensity assumptions.

The report also concluded that there is anecdotal evidence that 30,000 Mt of highly subsidized rice (sold for about $12.00/25 kg, or $0.48/kg) imported in 2010-2011 impacted on the incentive for farmers to grow more than their families' subsistence requirements. Farmers were, at the time, reporting: "there is no point in growing more rice as there is plenty of cheap rice in the market and even if we did grow more rice there are no markets for our surpluses".

In the longer-term the direct impact of importing (say) 80,000 Mt of rice valued at $52.8 million every year is obvious – Timor-Leste's rice farmers are not earning $52.8 million from the sale of domestically produced rice to local traders or MCIE, assuming that MCIE/Government is willing to absorb transaction and storage costs.

6.3 Effect of imported maize seed on agriculture in Timor-Leste

Introduction.

MAF has been importing mainly maize and some rice seed since independence. The early rationale behind this practice was that many farmers lost their seed stocks at the end of the Indonesian occupation, and again in 2006 when cropped areas were small and therefore retained low levels of seed stock.

Ten years later, and with projects/ programs such as MAF-SoL, three Rural Development Programs, and numerous NGO-supported activities focusing on seed production, distribution, and on-farm storage, the following question needs to be asked: "What is the impact of continued seed importation by MAF on: (i) longer-term staple food production; (ii) the entrenched "hand-out" mentality in rural communities; (iii) longer-term sustainability to establish communal seed production and storage groups; and (iv) MAF's operational budget in terms of the direct and opportunity cost".

Results and discussion

The study concluded that the practice of importing maize (and rice) seed and distributing it free-of-charge to Timor-Leste's farmers was a good measure to provide seed of improved varieties to farmers in early post-conflict situations. However, the practice is costly and may have a major and negative impact on staple food production and the emerging domestic seed industry in the long term. Modelling completed during the study showed that imported seed costs nearly $20.00/kg when the direct cost of inefficient seed distribution and the opportunity cost of production foregone are included. The Net Present Value of the two benefit streams (from the two options - import seed or produce locally) was calculated at $32.00/kg. There is now an opportunity to grow seed locally through the National Seed System for Released Varieties (NSSRV).

The report also expressed an opinion that the practice of handing out free seed is reinforcing an entrenched "dependency" mentality amongst Timor-Leste's farmers. This will become increasing difficult to break unless some examples (such as no more free seed) are set and adhered to. As a result of discussions on the economic cost of imported seed, the MAF plans to purchase some of its seed requirements from farmers associations in 2013.

6.4 Targeting vs. non targeting of free seed on crop production

Introduction.

This case study focused on the impact of free seed distribution by Government (MAF), FAO, NGOs etc. on different segments of Timor-Leste's seed market. Particular emphasis was placed on the use of seed sourced from the formal sector multiplied by MAF-SoL. Consideration of the return on MAF-SoL's investment in formal seed production was also included in this case study. The intention was to examine two issues in particular: (i) planning for formal seed production and attempting to minimise the production of surplus but expensive formal seed which is given away free-of-charge; and (ii) targeting those segments of the seed market which are least likely to buy seed, so a surplus of formal seed doesn't "cannibalise" the informal seed market.

The study required the preparation of complex models which reflect different combinations of seed sources and seed targeting, depending on which agency/ organization is responsible for seed sourcing/ production, and its distribution. These models enabled a comparison between net annual benefits flows to determine different impacts; and the comparison of the Net Present Values (at 30%) of differential net benefit flows to determine the opportunity costs of sub-optimal and inefficient practices, such as non-targeted seed distribution.

Results and discussion

Incremental benefits from targeting seed distribution are very large. Modelling shows that the annual cost to Timor-Leste of persisting with the practice of not targeting seed distribution could be as high as $26.00 million per year, based on 50 Mt of seed. Even if formal seed costs $30/kg, and is targeted, the NPV of incremental benefit flows is strongly positive at a discount rate of 60%, indicating a very acceptable rate of return from investment in formal seed production. It is therefore important that the MAF, development partners and NGOs target (and support) their seed distribution activities and that investment in formal seed production continue. It may be possible to reflect the impact of successful community seed production groups on seed supplies, by reducing the need for breeder and foundation seed because farmers are able to retain their own seed. A well-targeted seed system is able to achieve a simple rate of return of about 30%.

6.5 Complementarity between seed production and improved seed storage in Timor-Leste

Introduction.

Post-harvest losses of maize stored using traditional methods are high in Timor-Leste. The traditional method is to store unsheathed cobs above the fireplace, in trees and other places in or close to the house. Losses within 12 months of storage with these methods can be as high as 50%. The main losses are due to weevil damage (*Sitophilus zeamais*) but rats and other forms of deterioration also contribute (SoL, 2012). Many farmers are knowledgeable about the benefits of storing grain in clean drums with the lid screwed tight. In these conditions, the weevils do not live and the grain will remain undamaged (or not eaten by rats and other pests) for 12 months or more. One project, the International Fund for Agriculture Development (IFAD) funded Timor-Leste Maize Storage Project (TLMSP) commenced to distribute drums to poor farmers in 2013. There is potential for collaboration between the HYV identification and seed production activities promoted by the Seeds of Life program and the IFAD-funded Maize Storage Project. This study examined the financial and economic benefits of both programs collaborating closely to complement each other's activities.

In order to estimate the degree of complementarity between MAF-SoL and TLMSP it was necessary to design four "with project" (WP) and "without project" (WOP) production and financial models. These were: (i) neither MAF-SoL nor TLMSP (the base case); (ii) MAF-SoL only; (iii) TLMSP only; and (iv) MAF-SoL and TLMSP together. The differential outcomes between these models (in terms of incremental maize supplies and equivalent annual increased cash flows) indicate the degree of complementarity between the models.

Financial analysis is analysis at the farm-level and indicates the direct benefits for farmers and their families, whereas economic analysis assesses incremental benefits (differentials between models) in terms of the impact on Timor-Leste – based on the economic value of incremental supplies of staple food.

The key variables "driving" the analytical models relate to maize storage losses (percent) and the number of 200 litre storage drums used by maize growing families. The main assumptions which underpin the financial and economic models include household grain production, grain consumption, grain storage losses, retained seed, grain sales, grain purchases, hired labour, storage maintenance costs, and improved storage capacity.

Results and discussion

The results indicated that there would be considerable complementarity between MAF-SoL and TLMSP if these programs were implemented in unison in the same target districts, sub-districts and sucos. For example the NPV (30%) of incremental net farm income from maize growing with MAF-SoL alone is estimated to be $535. This would increase to $820 with MAF-SoL and TLMSP. Contributions to this increase would be about 35% from TLMSP and 65% from MAF-SoL.

In terms of returns to family labour-day, it is estimated that MAF-SoL alone would increase this figure by $1.07 per day, and TLMSP alone by $0.62 per day. When combined the two programs would increase returns per labour-day by $1.70, a significant figure when it is considered that the current unskilled daily wage rate is about $3.00. Contributions to this increase would be about 36% from TLMSP and 63% from MAF-SoL.

There would also be considerable economic complementarity between MAF-SoL and TLMSP. For example the NPV (30%) of incremental benefits from maize growing with MAF-SoL alone is estimated to be $408. This would increase to $549 with MAF-SoL and TLMSP. Contributions to this increase would be about 26% from TLMSP and 74% from MAF-SoL.

These conclusions are as expected, and the incremental financial and economic returns and benefits generated through joint program implementation are substantial. In addition “twinned” implementation would reduce the risks faced by the individual programs, and lead to more efficient allocation of MAF’s resources.

7. Climate and Cropping Systems

7.1 Meteorology with automatic weather stations

In October, 2012, 20 automatic weather stations were installed in 8 districts of Timor Leste to complement the existing network of rainfall gauges. These weather stations consist of 3 basic types: the standard Hobo weather station for research stations, the micro Hobo research station for OFTDs and the Data Garrison station uploading to the internet at Atauro and Oecussi. Each station records information on rainfall, temperature, solar radiation, humidity and wind speed at 10 minute intervals (except Oecussi and Atauro).

Figure 46. Micro Hobo automatic weather station at site in Balibo, Bobonaro

Figure 47. Map of automatic weather stations

Table 114. Automatic weather station locations with daily averages at each site 2012-2013.

Station Location					*Daily Average*							
Station	*District*	*Latitude*	*Longitude*	*Alt (m)*	*Rain (mm)*	*Temp Max (°C)*	*Temp Min (°C)*	*RH Max (%)*	*RH Min (%)*	*Solar Radiation ($MJ/m^2/day$)*	*Wind Speed (m/s)*	*Gust Max (m/s)*
Quintal Portugal	Aileu	-8.70451	125.5648	980	4.3	27.8	16.0	99.3	58.2	16.3	0.3	6.0
Urulefa	Ainaro	-8.83692	125.6124	1316	6.9	24.7	13.9	99.5	64.7	15.4	0.5	6.3
Darasula	Baucau	-8.5351	126.3465	690	5.0	28.0	18.5	96.1	67.5	15.5	0.5	5.7
Loes	Liquiça	-8.73720	125.13956	22	4.3	32.4	22.4	98.0	60.9	18.7	0.9	5.9
Betano	Manufahi	-9.16303	125.7185	9	6.3	31.2	23.0	95.0	67.2	17.1	1.1	6.3
Acumau	Aileu	-8.61661	125.6385	975	4.3	25.2	18.9	96.0	68.1	13.6	0.7	5.7
Seloi Malere	Aileu	-8.73364	125.5607	925	6.1	28.3	16.0	99.2	55.8	15.7	0.2	5.4
Aituto	Ainaro	-8.89135	125.59658	1667	6.9	22.1	14.9	98.4	65.4	14.1	1.0	8.2
Fatulia	Baucau	-8.65613	126.36072	854	6.7	26.1	19.1	95.0	66.6	15.4	1.5	7.4
Ostico	Baucau	-8.53551	126.33021	695	5.3	26.7	19.2	94.6	61.8	14.3	1.8	7.3
Balibo	Bobonaro	-8.98455	125.04008	529	7.1	28.7	19.6	97.4	64.8	16.0	0.3	4.7
Ritabou	Bobonaro	-8.94717	125.20537	163	9.1	32.5	22.1	97.7	56.0	17.2	0.2	5.2
Atauro	Dili	-8.26437	125.607271	4	4.1	32.3	24.8			17.0	0.2	4.1
Fuiloro	Lautem	-8.49582	127.02705	358	8.0	29.2	21.3	97.3	66.2	15.6	1.8	8.2
Darulete	Liquiça	-8.65123	125.347	1130	3.5	24.7	17.6	98.8	71.3	13.6	0.4	5.5
Dotik	Manufahi	-9.02642	125.92083	101	8.1	31.3	21.6	99.5	69.2	15.5	0.5	6.0
Holarua	Manufahi	-8.93483	125.62914	1033	11.4	26.1	16.1	86.2	66.8	14.0	0.1	4.5
Pante Macasar	Oecussi	-9.1999	124.34932	7	1.0	32.4	24.4	84.2	55.5	18.0	0.6	5.8
Bahalara-uain	Viqueque	-8.94973	126.27348	21	6.2	32.1	22.7	99.1	71.4	17.5	0.3	5.1
Ossu De Cima	Viqueque	-8.68865	126.37335	950	8.4	25.4	18.8	99.2	72.5	14.8	1.7	8.5

7.2 Analysis of weather data by AEZs for 2012-2013

Rainfall

Rainfall along the northern coast in AEZ 1 (**Table 17**) was higher during the first few months of the 2012-2013 wet season than the southern coast. In AEZ 6, the rainfall was quite low until the floods in June. Similarly, AEZ 2 on the north received higher rainfall than AEZ 5 on the south until April. High altitude locations in AEZ 4 on the south side had consistently higher rainfall than AEZ 3 on the north side of the ridge line. For the maize growing period of December to March, AEZ 2 received the most rainfall at 1854 mm.

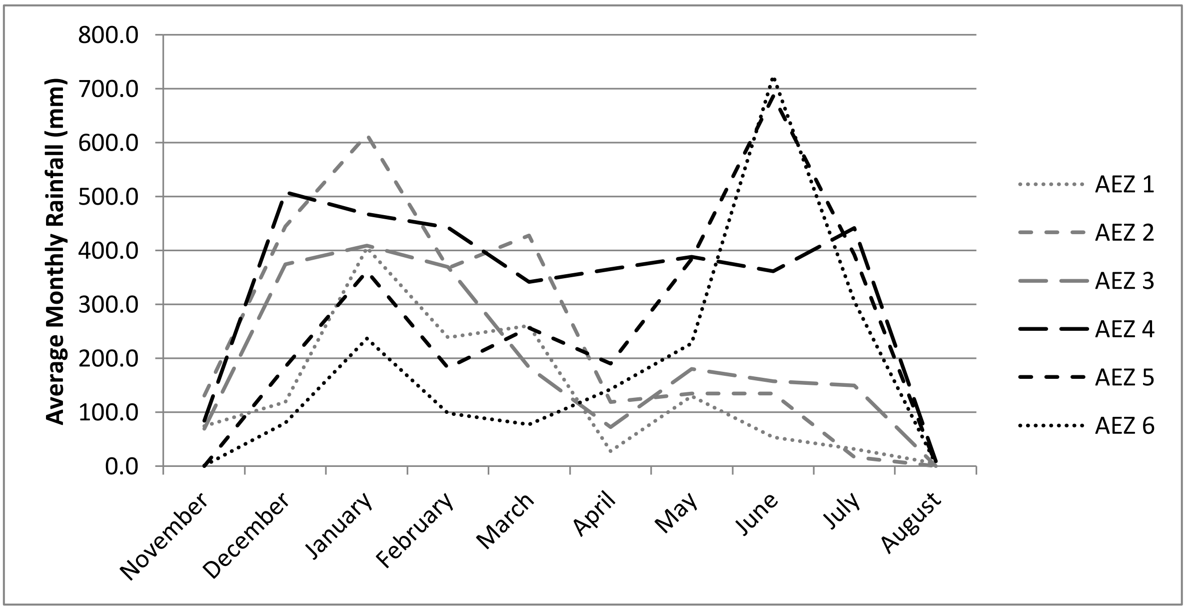


Figure 48. Monthly rainfall according to agro-ecological zones, 2012-2013.

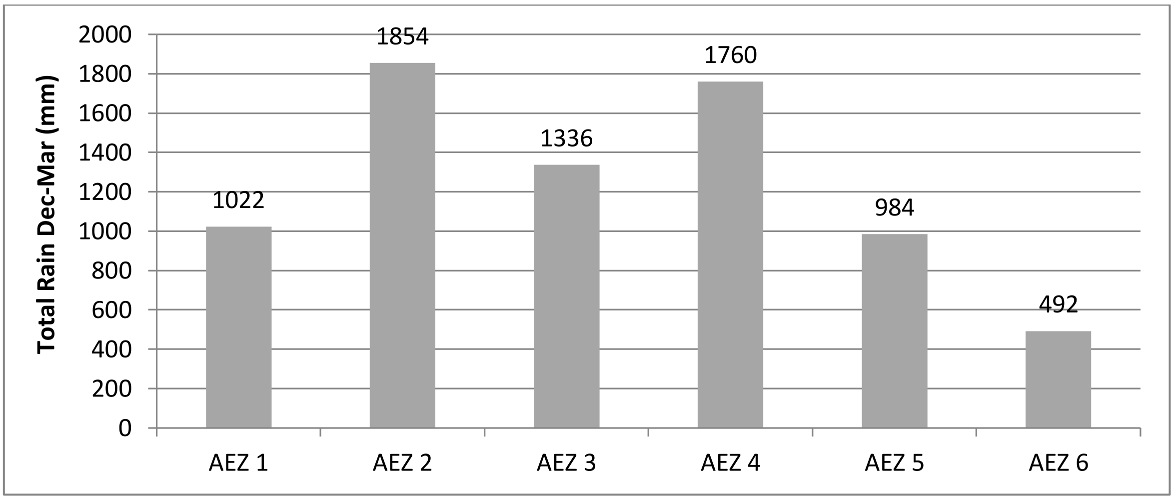


Figure 49. Total rainfall (mm) during growing period, Dec. 2012 to Mar. 2013.

Radiation

Solar radiation was plotted by AEZs. Reduced solar radiation will lead to reduced biomass and yield. Across the AEZs solar radiation was high during November and then quickly dropped off in the early maize growing period of December to January during the rainy season. During February and March the radiation was 20% lower than November. After a rise in solar radiation in April, it declined again in most regions through to June before increasing in August.

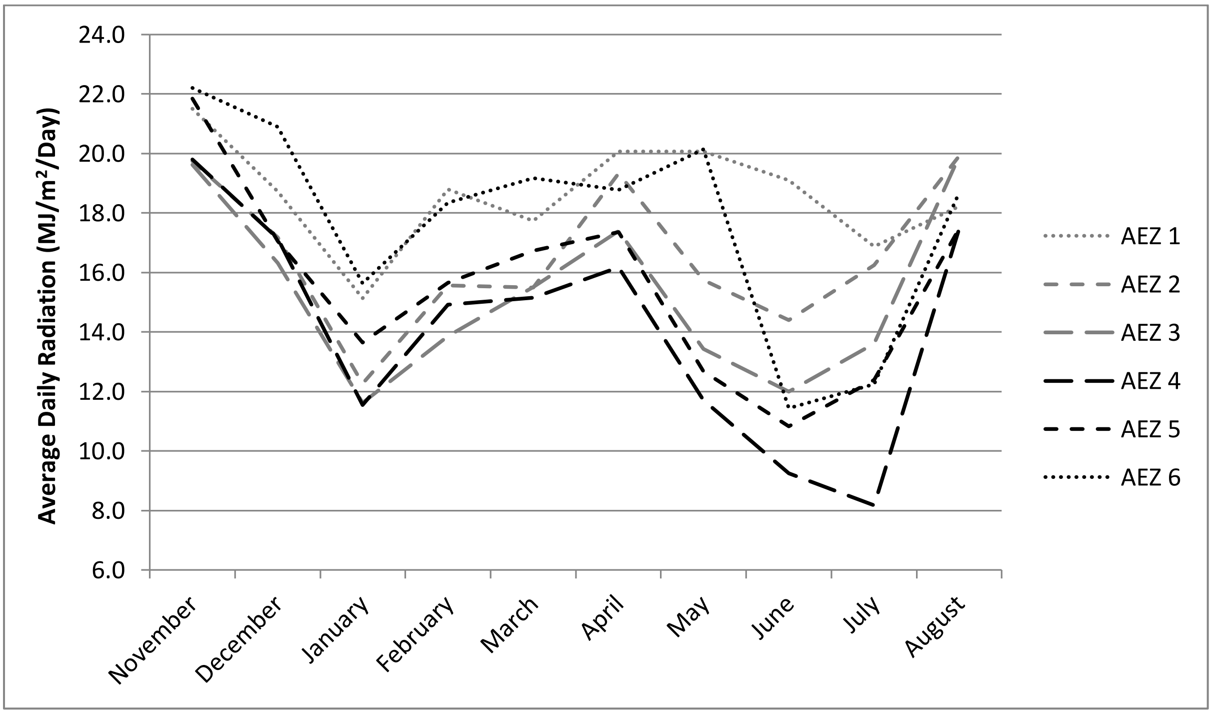


Figure 50. Average daily radiation (MJ/m^2/day) across agro-ecological zones, 2012-2013.

Total solar radiation for the maize growth period of December to February was plotted according to AEZs (Figure 51). Solar radiation declines with increase in altitude. This is consistent with cloud formation at high altitudes.

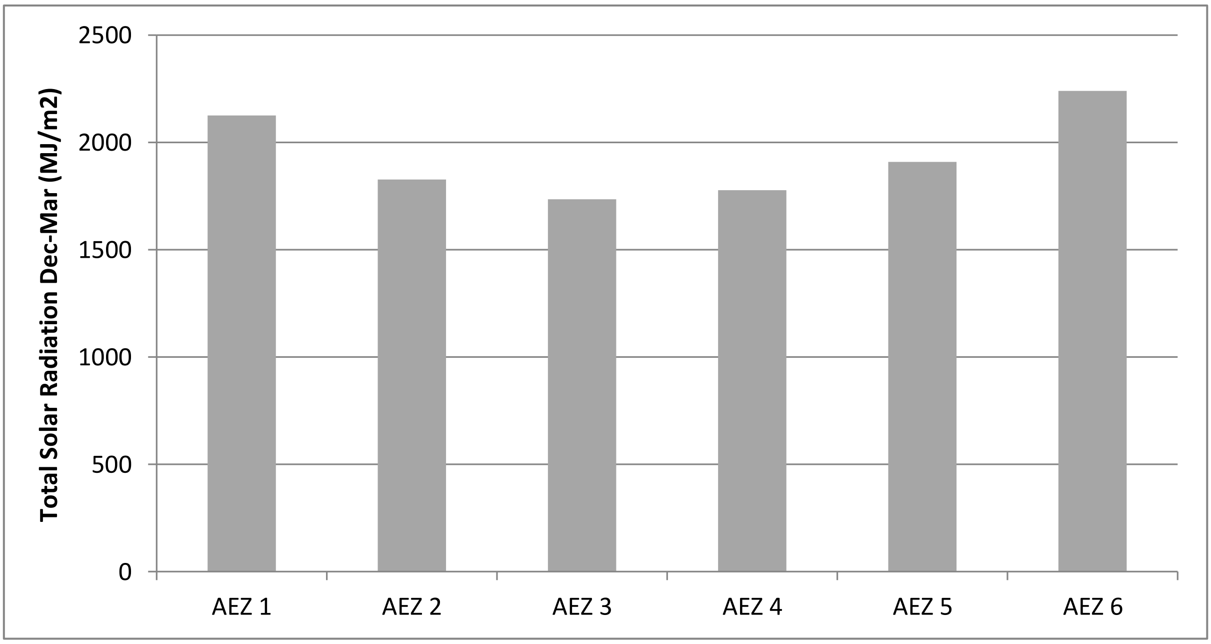


Figure 51. Solar radiation (MJ/m^2/day) across AEZs December, 2012, to March, 2013.

Temperature

Temperature affects the duration of growth for crops. Cooler temperatures result in longer growth periods allowing the plant more time to use energy from sunlight to produce more plant matter which can contribute to higher yields. AEZ 3 and 4 at high altitudes are approximately 6^{o} C cooler than AEZ 1 and 2 on the coast. November is the hottest month of the year and temperature drops by 4^{0}C from November to August. During the wet season, the temperature of AEZs at the same altitude are similar. During the drier months the temperature on the northern side of Timor-Leste doesn't decrease as much as the temperature on the southern side. This may reflect the position of the sun in the northern hemisphere during this time and will lead to an increase in evapo-transpiration on the northern side.

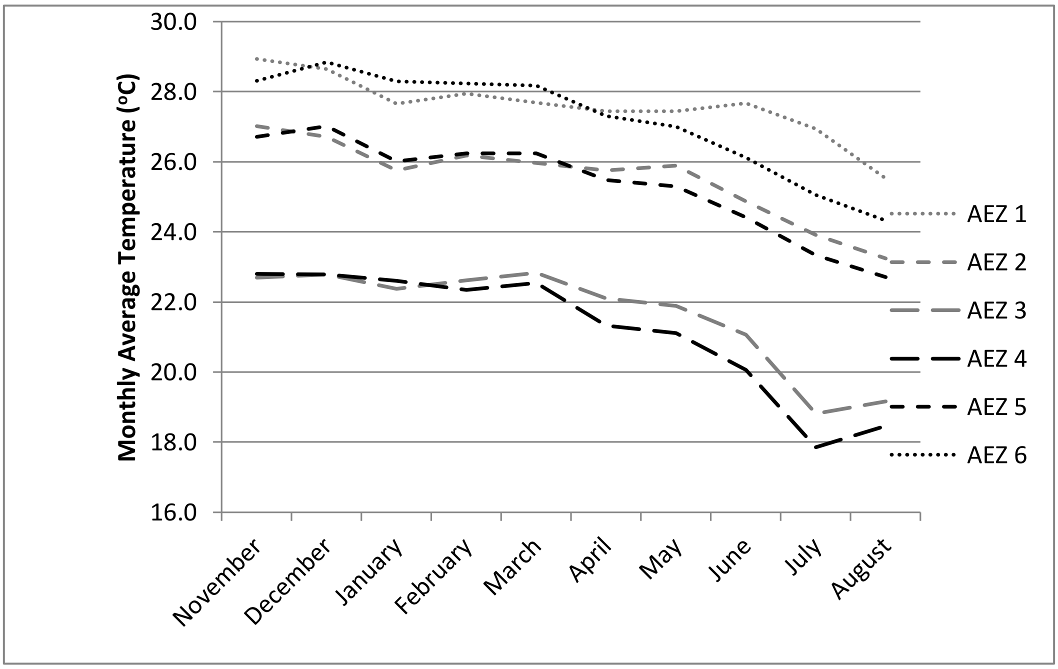


Figure 52. Average monthly temperature (^{0}C) compared across AEZs.

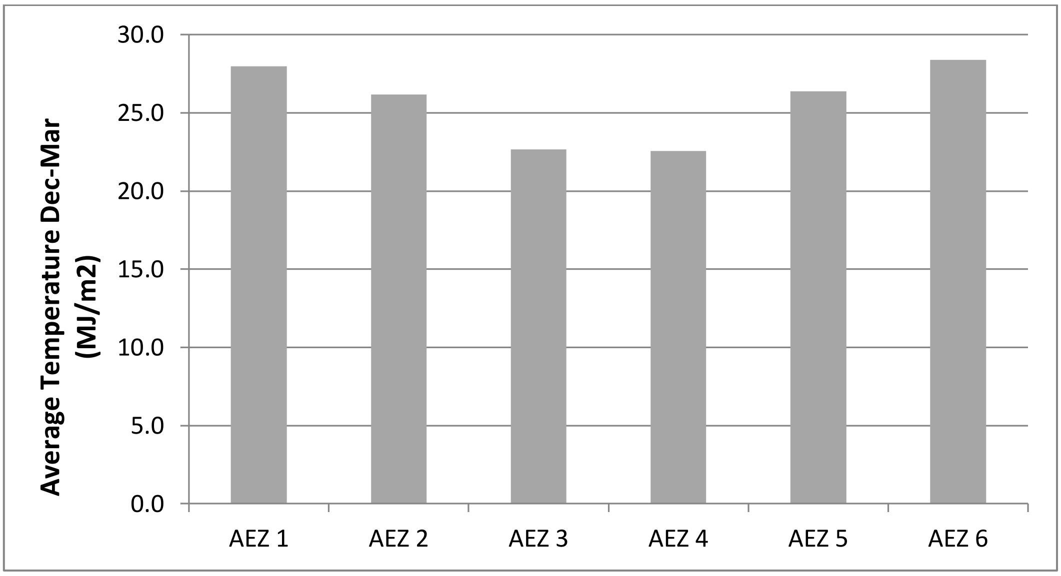


Figure 53. Average temperatures, December, 2012 to March, 2013.

Evapo-transpiration

Potential evapo-transpiration (Eto) was calculated using solar radiation, temperature, humidity and wind speed as well as the latitude and altitude. Calculations were made using the standard Penman-Monteith equations (Snyder, 2002).

The availability of water in the soil is a balance between water received by precipitation and water lost from the soil due to run-off, evapo-transpiration, recharge into the lower soil profile and utilisation by plants.

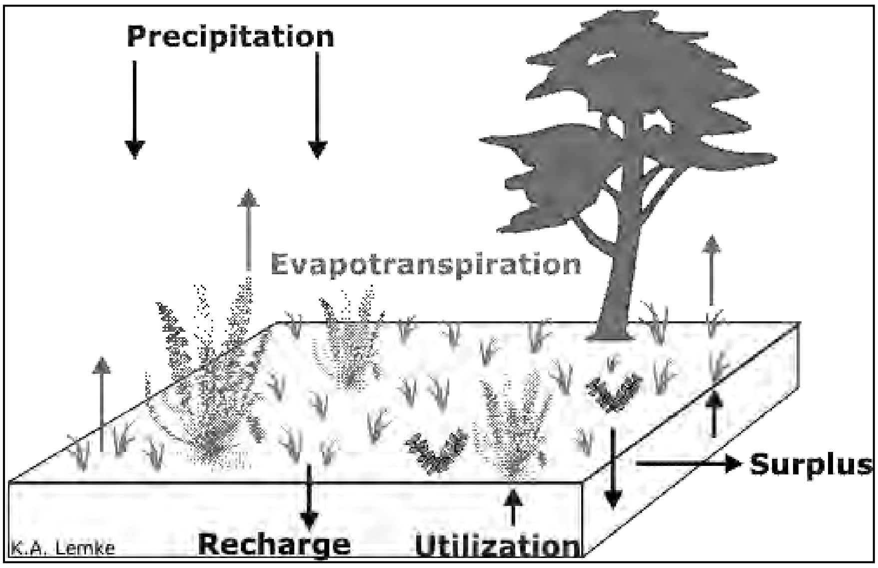
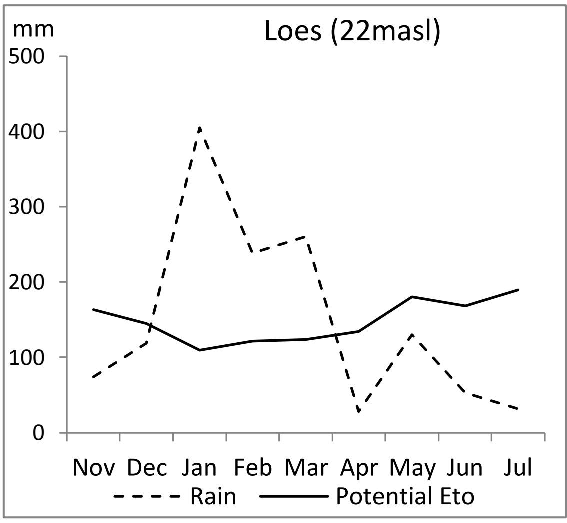
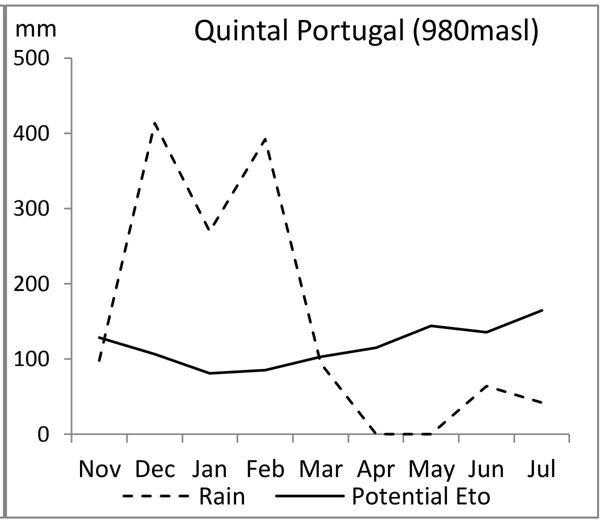


Figure 54. Diagram showing movement of water in and out of soil.

The potential evapo-transpiration is calculated based on the soil having a full canopy cover which will not be the case just before planting and when crops such as maize are in the early growth stages. Movement of water through the soil depends on soil texture down through the soil profile. The following graphs provide a simple comparison of precipitation and potential evapo-transpiration at four research station sites in Timor-Leste. (Figure 55)





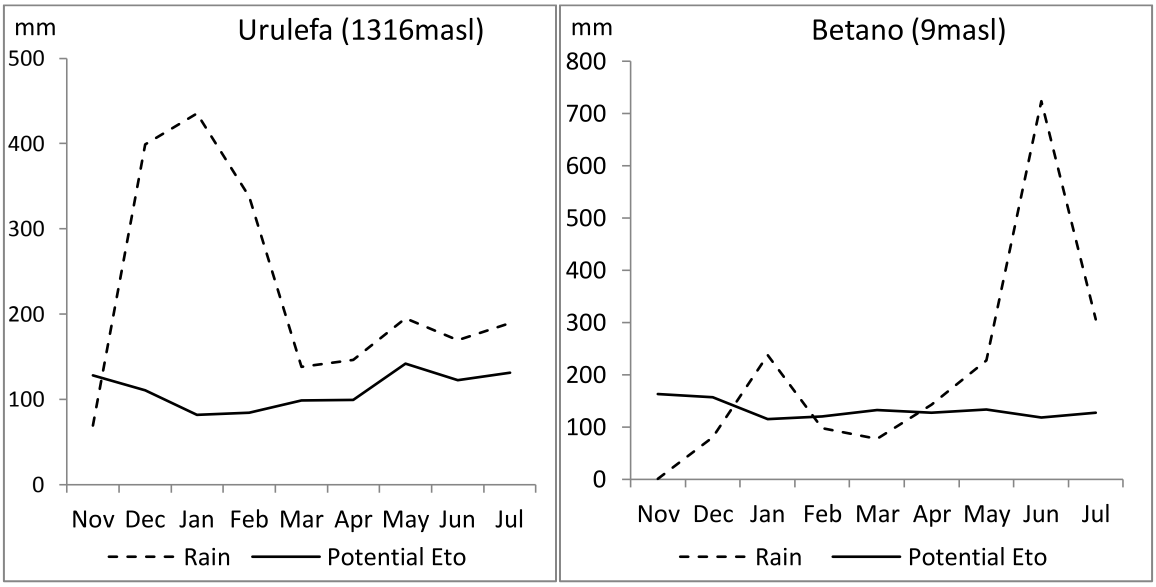


Figure 55. Rainfall and potential evapo-transpiration (Eto) (mm), four research stations.

The rainfall profile at these four sites gives an indication of the dramatic variation across Timor-Leste. In Loes and Betano, rainfall rates did not exceed potential evapo-transpiration rates until January whereas in Quintal Portugal the large amount of rainfall in early December quickly resulted in an excess of water. For Betano, excess water occurred quite late in the season with floods experienced in June.

Extreme weather events

Table 115. Extreme daily weather recordings for 2013

Event	*Location*	*Date*	*Data*
Highest rainfall	Betano	21/06/2013	238 mm
Hottest Day	Ritabou	23/10/2013	37.2 ^{0}C
Coldest Day	Urulefa	11/08/2013	4.4 ^{0}C
Highest Radiation	Holarua	29/10/2013	28.3 MJ/m^2
Highest Wind (gust)	Aituto	10/01/2013	27.2 ms^{-1} = 98 km/hr

During 2013, Timor-Leste experienced at least 2 notable flood events that were recorded on automatic weather stations. The 10-15 minute data logging interval allows closer analysis of the development of a storm event.

Heavy rains were recorded at Bahalara-Uain near the coast in Viqueque on the 7th of June, 2013. (Figure 56) Rain began during the early morning hours with high intensity from 8 am to 9 am where 53.0 mm fell in one hour. Heavy rains were also recorded further up in the mountains in Ossu De Cima but delayed by several hours with steady heavy rain from 8 am to 3 pm in the afternoon. (Figure 57) In total, Bahalara-Uain received 276.4 mm and Ossu De Cima received 222 mm in one day. The average rainfall in Viqueque during the Portuguese era for the month of June is 164 mm.

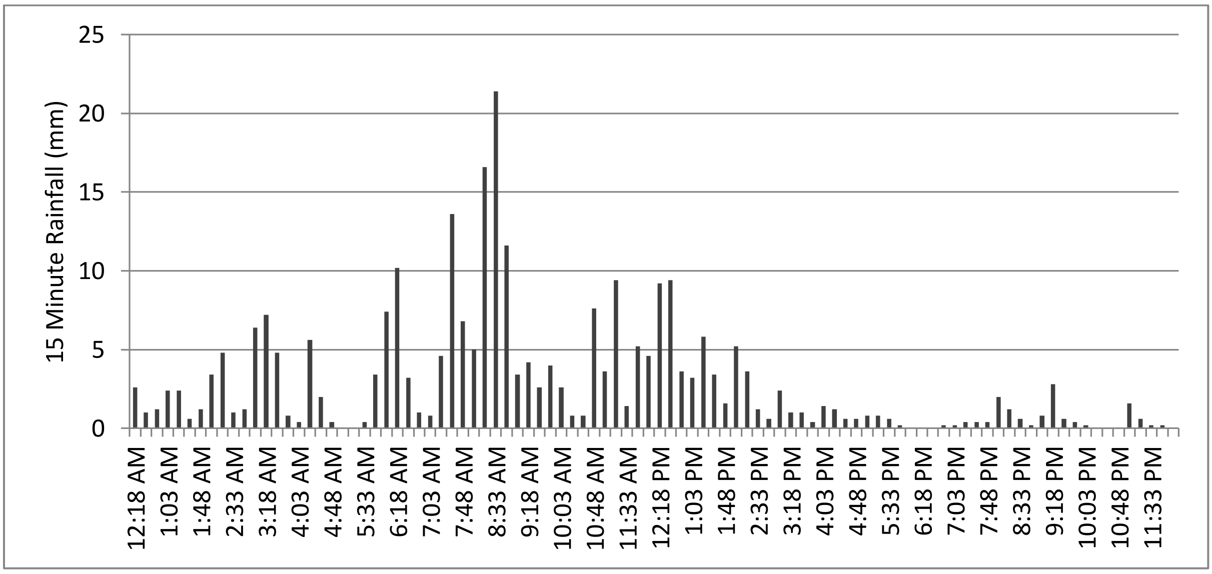


Figure 56. Rainfall (mm) at Bahalara-Uain on the coast in Viqueque on 7/6/2013.

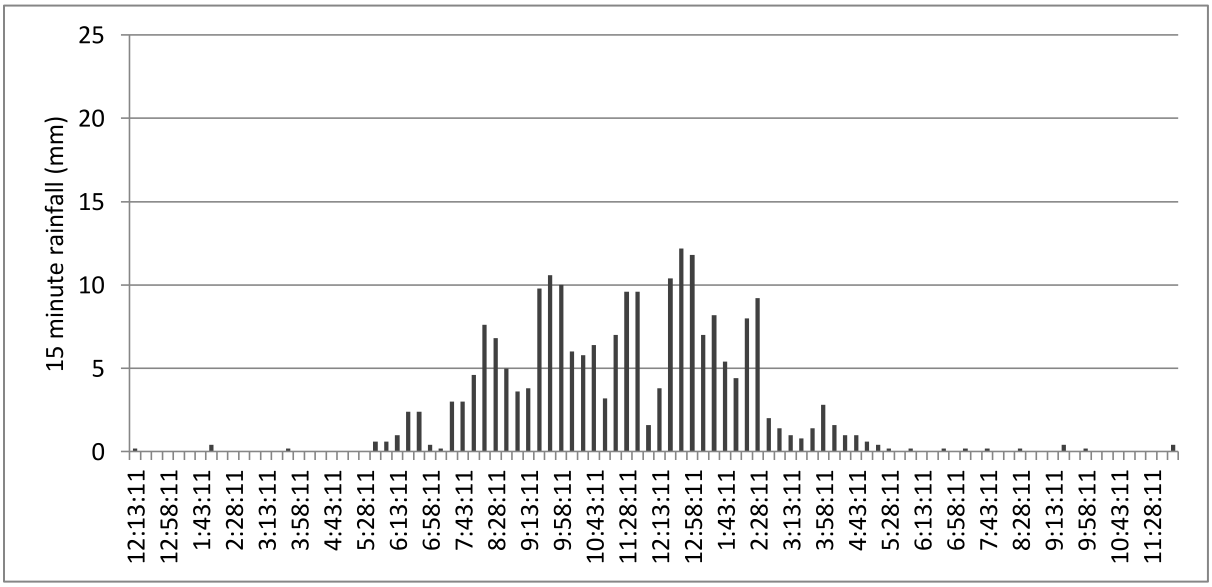


Figure 57. Rainfall (mm) at Ossu De Cima in the mountains of Viqueque on 7/6/2013.

Heavy rains in Viqueque district resulted in extensive flooding and loss of fields, crops and buildings.

Figure 58. Impact of floodwaters around Viqueque. (Photos courtesy of Luc Sabot, ADRA)

Heavy rains also fell in Betano during the early morning of the 21st of June, 2013, with a peak in rainfall of 53.2 mm from 4 am to 5 am. (Figure 59) Steady rain continued until mid-afternoon resulting in 238.0 mm for the day. A similar pattern of rainfall occurred for the following day resulting in 232.8 mm. Average rainfall in June in Betano from historical data is 147 mm with the maximum monthly rainfall previously recorded at 269 mm. The total June, 2013, rainfall was 723.6 mm which is higher than any monthly rainfall on record for Betano.

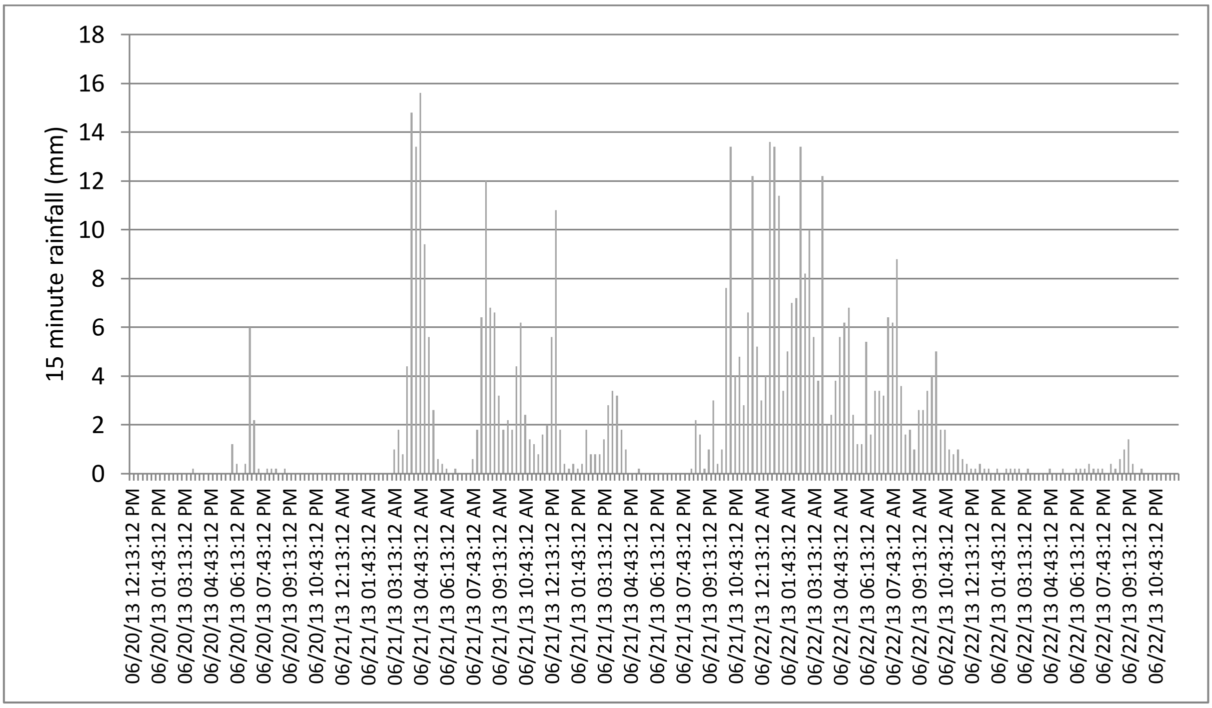


Figure 59. Heavy rainfall (mm) recorded in Betano during 20-22/6/2013.

7.3 APSIM Modelling

The software program Agriculture Production Simulation (APSIM) is being used to assist in maize research. APSIM can be used to modify crop management practices and assess the impact of various climate and soil conditions on crop production. Results from trials at seven sites were compared with APSIM modelled results. Two maize varieties, Dekalb XL82 and Katumani, were used to compare with the modelled results. The number of days taken for a maize crop to reach maturity provide an indication of the match in phenological development of the observed crops with the model. This assists in selecting a suitable variety in the model that matches the Sele variety in the field. Figure 60 shows that Katumani models the observed phenology well at higher altitudes (cooler temperatures) but not at lower altitudes (warmer temperatures).

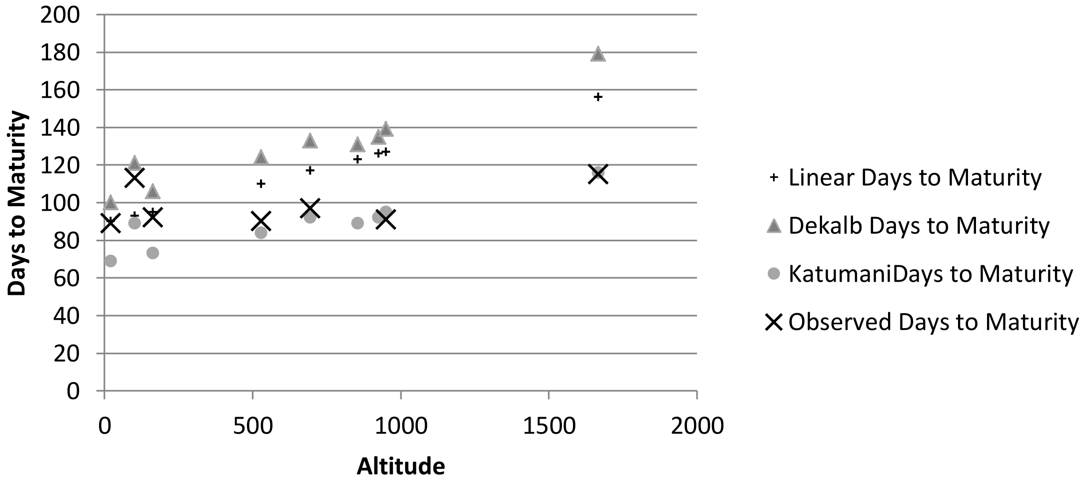


Figure 60. Modelled days to maturity, Dekalb and Katumani varieties.

The modelled yield results for the 7 sites were also compared with the observed yields. Modelled Katumani yields compared more favourably with observed yields than the modelled Dekalb yields (Figure 61). The observed yields are highly variable between sites indicating significant differences in soil fertility from one location to another. Further improvement in the model is required especially in calibrating soil type and fertility with field conditions.

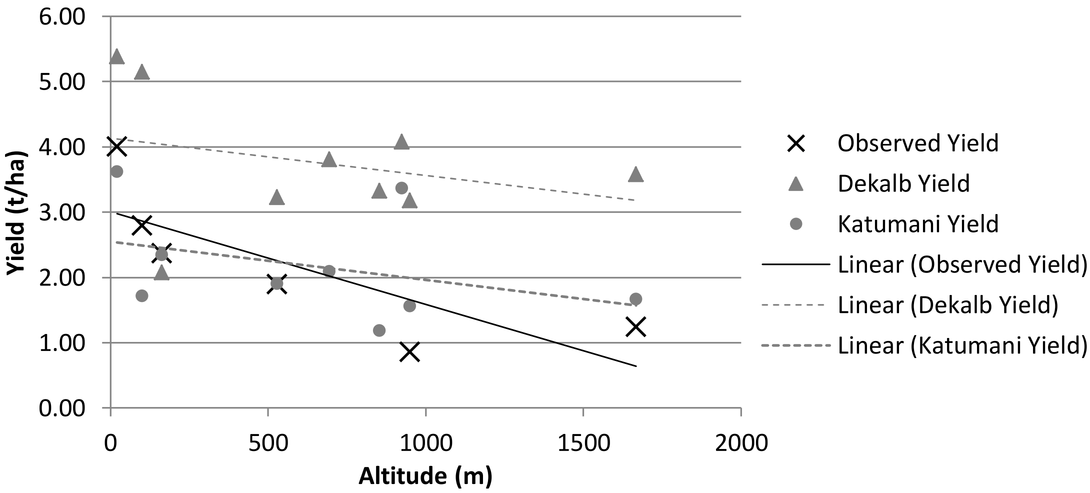


Figure 61. Modelled yield of Dekalb and Katumani with the observed yield, 7 locations.

A general assessment of solar radiation during the cropping period shows that solar radiation declines with increase in altitude. However, modelling the crops in APSIM shows that the actual total solar radiation *during the grain filling phase* can increase with altitude. A crop model was run at 12 locations using the variety Katumani which resembles the growth duration of Sele. (Table 116) Planting dates were used from observed 2012 planting dates in the field at OFDT sites. Total solar radiation received by plants during the grain filling phase is related to two factors. Firstly, at lower altitudes maize develops quicker resulting in the grain filling phase occurring closer to the radiation 'dip' in January. At higher altitudes, grain filling occurs during February and March when the daily solar radiation has increased again. Secondly, at higher altitudes, maize develops more slowly resulting in a longer grain filling phase with more days to capture sunlight. For example, Aituto in Ainaro (1663 masl) had 53% more solar radiation than Ritabou, Bobonaro (163 masl) during grain filling.

Table 116. APSIM simulation, variation in solar radiation during the grain.

				During grain filling (GF)				
Location	*Alt (masl)*	*Yield (t/ha)*	*Days to Matur.*	*Start of GF*	*End of GF*	*GF matur. days*	*Average Radiation (MJ/m2/day)*	*Total Radiation (MJ/m2)*
Bahalara-uain	21	3.62	69	12/02/13	14/03/13	31	16.6	513.1
Dotik	101	1.72	89	29/01/13	1/03/13	32	16.9	541.8
Ritabou	163	2.35	73	3/01/13	5/02/13	34	13.7	464.4
Fuiluro	358	1.88	81	4/02/13	10/03/13	35	15.6	545.5
Balibo	529	1.91	84	25/01/13	2/03/13	37	14.8	546.9
Ostico	695	2.09	92	23/01/13	3/03/13	40	12.5	500.7
Fatulia	854	1.19	89	3/02/13	13/03/13	39	12.0	467.5
Seloi Malere	925	2.63	91	15/01/13	23/02/13	40	14.2	569.9
Ossu De Cima	950	1.73	94	1/02/13	13/03/13	41	12.2	501.6
Quintal Portugal	980	1.47	97	21/01/13	2/03/13	41	14.3	585.0
Urulefa	1316	2.74	113	9/02/13	26/03/13	47	13.8	648.0
Aituto	1667	1.67	116	26/02/13	15/04/13	49	14.5	711.1

7.4 Mapping Agro-Ecological Zones

Traditionally, Timor-Leste has been recognised as having 6 different agro-ecological zones (AEZs). The AEZs are defined according to altitude, with AEZs 1-3 on the northern side of Timor-Leste and AEZs 4-6 on the southern side of Timor-Leste. The division between the two is along the top of the ridge line indicated by watershed boundaries. Table 117 (also Table 17) outlines the different AEZs as they are currently accepted:

Table 117. Accepted AEZ categories in Timor-Leste

Region	*AEZ*	*Altitude*
Northern Side	1	0-100m
	2	100-500m
	3	>500m
Southern Side	4	>500m
	5	100-500m
	6	0-100m

A modification to this categorisation is proposed by introducing a temperate zone for altitudes above 1500 masl. At these high altitudes with cool temperatures staple crops such as wheat and barley are grown instead of maize. It is proposed that this would be one AEZ with no separation between the north and south side. The current numbering system could be kept with the simple addition of a new zone called “Temperate Zone” (Table 118). This would bring the agro-ecological zones more in line with previous zonings established during the Portuguese period which had a high altitude zone above 1600 masl. (Soares, 1957)

Table 118. Proposed AEZ categories in Timor-Leste

Region	*AEZ*	*Altitude*
Northern Side	1	0-100m
	2	100-500m
	3	500-1500m
Temperate Zone		>1500m
Southern Side	4	500-1500m
	5	100-500m
	6	0-100m

A second modification refers to the traditional method of mapping the AEZs particularly at the eastern end of the country. The large Los Palos Plateau experiences a bimodal wet season with monthly rainfall above 100 mm extending through to July and is an important area for maize cropping. Water drains into Lake Iralalaru and then flows underground to the south. Traditionally, the Los Palos plateau has been placed in AEZ 2 with the high mountain range to the south of the lake being the boundary between northern and southern AEZs. During analysis of regional rainfall it was found that the bimodal pattern of rainfall on the plateau is more similar to the rainfall experienced along the southern slopes than the drier northern slopes. It is proposed that the north-south boundary be moved to the hills to the north of the plateau to match the rainfall and agricultural conditions of the plateau. This would change the Los Palos Plateau from AEZ 2 to AEZ 5. Both the proposed Temperate Zone and the rezoning of the Los Palos plateau can be seen in the map in Figure 62. Agro-ecological zones of Timor-Leste showing proposed changes..

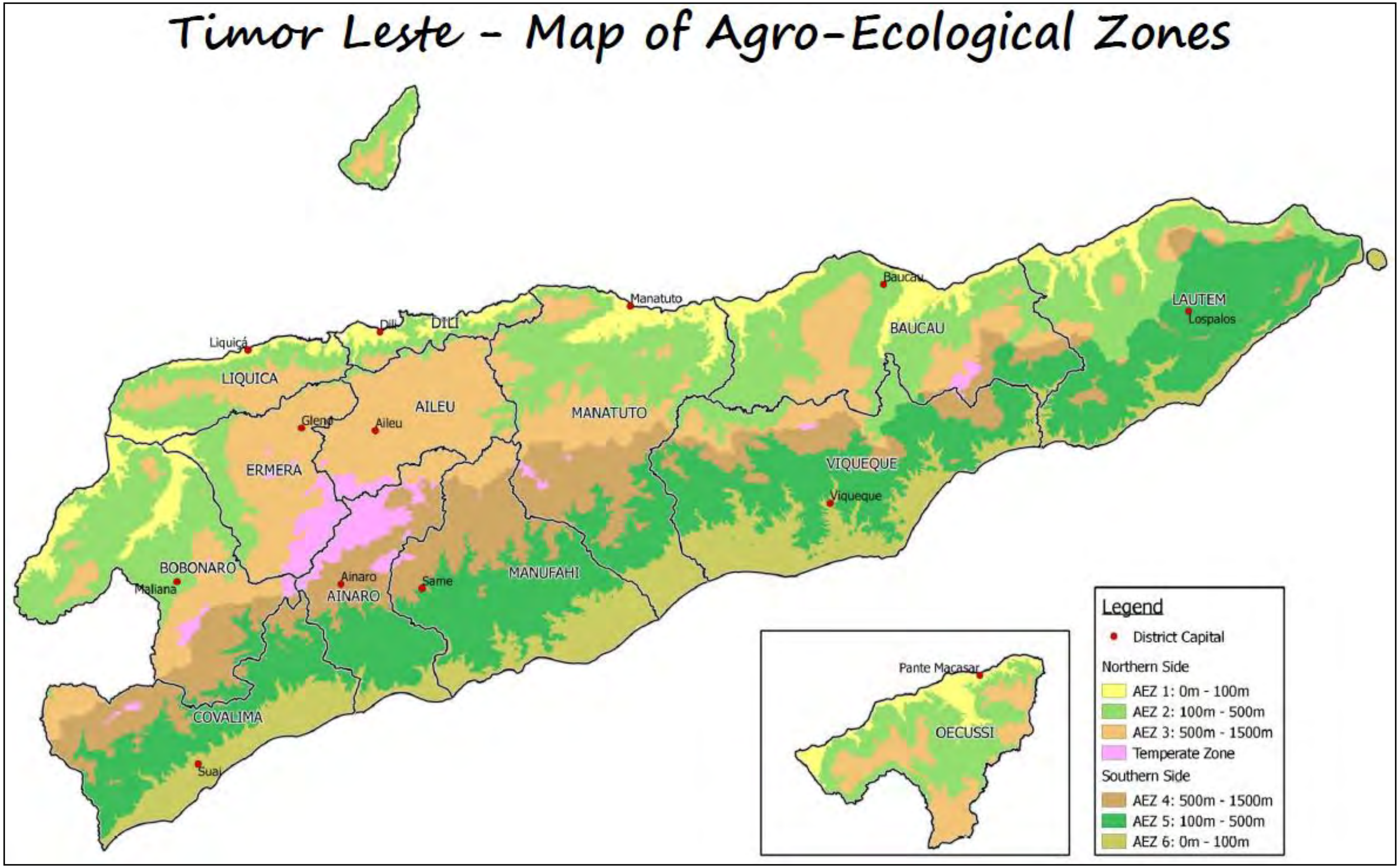


Figure 62. Agro-ecological zones of Timor-Leste showing proposed changes.

7.5 El Niño Southern Oscillation and Rainfall

The El Niño Southern Oscillation (ENSO) has a major impact on the variability of rainfall across Timor-Leste. The average of the total annual rainfall, as measured in 13 district centres, is 1583 mm. During an El Niño event the annual rainfall falls by 17.0% to 1313 mm on average. During a La Niña event the annual rainfall rises by 19.1% to 1885 mm on average. The change in rainfall is greater in locations where more rainfall is received as shown in the map in Figure 63.

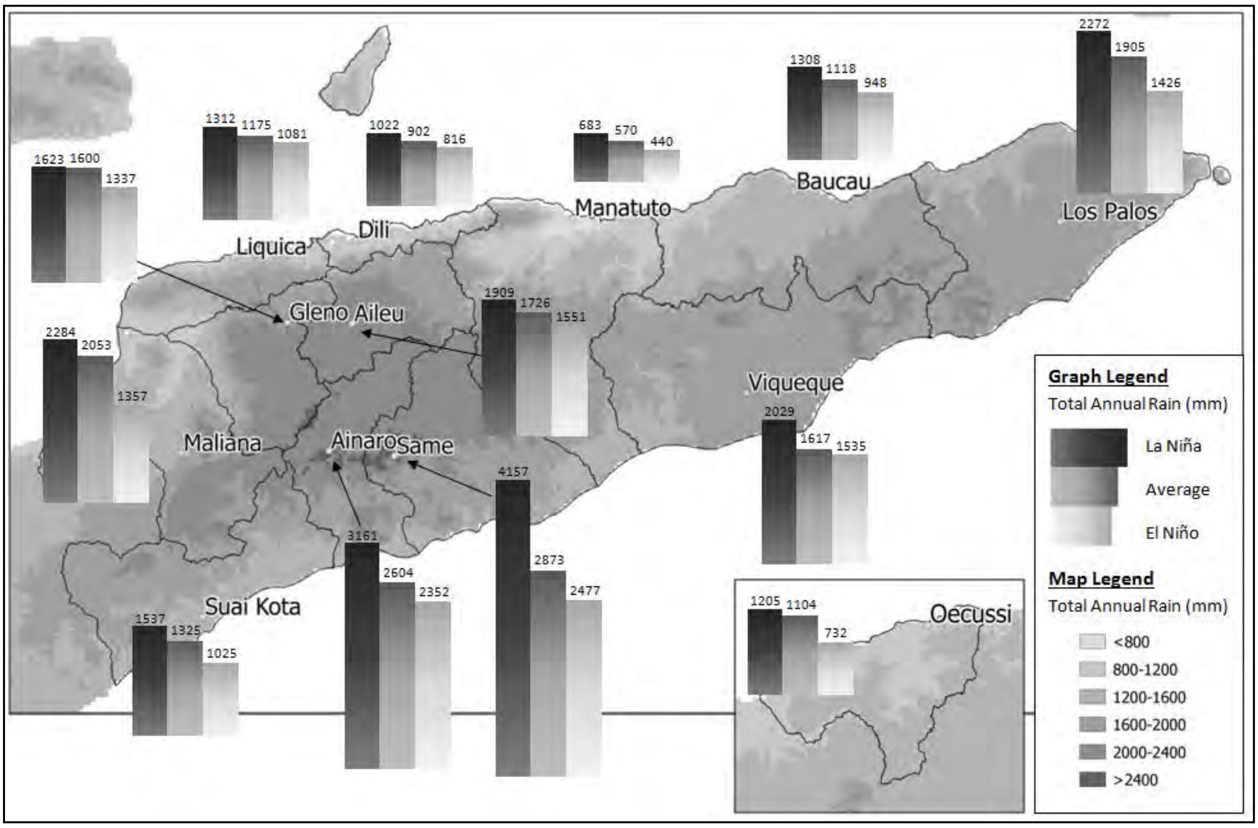


Figure 63. Rainfall distribution La Niña, Neutral and El Niño ENSO phases

ENSO also has an impact on the timing of the wet season (CAWCR, 2004). Of particular importance is the beginning of the wet season. Wet season onset is defined as when rainfall exceeds 50 mm in two successive 10-day periods where each month is be divided into three periods of 10 days each. During La Niña, the wet season onset moves forward by an average of 51 days from the average wet season onset date. During El Niño, the wet season onset is delayed by 29 days on average. In Manatuto, there is very little rain during El Niño and the wet season does not start according to the definition. (Figure 64)

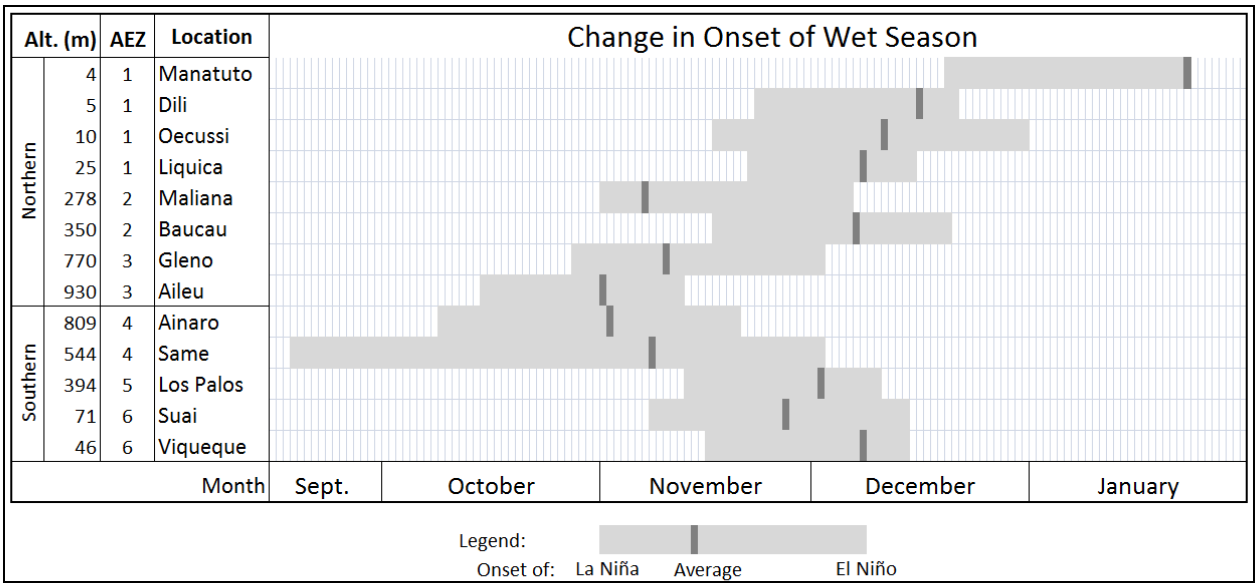
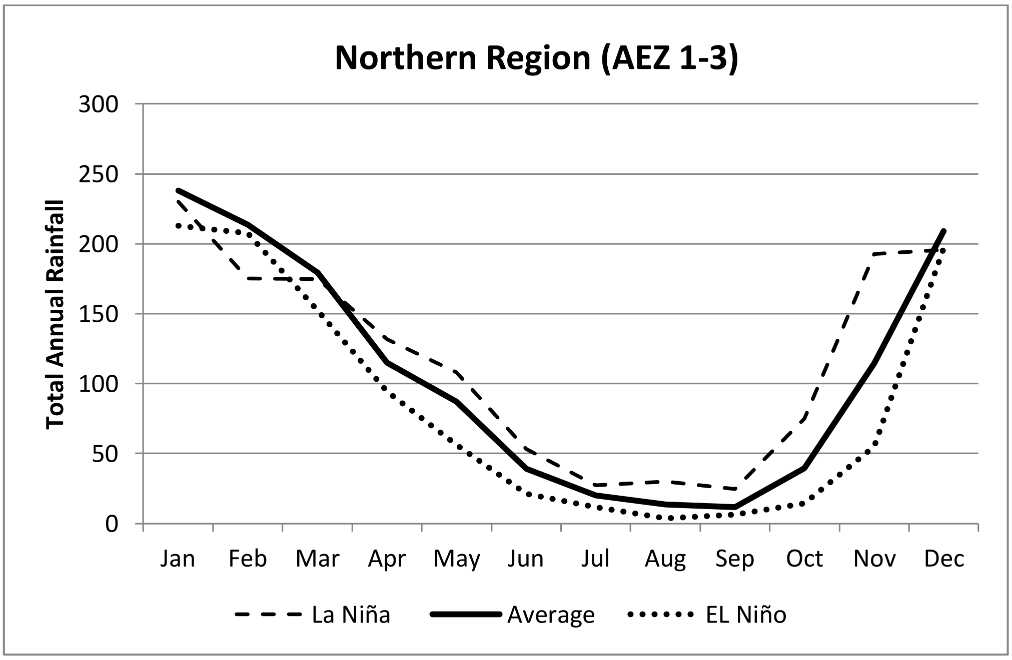


Figure 64. Change in the onset of the wet season according to agro-ecological zones.

Differences in rainfall in Timor-Leste can be broadly categorised into two main regions: northern and southern region. This is due to the mountain chain that runs east-west along the middle of the country. The impact of ENSO on these two regions is shown in Figure 65. In the northern region, the impact of ENSO occurs primarily during the late dry to early wet season. In the southern region, ENSO has a greater impact throughout the year.



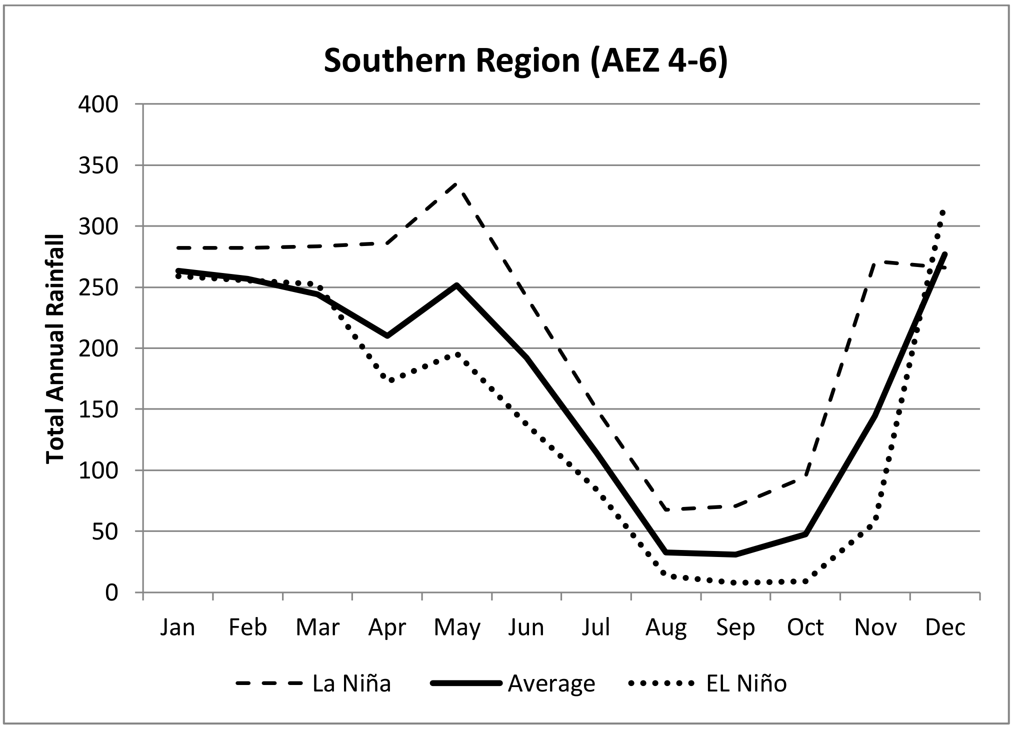


Figure 65. ENSO comparison Northern (AEZ 1-3) and Southern (AEZ 4-6)

Graphs of rainfall for individual district locations are shown in Figure 66 (Northern Region) and Figure 67 (Southern Region). The results of this analysis demonstrate that the impact of ENSO varies according to location. Even within regions there can be large differences such as Same with extremely high bi-modal wet season rainfall compared to Suai. On the north coast, ENSO has a greater impact on rainfall in Maliana compared to Liquiça.

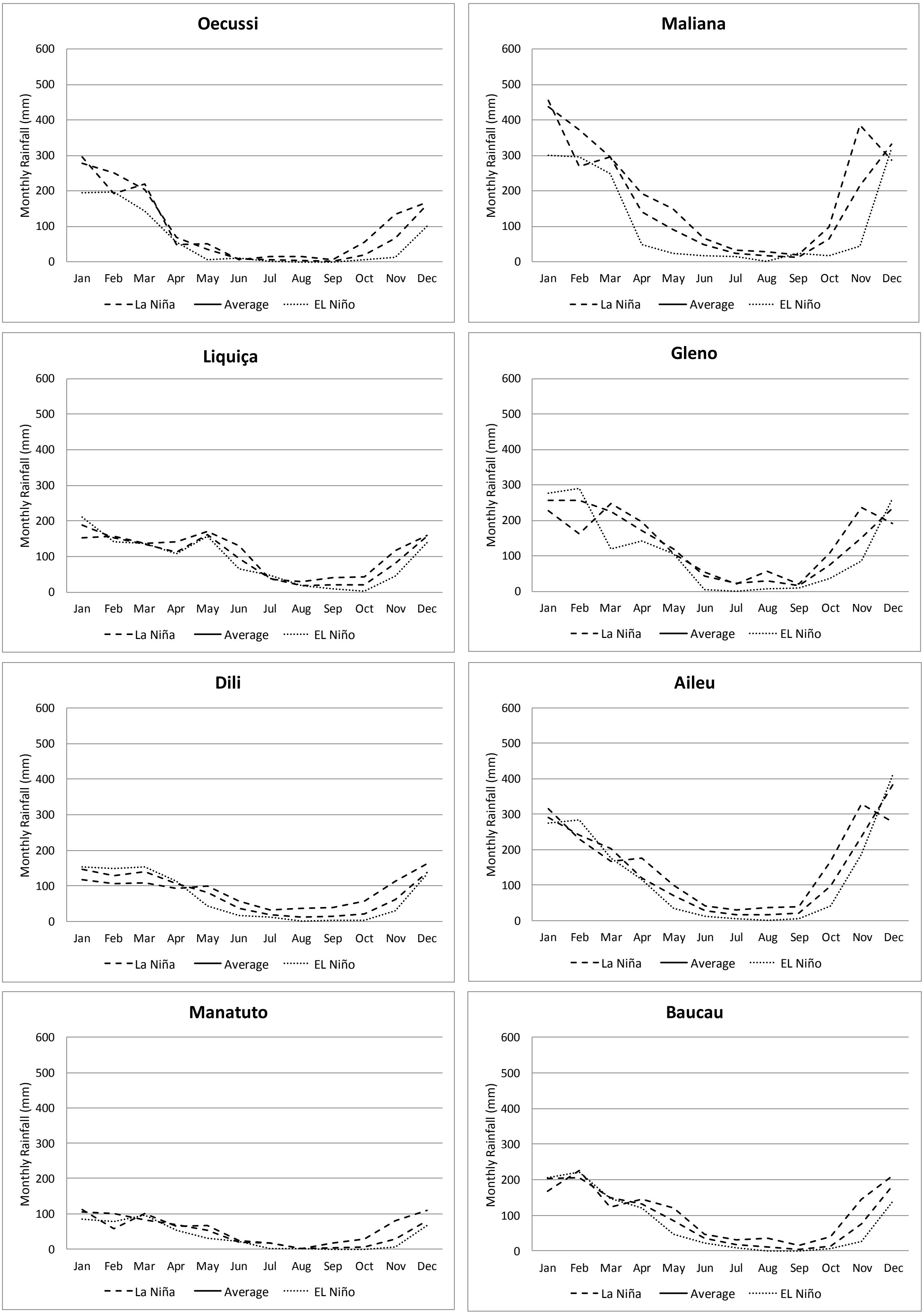


Figure 66. Monthly rainfall (mm) on northern slopes during El Niño and La Niña.

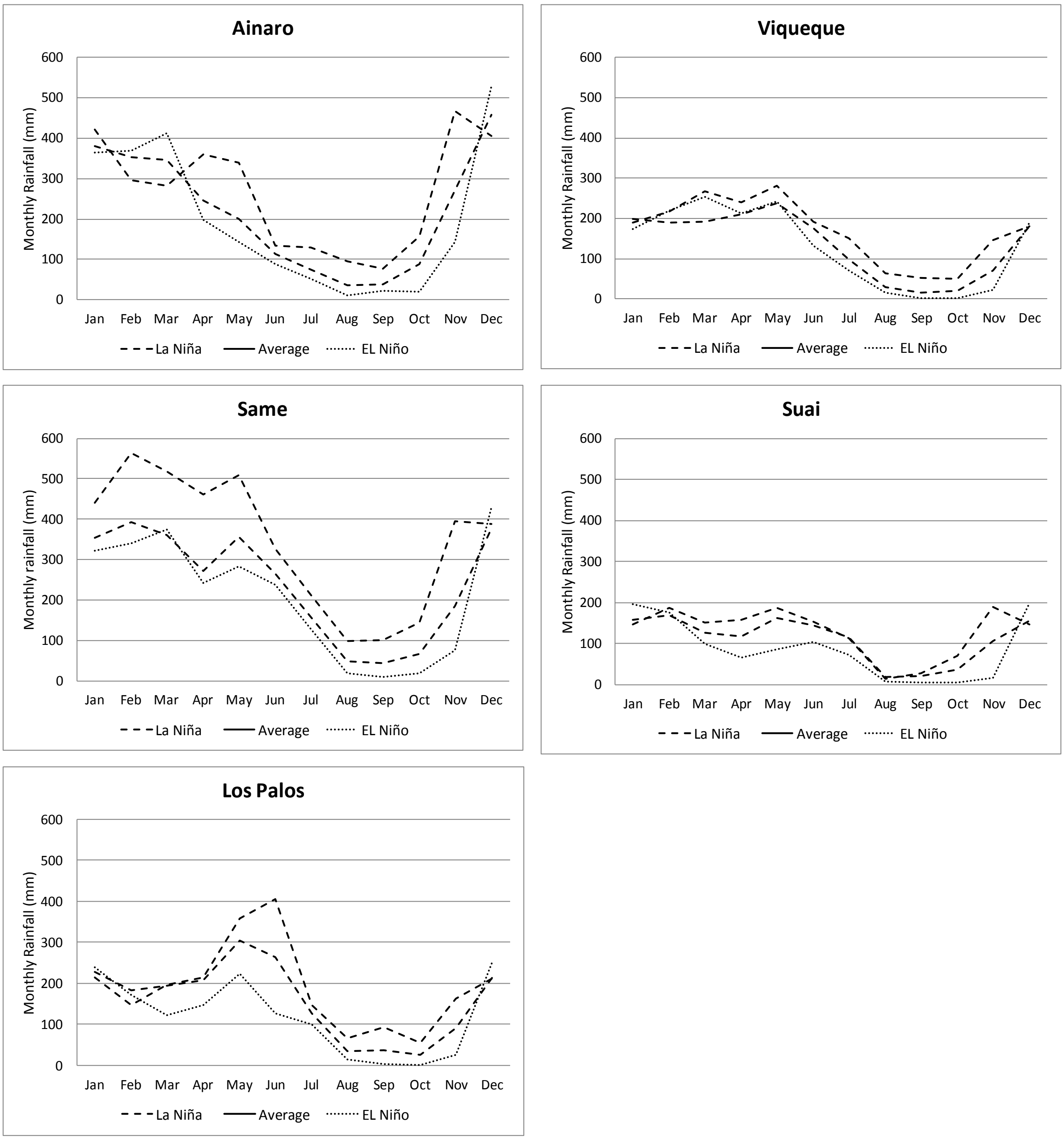


Figure 67. Monthly rainfall (mm) on northern slopes during El Niño and La Niña.

SOI and food production

One indicator of an ENSO event is the Southern Oscillation Index (SOI). The SOI was compared to the maize production for Timor-Leste from 1990 to the present. (BOM, 2013; FAO, 2013) Figure 68 indicates that when the SOI is either strongly positive (La Niña) or strongly negative (El Niño) around the time of planting and early crop growth then total maize production is reduced. ($R = 0.55^*$ for $P<0.01$) There is a drop in production of 11.5% during El Niño (if the 2010 production of 149,000 t is considered an outlier (Young, 2013)). During La Niña, the production falls by 17.2%. This was then analysed further into the production components of yield and area harvested. There was not found to be correlation with maize yield and SOI. (Figure 69) However, SOI was found to be correlated with the area harvested. ($R=0.61^*$ for $P<0.01$) (Figure 70). That is, during El Niño and La Niña less area is harvested for maize.

Rice production, including area harvested and yield was not found to be correlated with SOI. However, years with strongly positive SOI (above 14) show high annual rice production. (Figure 71).

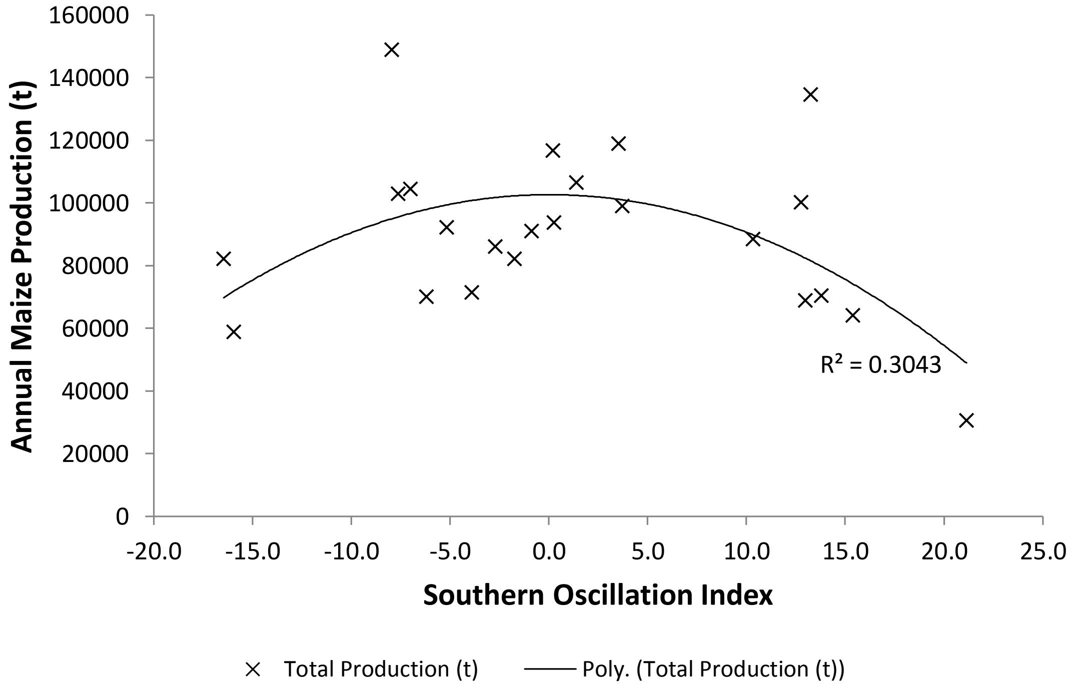


Figure 68. Annual maize production versus average SOI Nov-Jan from 1990-2012.

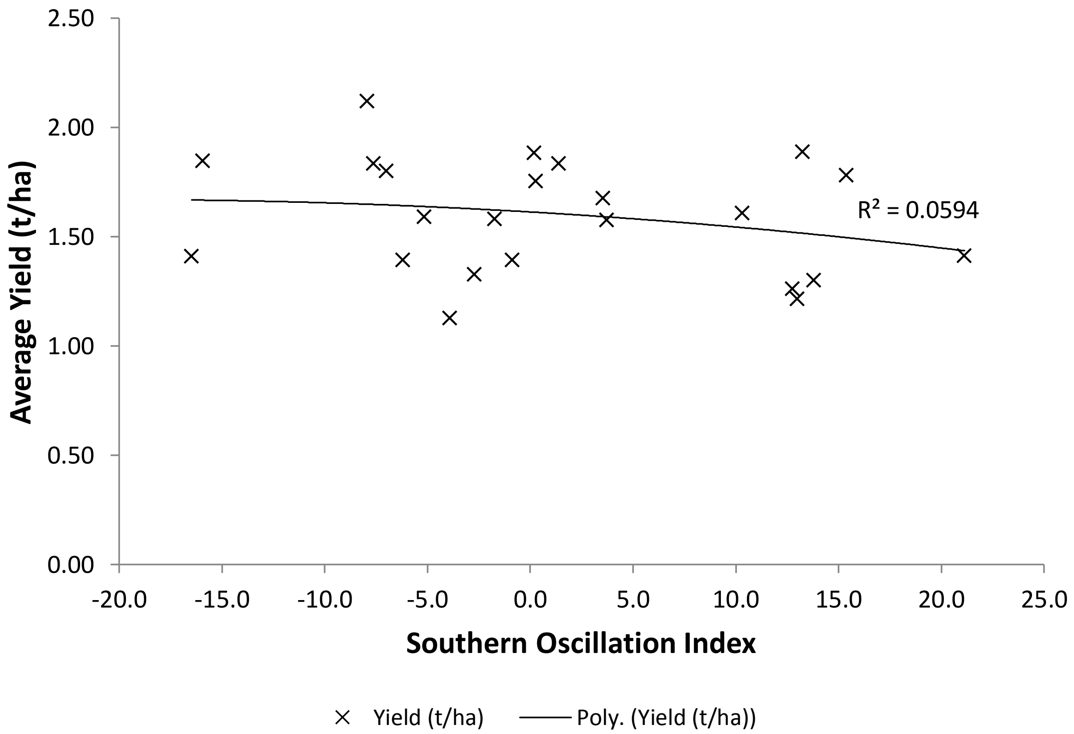


Figure 69. Average maize yield versus average SOI Nov-Jan from 1990-2012

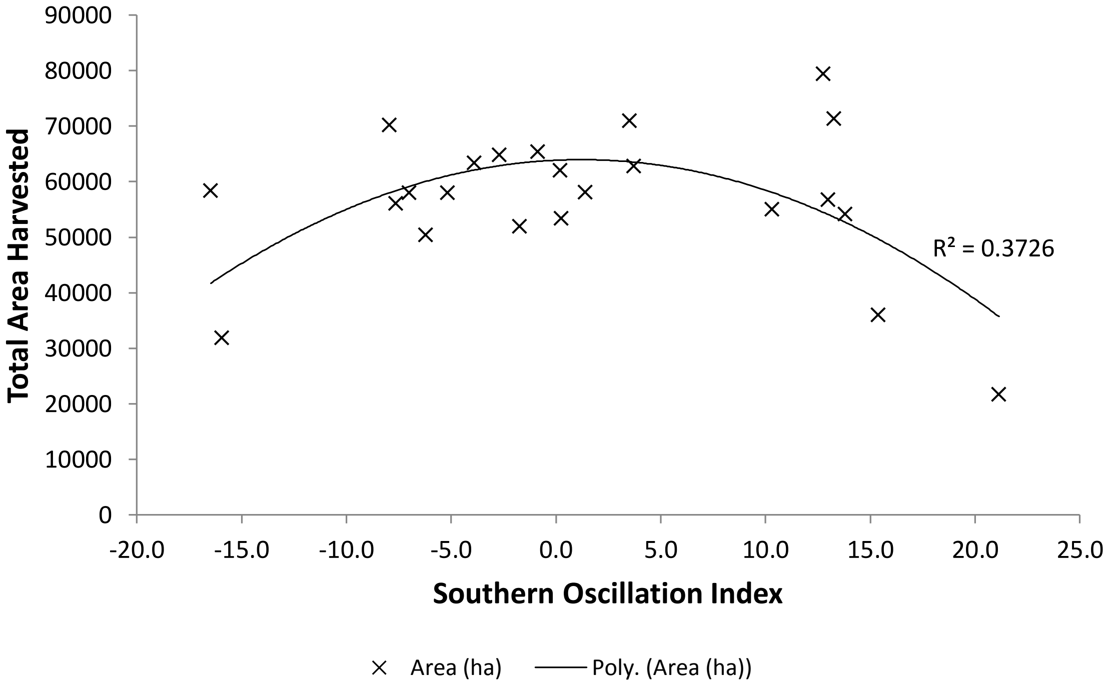


Figure 70. Average maize area harvested versus average SOI Nov-Jan from 1990-2012

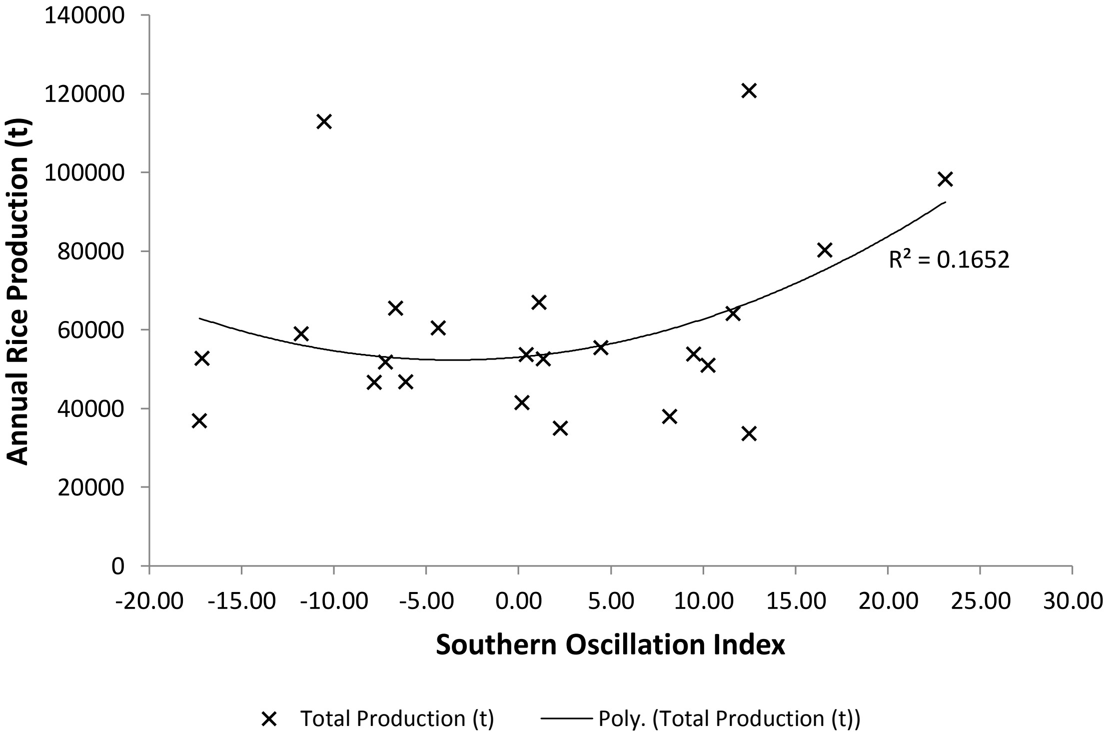


Figure 71. Annual rice production versus SOI Dec-Feb

The drop in maize production from 11% (El Niño) to 17% (La Niña) is greater than the predicted drop in maize production in Timor-Leste of 6% by 2050 due to a 1.5^0 C rise in temperature. (Molyneux N, 2012) However, if these two factors are compounded Timor-Leste may experience falls in production of up to 23% in the future.

7.6 Climate change from the Portuguese era to the present

The current understanding around climate change states that the temperature is rising and the rainfall will increase in wetter areas but decrease in drier areas. Climate modelling by CSIRO based on an A2A (high emissions scenario) from data released by the International Panel for Climate Change (IPCC) Report 3 showed that the temperature in Timor-Leste would increase by 1.5° C and rainfall would increase by 0-10% in 2050. (Molyneux, 2012) In 2007, IPCC released their 4th report which supported a 1.5° C change in temperature but rainfall predictions were modified to not changing or a slight decrease in Timor-Leste. (Aust. BoM, 2011) The following research considers how climate has changed from the 1960s using temperature data (Ferreira, 1965) and rainfall data (Santika, 2004) collected during the Portuguese period compared to 2004-2012 using data collected by Agro-meteorology, Land use and Geographic Information Systems (ALGIS) department in the Ministry of Agriculture (Mau, 2012). Current data was used from 9 automatic weather stations established at Ainaro, Maubisse, Maliana, Aileu, Fuiloro, Dare, Betano, Manatuto and Viqueque.

During the last 50 years it was found that the average monthly rainfall across the 9 sites has decreased by 30.7 mm. This is a 19% decrease in rainfall. The average maximum temperature increased to 1.8^0 C and the average minimum temperature has remained unchanged when compared with temperatures in the Portuguese period. (Table 119) An exception to the trend in warming was that the minimum temperatures during June were cooler than historical minimums. In Aileu, minimum temperatures were significantly lower than the general trend. For the other 8 sites, minimum temperatures rose on average by 0.5^0 C.

Results show that changes in rainfall and temperature are not consistently the same across all sites. In Maubisse at an elevation of 1406 m above sea level, the maximum temperature increased by 0.5°C, the minimum temperature decreased by 0.4° C and rainfall decreased by 31%. By comparison, in Manatuto on the north coast, the maximum temperature increased by 2.6° C, the minimum temperature increased by 0.2° C and rainfall increased by 23%. The change in climate is site specific especially in Timor-Leste which has large variation in climate and topography.

Table 119. Annual rainfall, temperatures with anomalies showing the change in climate.

		1954-1974			*2004-2012*			*Change in Climate*			
Location	*Alt.*	*Tmax (°C)*	*Tmin (°C)*	*Annual Rain (mm)*	*Tmax (°C)*	*Tmin (°C)*	*Annual Rain (mm)*	*Δ Tmax (°C)*	*Δ Tmin (°C)*	*Δ Ann. Rain (mm)*	*Δ Rain (%)*
Aileu	990	26.0	18.4	1726	28.3	15.0	1383	2.3	-3.3	-343	-20%
Ainaro	809	25.8	16.2	2604	27.8	17.5	2212	2.0	1.3	-392	-15%
Betano	3	-	-	1329	31.7	22.0	1128	-	-	-201	-15%
Dare	492	27.0	21.3	1572	30.1	21.8	1073	3.1	0.6	-499	-32%
Lospalos	394	27.8	19.1	1905	28.9	20.2	1213	1.1	1.0	-693	-36%
Maliana	298	30.9	20.7	2053	33.0	20.9	1315	2.1	0.2	-738	-36%
Manatuto	4	30.1	22.5	570	32.7	22.6	698	2.6	0.2	128	23%
Maubisse	1406	22.3	14.7	1500	22.8	14.3	1031	0.5	-0.4	-469	-31%
Viqueque	108	30.9	21.2	1617	31.3	21.9	1506	0.4	0.7	-111	-7%
Average		27.6	19.2	1653	29.6	19.5	1284	1.7	0.0	-369	-19%

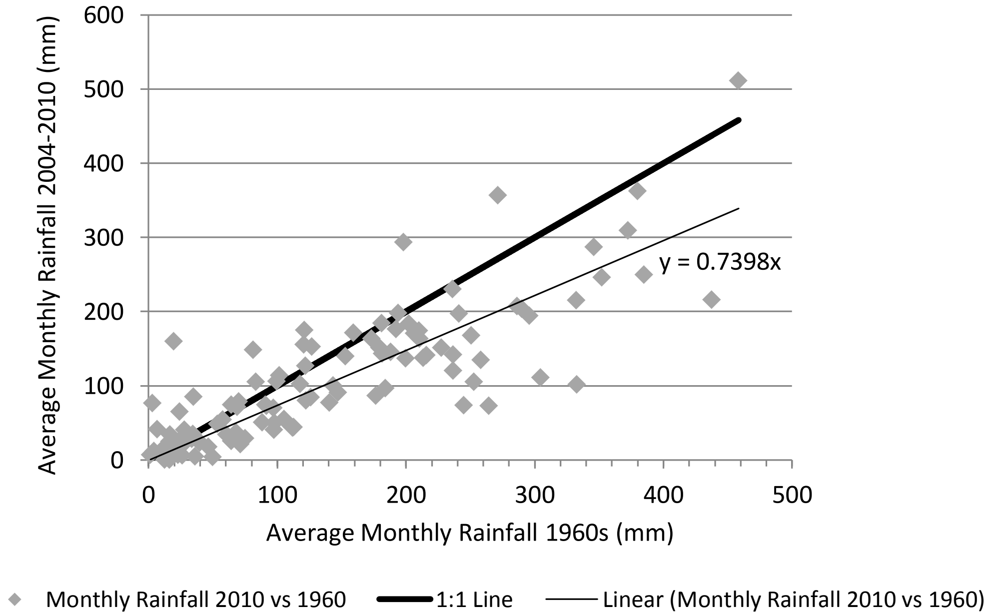


Figure 72. Current monthly rainfall plotted against historical rainfall.

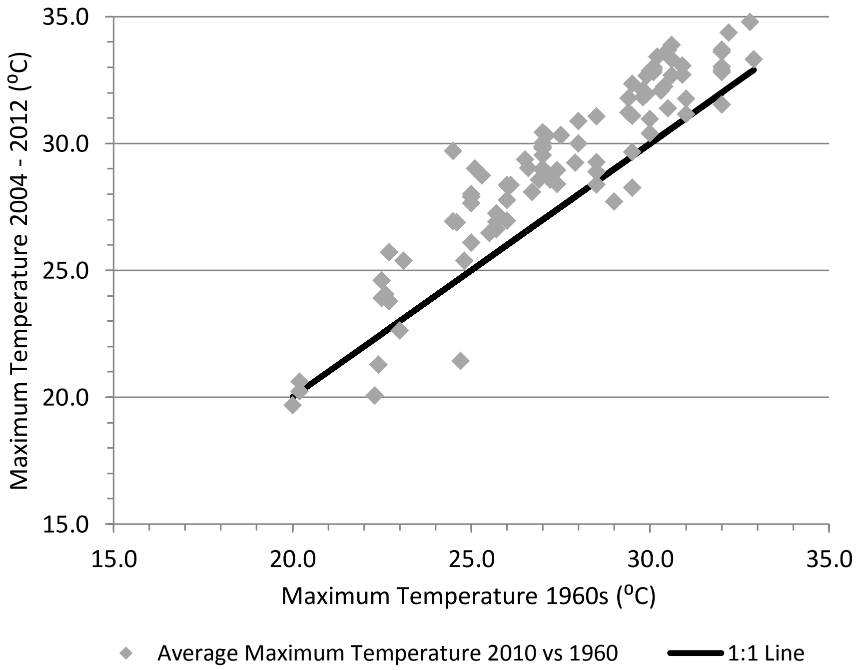


Figure 73. Current and historic monthly maximum temperatures.

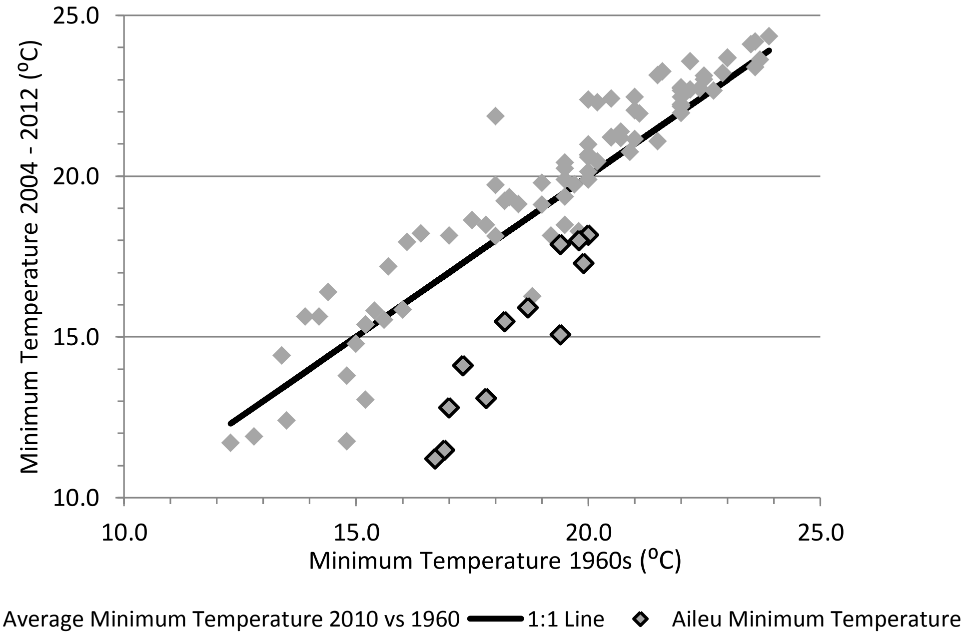


Figure 74. Current and historic monthly minimum temperatures.

Minimum temperatures do not show the same dramatic increase as the maximum temperature change. For Aileu, monthly minimum temperatures have decreased especially during the dry season months. Due to this dramatic drop in minimum temperatures, extra sources of Aileu temperature data were accessed for comparison (Table 120). Temperatures collected at 3 different sites around Aileu town all show a similar pattern of maximum and minimum temperatures. A calibration test of the ALGIS temperature gauge showed that it was recording temperatures 0.7 ^oC lower than the SoL temperature gauge at the same location for a 24 hour period.

Table 120. Comparison of various data sources for temperatures at Aileu

Data Source	*Max Temp (^oC)*	*Min Temp (^oC)*
O Clima 1916-1923	26.1	18.3
O Clima 1965	26.0	18.4
ALGIS 2004-2012	28.3	15.0
SoL Quintal Portugal (2012-2013)	28.1	15.9
SoL Seloi Malere (2012-2013)	28.6	15.8

The changes in climate presented here are in contrast to the current perception of climate change. Many older Timorese say that there is much more rain now than there was 30 or 40 years ago. Although the data demonstrates a clear decline in rainfall, further analysis could be conducted on climate data in relation to long term climate variation such as the Inter-decadal Pacific Oscillation which varies over a 20 year cycle. The change in rainfall should be considered in management of agriculture, health and infrastructure. An important threat to crop production is high temperatures during flowering. Climate change research for Timor-Leste should consider the significant changes in maximum temperatures at different sites across the country that are important for cropping.

8. Communication and technology dissemination

During 2013, information about Seeds of Life and its activities were shared with audiences through a range of channels (Table 121).

Table 121. Communication types, 2013

Audience	*Communication medium*
Farmers	Face to face communication with SoL OFDT staff Farmer field days Research results meetings Seed production workshops Socialisation workshops Printed materials (posters, banners, brochures, etc) Community radio Community theatre
MAF district staff	Ongoing liaison with SoL district staff and leaders Trainings Farmer field days Printed materials (booklets, brochures, etc) Research results meetings
NGO & agency partners	Ongoing liaison with SoL district staff and leaders Research results meetings Website Publications Social media networks Printed materials (brochures, banners, etc)
Timorese public	Conferences Tetun-language publications Local media Information distribution at local and national events Website Social media networks
Australian & international public	Website Printed and radio stories International conferences English-language publications Social media networks

NSSRV socialisation

Workshops about the National Seed System for Released Varieties (NSSRV) were held in every district in September 2013. The purpose of the workshops was to inform MAF-SoL staff, extension officers, local NGOs working in the districts and farmers groups about the NSSRV. Topics included the benefits of the NSSRV, registration process for commercial seed producers and the quality control guidelines. The workshops were well attended with 811 people participating in the 12 workshops.

International journal publications

Correia, M.V., Pereira, L.C.R., De Almeida, L., Williams, R.L., Freach, J., Nesbitt, H., Erskine, W. (2013). Maize-mucuna (Mucuna pruriens (L.) DC) relay intercropping in the lowland tropics of Timor-Leste. Food Sec. published on-line
http://www.sciencedirect.com/science/article/pii/S0378429013003626

da Costa, MDJ., Lopes, M., Ximenes, A., Ferreira, AdR, Spyckerelle, L., Williams, R., Nesbitt, H., Erskine, W. (2013). Household food insecurity in Timor-Leste. Food Sec. 5:83–94

Williams, R., Soares, F., Pereira, L., Belo, B., Soares, A., Setiawan, A., Browne, M., Nesbitt, H., and Erskine, W. (2013). Sweet potato can contribute to both nutritional and food security in

Timor-Leste. Field Crops Research 146, 38-43.

Reports

Imron, J. (2013). Mid-Term Survey. 96p.

Silva Solano, L. (2013). Drivers and Determinants of Sustainability and Development of Savings and Loans Groups. 46p.

SoL (2012) Annual Research Report, 2012. 140p

Venroij, L. (2013). Comparison of variety adoption in two sucos in Bobonaro.

Venroij, L. (2013). Women farmers participation in agriculture and access to improved seeds.

Young, P. (2013). Complementarity Between Maize Seed Production and Good Storage. 25p.

Young, P. (2013). Benefits of Targeted vs. Non-Targeted Seed Distribution. 29p.

Young, P. (2013). Effect of Importing Maize and Rice Seed on Agricultural Production in Timor-Leste. 37p.

Young, P. (2013). Impact of Rice Imports on Rice Production in Timor-Leste. 61p.

Conference presentations

Timor-Leste Study Association conference, Dili, 15-16 July, 2013

Topiku	*Autores*	*English translation*
Oinsa Lalaok Mudansa Klimatika Hahu Husi Tempo Portuguesa To'o agora?	Isabel Soares Pereira, Florindo Morais Neto, Raimundo Mau, Samuel A. Bacon, Robert Williams.	How the climate has changed from Portuguese time to now.
Koto Nani Afrika Hetan Produsaun Aas Iha Timor Leste	Armindo Moises, Luis Fernandes, Antonio do Rego, Abril de Fátima, Tobias Moniz Vicente no Amandio Ximenes	Climbing beans from Africa produce a good yield in Timor Leste.
Konserva aihoris leguminosa iha timor leste	Juliana de jesus Maia, Denisia Brito no Robert William	Conserving legumes in Timor Leste
Ho hare varidades Introdus sei aumenta Aihan iha Railaran	Rojino Da Cunha ,Cipriano Martins,Tobias Monis Vicente, ho Ermelinda Hornai Lopes	Introduced rice varieties can increase food production in Timor Leste
Duhaen Nudar Fore Ida Riko Ho Nutrisaun	Jose da Costa Ronal Freygen	Wing beans, a wild and cultivated food good for nutrition
Aifarina varidade foun nia produsaun a'as no sabour diak iha Timor Leste	Jose da Costa Ronal Freygen, João Bosco Costa Belo, Marcos Correia Vidal no Abril de Fatima	New cassava varieties for Timor Leste have a good production and taste.
Fehuk introdusaun haforte seguranca aihan TL	Felisberto Amaral Soares, Leandro C.R. Pereira, Joao Bosco Belo, Denisia Raquela Brito & Armindo Moises.	Introduced Sweet potatoes increase food security
Varidade Batar Mutin Sai prekupasaun ba To'os Nain iha Timor- Leste	Leandro C.R.Pereira, Felisberto Amaral Soares, Armindo Moises, Rojinho da Cunha, Denisia Raquela Soares de Brito,Robert Williams.	Looking for a white maize variety for Timor Leste.
Efeitu tempu muda Viveros no quantidade Bele Hasae Produsaun Hare	Tobias Moniz Vicente, Ermelinda Hornai Lopes	Effect of planting time and seedling age on rice yield.
Variasaun Fore Munggu hodi hadia Moris Toos nain no hamenus mal nutrisaun iha Timor Leste.	Marcos Correia Vidal, Jose da Costa Ronal Fregen, Robert Williams	Mung bean varieties can increase food production and reduce malnutrition in Timor Leste
Efeitu Adaptasaun Variedade Fehuk Ropa iha Tempu Udan no Tempu Bailoro Husi	Husi Inacio Savio Pereira	Adaptation of potatoes to wet and dry season in Timor Leste
Batar Noi Mutin produsaun a'as no k'or mutin.	Maria Martins & Salvador de Jesus, Apolinario Ximenes, Antonio pereira. do Rego, Amandio da Costa Ximenes, Inacio Savio Pereira, Mario Tavares, Leao Mauleto, Luis Fernandes, Luis da Costa Patrocinio,	White maize variety Noi Mutin has increased yield.

	Julio Filipe da Costa.	
Mudansa no progresu nebe peskizador hetan iha to'os nain to'os nain nia to'os husi 2008-2011	Julieta Lidia, Maria Martins ,Salvador de Jesus, Apolinario Ximenes, Antonio pereira. do Rego, Amandio da Costa Ximenes, Inacio Savio Pereira, Mario Tavares, Leao Mauleto, Luis Fernandes, Luis da Costa Patrocinio ho Julio Filipe da Costa	Changes and progress researchers have found on farm from 2008 to 2011.

Timor-Leste media coverage 2013

Business Timor. (Aug 12). Investimentu Fundu Minarai 27%; ETAN. (17 mentions during the year); RTTL. (8 mentions during the year); Timor Post. (8 mentions during the year).

Timoroman.com. (1 mention)

Australian and international media coverage 2013

Articles publichsed on-line and included in ACIAR, IRRN, Aljazeera and other news and research sites 31 times during year.

Printed materials

Included banners as extension material and for conferences, booklets, brochures, labels, posters, report covers, signs and calendars.

Website http://www.seedsoflifetimor.org/

9. Capacity building

In 2013, two MAF staff were awarded John Allwright scholarships to pursue post-graduate studies in University of Western Australia. This makes the total of five (5) MAF staff studying for Masters degree overseas during the year. One staff completed his studies during the year and returned to work for the program while the 2 staff studying in Bogor Agricultural University in Indonesia are expected to return to Timor-Leste in 2014 **(**see Table 1**).**

The total training opportunities for short-term courses during the year was 4722 days or equivalent to 18 training opportunities per working day which means that a total of 18 MAF staff were attending training every working day of the year (see Table 2).

The bulk of training focused on seed production followed by English and research data analysis and reporting (see Figure 75). Staff were provided with English training to help them achieve language proficiency required when pursuing postgraduate degree overseas. Other technical trainings provided included agronomy, crop modeling, M&E as well as courses on nutrition, savings & loans. Furthermore, general courses such as mathematics, IT, communication, gender and administration were organized.

Most courses were held in-country however the program also sent few selected staff to attend international workshops and training overseas in countries such as Indonesia, Australia, Czech Republic and China.

The program also provided technical assistance to 10 students of the Faculty of Agronomy in Universidade Nacional Timor Lorosa'e (UNTL) in preparing their Bachelor's research paper.

Table 122 Masters degree training

Start Date	*End Date*	*Course title*	*M*	*F*	*Total*	*Training days/ training opportunities*
1/1/2011	31/12/2013	Social Science	1	0	1	1096 (1096)
29/08/2012	31/08/2014	Agronomy - Plant Breeding	1	0	1	733 (733)
29/08/2012	31/08/2014	Agronomy - Plant Breeding	0	1	1	733 (733)
8/3/2013	7/3/2016	Agronomy - Tissue Culture	0	1	1	1096 (1096)
2/7/2013	2/7/2016	Agronomy - Plant Breeding	0	1	1	1097 (1097)

Table 123. Final university year research projects (scripsi) at UNTL

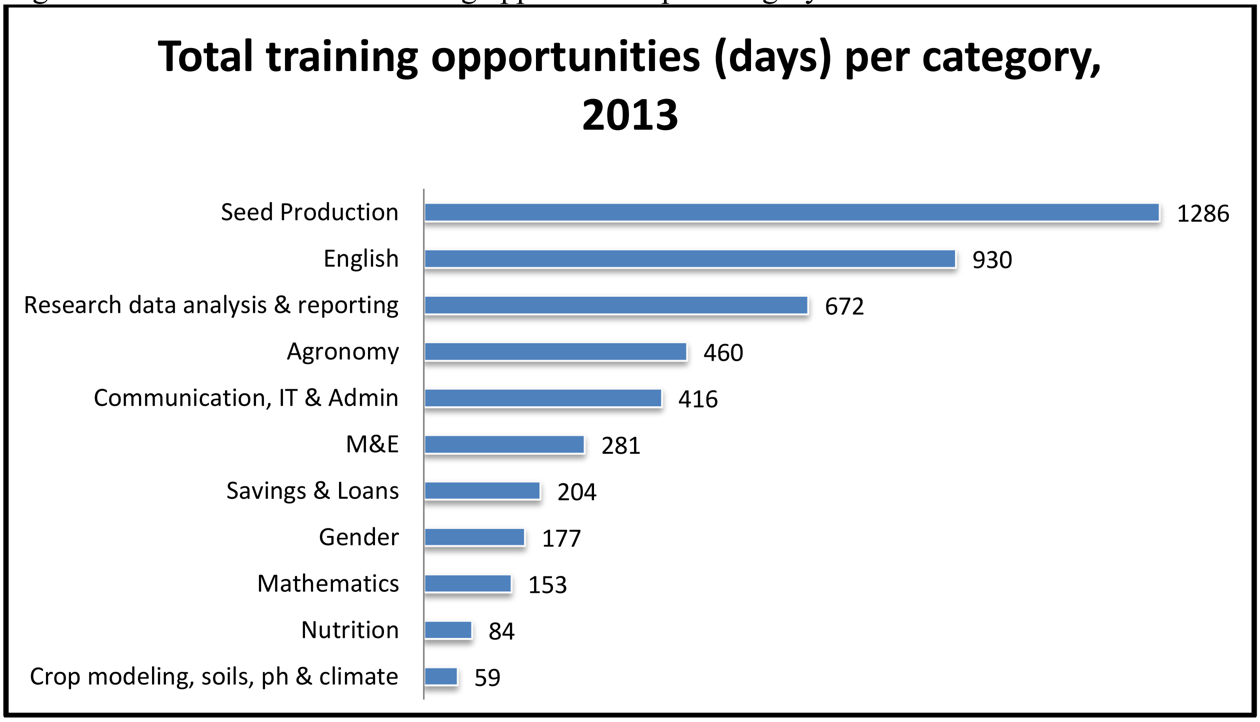
2013	Agronomy scripsi's at UNTL	9	1	10

Table 124. Short-term training (days) in 2013

Course Category	*Participants*			*Training Opportunities*
	M	*F*	*Total*	
Agronomy	79	8	87	460
Communication, IT & Admin	139	22	161	416
Crop modeling, soils, pH & climate	33	9	42	59
English	163	34	197	930
Gender	150	27	177	177
M&E	23	22	45	281
Mathematics	55	22	77	153
Nutrition	61	23	84	84
Research data analysis & reporting	112	30	142	672
Savings & Loans	80	29	109	204
Seed Production	759	137	896	1286
Total	*1654*	*363*	*2017*	*4722*

Note: Training opportunities is calculated by multiplying total number of participants and total number of training days.The number of training opportunities each working day in 2013 was 18.

Figure 75. Total number of training opportunities per category in 2013



10. Technology recommendations

10.1 Released and potential varieties

Ten improved crop varieties identified by SoL/MAF had been released by the MAF at the end of 2013. The first seven varieties identified by SoL were released by the Variety Release Committee on 8 March 2007. 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 and in later years. Their evaluations are fully described in the Seeds of Life Annual Research Report for 2008.

Two cassava varieties were released by the MAF on 27 August, 2009 and multiplied in 2009-2010 for distribution to seed producers. These varieties were released as Ai-Luka 2 and Ai-Luka 4. A description of the evaluations leading to the release of these varieties including the variety release documents is presented SoL, 2009.

A high yielding white variety, Noi Mutin evaluated years from 2009 to 2012 was released on 27 July, 2012 with the name Noi Mutin (white darling). Details of the evaluation of this variety leading to it being recommended to the Variety Release Committee are included in the 2011 SoL Annual Research Report.

Most of the ten released varieties were included in replicated and on-farm trial after their official release. Details of these are included under the species names below.

10.1.1 Maize

Sele, Suwan 5 and Noi Mutin

Of the two released yellow maize 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 the period from 2007 to 2012. 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 2012 (See SoL, 2012) as it did in earlier years (Table 125, Table 126). 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 2011-2012 were white grained as these varieties are preferred by farmers in many parts of Timor-Leste. A comparison of the yield of Sele and P07 (released as Noi Mutin in 2012) with the controls during replicated trials conducted over a six year period is presented in Table 125. Sele outyielded the locals by an average of 50% over this period and P07 (Noi Mutin) by 46%.

White grained Noi Mutin was included in OFDTs for the fourth year in 2011-2012. This variety continued to out yield local varieties as did Sele. Sele out yielded the locals by an average of 43% and Noi Mutin by 27% over 662 sites between 2009 and 2012 (Table 126).

Four other white maize varieties (V11, V15, V41 and S07) performing well in replicated trials in 2010-2011 and 2011-2012 were initially being considered for inclusion in OFDTs for 2012-2013 but were rejected due to weevil damage and downy mildew susceptibility during dry season trials.

Table 125. Sele and Noi Mutin maize yields and yield, advantages res. stns, 2007-2012

Year	*Yield (t/ha)*			*Yield advantage (%)*	
	Sele	*Noi Mutin*	*Local*	*Sele*	*Noi Mutin*
2007 (Six sites)	2.6	2.6	1.5	73	73
2008 (Four sites)	1.5	1.3	1.0	53	33
2009 (Five sites)	1.8	1.6	1.0	81	58
2010 (Four sites)	1.7	2.1	1.2	42	75
2011 (Four sites)	2.2	2.3	1.5	47	53
2012 (Six sites)	2.5	2.2	2.0	25	5
Mean (2007-2012)	2.1	2.0	1.4	50	46

Table 126. Sele and Noi Mutin maize yields and yield advantages, OFDTs, 2009-2012

Year	*Yield (t/ha)*			*Yield advantage (%)*	
	Sele	*Noi Mutin*	*Local*	*Sele*	*Noi Mutin*
2009 (235 sites)	2.2	1.7	1.4	57	21
2010 (188 sites)	2.7	2.5	1.8	51	40
2011 (86 sites)	2.1	1.9	1.5	34	21
2012 (153 sites)	2.6	2.4	2	31	23
Mean (2009-2012)	2.4	2.1	1.7	43	27

10.1.2 Peanuts

Utamua

The released peanut variety, Utamua, continued to average good yields during 2012. However, the results were very variable with some sites failing. (Table 127). No peanut on-farm trials were conducted during the 2011-2012 wet season but in previous years performed well against the test entries in OFDTs (Table 128).

Table 127. Utamua peanut yields and yield advantages, research stations, 2001-2012

	Yield (t/ha)					*Yield advantage (%)*			
Year	*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
2011 (Four sites)	1.1				0.4	86			
2012 (Two sites)	1.2				0.9	27			
Mean (2006-2012)	1.3	1.6	1.5		0.9	38	24	21	18

* Only two sites for Utamua and only respective controls considered for this evaluation

Table 128. Utamua peanut yields and yield advantages, OFDTs, 2006-2010

	Yield (t/ha)					*Yield advantage (%)*			
Year	*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

The three released varieties, Hohrae 1-3 (Table 129) continued to perform well in replicated trials during 2012. All three varieties are highly popular with the farmers, particularly Hohrae 3 which is an orange coloured flesh variety bringing extra vitamin D into the diet of consumers. The results of trials conducted in 2011 also indicated that both CIP 83 and CIP 72 performed well. The yield results of these entries from replicated trials are presented in Table 130. Hohrae continued to be included in OFDTs during 2012 as the best performer to date for comparison purposes.

Table 129. 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 (Five 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 130. Select sweet potato yields and yield advantages, research stations, 2011 and 2012

Year	*Yield (t/ha)*				*Yield advantage (%)*		
	Hohrae 3	*CIP83*	*CIP72*	*Local*	*Hohrae 3*	*CIP83*	*CIP72*
2011 (Four sites)	10.2	9.1	14.8	4.2	145	118	254
2012 (Five sites)	14.0	7.9	12.7	7.2	95	10	76

OFDTs conducted between 2007 and 2010 demonstrated the capacity of the Hohrae varieties to perform on-farm under a range of conditions (Table 131). Hohrae 3 was included in 41 OFDTs in 2012 and was the equal best performer with CIP83 (Table 132).

Table 131. Sweet potato yields and yield advantages, OFDTs, 2007-2010

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

Table 132. Select sweet potato yields and yield advantages, OFDTs, 2011 and 2012

Year	*Yield (t/ha)*				*Yield advantage (%)*		
	Hohrae 3	*CIP83*	*CIP72*	*Local*	*Hohrae 3*	*CIP83*	*CIP72*
2011 (44 sites)	13.4	9.3	4.0	4.0	235	127	0
2012 (41 sites)	10.6	10.9	7.4	4.6	130	137	61

10.1.4 Rice

Nakroma

Nakroma (released in 2007) was included in the Aromatic Rice Observational Trials reported in Section 2.4.1 of this report and performed as well as other aromatic rices. Performed extremely well in farmers' fields between 2005 and 2010 averaging 31% more yield on 51 sites (Table 133). 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 favourably received by farmers. This variety and PSB RC 82, Matatag 2 and Angelica were included in OFDTs during 2011 and with Matatag 2 in 2012 (Table 134).

Table 133. Rice yields of OFDT, all Districts, 2005 - 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	

Table 134. Rice yields of OFDT varieties 2010-2011 and 2011-2012

	Mean predicted yield (t/ha)						
	Significance	Local	Nakroma	PSBRC 80	PSBRC 82	Matatag 2	Angelica
2010-2011 (17 sites)	ns	2.4	3.3	3.0	2.5	4.2	2.1
2011-2012 (29 sites)	ns	2.1	2.7			2.6	

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 Noi Mutin are well adapted over all testing regions. There is no indication that Sele or Noi Mutin 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 hill. 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 between 2006 and 2012 indicated that velvet bean will need to be planted after maize to avoid smothering the crop during the wet season. 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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