Enhancing groundnut productivity and production in Eastern and Southern Africa

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Summary

The Tropical Legumes Project is a research and development approach that is complementary to the CGIAR Research Program being implemented by a global consortium of partners. The project targets production of legumes that have high nutrient content and possess commercial potential to fight hunger, increase income and improve soil fertility for the resource-poor farmers. The groundnut improvement and seed systems under the Tropical Legumes II Project is implemented by ICRISAT with full participation of four national program partners in Malawi, Mozambique, Tanzania and Uganda. There is strong involvement of public sector, private sector and non-governmental organizations that assure relevance and effectiveness in delivery of groundnut innovations. These technologies must inter alia secure harvests against drought and outburst of major pests and diseases, in the process guaranteeing high yields and quality. In addition, the program seeks to strengthen the capacity to deliver seeds of new varieties and build capacity of partners to utilize integrated legume innovations for research and production purposes. The key achievements of the program over the last seven seasons include:

1. **Improved access to seed**. Increased adoption of improved varieties by farmers, in some cases, new varieties accounting for up to 40% of cropped area in the case of Malawi. This has led to improved productivity from about 450 kg ha^{-1} in the pre-TL II period to about 800 – 1,000 kg ha^{-1} in 2013[1].
2. **Benefits from farmer participatory research**. By engaging farmers during the pre-release variety selection, breeding programs have been able to better target varieties to both the ecological and market needs. In all anchor countries, an average of five new varieties were released including on-the-shelf material.
3. **Stronger regional breeding pipelines**. In both phases of the project, the ICRISAT regional program has been strengthened through both human capital and infrastructure development over the seven seasons. Accordingly, the program has provided over 2,500 new breeding lines to the partners of anchor countries, such as Tanzania, Malawi, Mozambique and Uganda as well as spill over countries (non anchor countries – Sudan, DR Congo, South Africa and Zambia).
4. **Strengthening of seed system**. A semi-commercial to commercial seed systems that link breeders to smallholder seed producers and marketers run on the basis of a revolving fund has been explored in Malawi. This system provides over 50% of the legume seed used in Malawi. Based on working through farmer organizations, alternative pro-poor seed delivery scheme in all partner countries have facilitated access to good quality seed.
5. **High net impacts**. The farmer field schools have delivered improved groundnut seed to more than 100,000 households in Malawi and Tanzania over the past three years. At the current production levels, it is estimated that the total seed produced in these countries if availed in 2 kg small seed packs would benefit a total of 17,096,425 individual farmers.

1. More details can be found from ICRISAT Groundnut R4D Impact Assessment Report 2013.

Key achievements

Crop improvement

Development and research context

Groundnut (*Arachis hypogaea* L.) is a major valuable and versatile grain legume crop that contributes tremendously to economies and livelihoods of smallholder farmers in Eastern and Southern Africa (ESA). The crop plays an essential role in determining the economies and livelihoods of smallholder farmers contributing to their household nutrition and food security, as well as soil health. The crop is well adapted to low rainfall an increasing phenomenon especially now, with the threat that is posed by climate change[2]. This resilient crop, thus, continues to form part of the adaptability strategies to an ever-present threat to their livelihoods that is now predicted to have even more severe effect[3]. The ESA region has 2,631,167 ha of groundnut cropped area, with four CGIAR Research Programs (CRP) and TL II anchor countries accounting for 76% of the total cropped area (2,003,035 ha)[4]. The yield of groundnuts in the region is limited by four major constraints that are as follows: (i) Low productivity with yields hovering around 400 kg ha^{-1} in most countries compared to 1,700 – 2,500 kg ha^{-1} possible from elite varieties; (ii) Obsolete varieties, such as *Chalimbana* in Malawi, *Bebiano blanco* in Mozambique and *redmwitunde* in Tanzania are still common, highlighting the importance of limited access to improved seed varieties. A recent impact assessment study in Malawi showed that the proportion of recycled seed used by farmers ranged from 30% for new varieties to over 62% for old obsolete varieties[5]; (iii) Biotic stresses still impede production, with major diseases, such as rosette, early leafspots (ELS), rust and contamination of grain with *Aspergillus*-produced aflatoxin, being common. Under severe epidemics the entire crop may be lost to disease though in majority of years approximately 30% yield loss from all diseases combined is common. It has been estimated that in Malawi alone, approximately $12 million produce is lost annually from the combined effect of ELS and rosette; (iv) In addition, drought due to the erratic rainfall has affected the groundnut production agro-ecological zones in the three target countries. Thus, strategic investment in groundnut research for development (R4D) will go a long way in unlocking potential of the crop to contribute to economic growth with more direct impacts on livelihoods and ecological services, especially improvements in the agro ecological productivity.

Groundnuts production trends in target countries

In general, groundnut production has been increasing in the region especially after the intensified investments in groundnut research for development activities (Figure 1). In each of the anchor countries, the yield increase ranges from 25% in Mozambique that has just released new varieties in 2011 to almost 90% in Tanzania between 2007 and 2012. In particular, Tanzania has been very successful due to its official policy on production and use of Quality Declared Seed (QDS) produced under supervision by the National Seed Agency. The increase in production is attributed to adoption of new varieties. In Malawi, recent impact studies showed that up to 80% of the planted groundnut area is under two main improved varieties, CG 7 and *Nsinjiro*, with average yields on-farm of 560 kg ha^{-1} well above the 1980s average yield of 368 kg ha^{-1}.

2. World Bank, 2012. 4°C. Turn Down the Heat. Why a 4°C Warmer World must be Avoided. A Report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics. World Bank Washington DC, November 2012.
3. IPCC 2014. Intergovernmental Panel on Climate Change report. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Working Group II Contribution to the IPCC 5th Assessment Report — Changes to the Underlying Scientific/Technical Assessment.
4. FAO Stat, 2014. Production statistics, Food and Agriculture organization of the United Nations, Rome, Italy.
5. Davies Ng'ong'ola et al., 2014. Adoption of groundnut production technologies by smallholder farmers in Malawi. Impact assessment study Groundnut investments in Malawi from 1982 – 2013.

In Malawi, the averagely lower yield compared to national averages of 1,000 kg ha^{-1} is indicative of the need to target deployment of genotypes to different agro-ecological needs. Whereas, better endowed agro-ecologies like the Central plateau (comprising Mchinji, Dowa, Dedza, Lilongwe) and high altitude areas of Rumphi, Shire Highlands, and Phalombe managed above 1 ton ha^{-1} on farmer's fields and could utilize full season varieties like CG7 and *Nsinjiro* for maximized production. The need for early maturing or short duration varieties for the low altitude short season agro-ecologies is normally found in Chitipa, Karonga, lower Thyolo, Mangochi, Machinga, Balaka, Neno, Chikwawa and Nsanje (whose productivity was less than 0.75 t ha^{-1} in 2008). Deployment of relevant genotypes has improved productivity in some of these areas although full-scale adoption is still limited (Table 3).

Table 3. Groundnut productivity in major groundnut producing agricultural development divisions of Malawi in 2012.

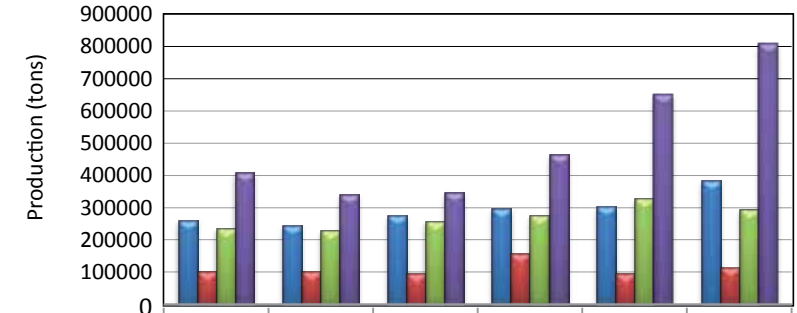
Agriculture Development Division	Productivity (kg ha^{-1})
Shire valley	620
Blantyre	990
Machinga	609
Lilongwe	1,266
Salima	972
Kasungu	1,123
Mzuzu	820
Karonga	990

Source: Ministry of Agriculture and Food Security Malawi.

In Tanzania, groundnut is grown by smallholder farmers with the major growing regions being Mtwara, Tabora, Shinyanga, Kigoma, Dodoma and Mwanza. The area under groundnut in Tanzania is estimated to be 810,000 ha with a rate of growth of 4.63% per annum. The current national average yield[6] is 721 kg ha^{-1}. There has been tremendous increase in the yields with more than 90% increase in production over the last seven years. The yield still hovers around 545–723 kg ha^{-1}. The production has been extensively weather dependent, marked by sharp declines in production during the drought years (2008 – 2009 and earlier in 2000). In order of importance, the largest groundnut production regions of Tanzania are Shinyanga, Dodoma, Tabora and Mtwara accounting for over 60% of the national production. Mtwara and western Shinyanga have slightly better rainfall distribution and can accommodate some of the medium duration Virginia groundnuts whereas Spanish early duration varieties are more adapted to the rest of the country.

The growth and production trends of groundnuts in Mozambique have been reported. The data shows that while the areas under the crop remain relatively stable at about 280,000 ha, the productivity still remains low with declining yields that might be due to the limited access to improved seed varieties. Five new varieties were released in 2011 but they are yet to spread out in part due to a compromised seed system. About 99% of the area under groundnut is cultivated by small-scale peasant farmers on traditional farms and the crop is important both as a subsistence food crop and source of cash and oil (Diop et al. 2003[7]). The oilseed sector in Mozambique has expanded, especially through the interventions of various NGOs, principally in Manica, Zambezia and Nampula[8], which takes lead in

6. Ministry of Agriculture Food Security and Cooperatives (MAFSC 2011). Proceedings of the seed industry stakeholders' workshop held on 3rd June, 2011 at Naura springs hotel, Arusha, Tanzania.
7. Diop, N., J. Beghin, and M. Sewadeh. 2003. Groundnut Policies, Global Trade Dynamics and the Impact of Trade Liberalization. Mimeo. The World Bank, Washington, D.C.
8. Diagnostic Trade Integration-Mozambique, 2004. Crop subsector analyses results of trade transport facilitation audit. Study Volume 3.



	2007	2008	2009	2010	2011	2012
Malawi	261810	243215	275176	297487	304868	384869
Mozambique	102932	102520	97000	157685	95700	112913
Uganda	235000	229636	257967	275767	327000	295000
Tanzania	408058	340770	347970	465290	651397	810000

Figure 1. Groundnut production in TL II anchor countries during 2007 – 2012.
Source: FAOSTAT 2014

production of the crop. The main varieties are farmers' local varieties, such as *Bebiano blanco* and newer varieties, such as *Mamane* and *Nematil*. The main challenge to increase productivity is access to seed. For southern Mozambique (Inhambane, Gaza and Maputo), the focus is on high yielding short duration varieties (90 – 110 days) with resistance to ELS and rust. For northern Mozambique (Nampula, Zambezia, Cabo Delgado), the major focus is on medium-duration varieties (110 – 130 days) with resistance to rosette and ELS. For the whole country, the strategy is to provide varieties and agronomic packages targeting reduction of aflatoxin contamination.

Seed systems

Improving groundnut seed systems

The access to improved seed variety is fundamental for the development and growth of the agricultural sector worldwide. In general, the legume seed systems in ESA are improving, especially under TL II project. This weakness is conditioned in part by non-competitive public sector-led seed production systems and low interest by the private sector to invest in a crop characterized by high seed rates (approx. 100 kg ha^{-1}), low seed multiplicative ratio (approximately 1:10) and high opportunity for seed recycling by the farmers. TL II investments sought to develop efficient seed systems for reaching smallholder farmers in drought-prone areas of SSA and SA. The outcomes of investments in ESA are highlighted below.

Planning for success through country seed strategies and road maps

Strategic planning. One of the major achievements of TL II has been the development of Country Seed Strategies and Road Maps to guide production and distribution of improved seed by all anchor countries. Each strategy clearly defines and sets targets for groundnut seed production for the various classes of seed (breeder, foundation, certified or QDS); partnerships for producing, marketing and delivering the seed to farmers; capacity strengthening entry points and critical challenges and opportunities to be harnessed per country.

Strengthening seed production and delivery strategies. In order to ensure sufficient seed production, TL II has supported production of all classes of seed. The highlights are provided below.

1. Breeder seed. In all anchor countries, most of the varieties are released by public research agencies. Yet these research bodies are under resourced to produce breeder seeds more effectively. Therefore, the project has invested in strengthening NARI production of breeder seed. Two models are being used, ie, (i) National Agricultural Research Systems (NARS) alone and (ii) NARS + ICRISAT. The NARS + ICRISAT model is being used to inject up to 0.5 tons of breeder seed upon request to NARS partners in addition to what NARS have produced. Using this approach, Malawi produces about 27 tons of breeder seed (*Nsinjiro, CG 7, Chitala, Kakoma* and *Baka* and *Chalimbana* 2005) up from about 0.5 – 1 ton in 2007. Similarly in Tanzania, breeder seed production of Pendo was spread across three major research stations and one FTC producing 5 tons per year. A similar strategy is being used in Uganda with about 8 tons of seed produced, of which 4 tons come from TL II support, up from a case of less than 0.5 tons in 2007.

2. Foundation seed. Two strategies are being used for foundation seed production. The first is the use of contract farmers with proven track record as implemented in Malawi and Uganda and use of Farmer Field Schools and farmer groups as implemented in Malawi, Tanzania and Mozambique. In both the cases, the farmers are trained on seed production and they annually receive infusions of seed from the breeder. The smallholder farmers initially receive seed grants and following successful payback can be given even more seed to produce on a contractual basis. The farmer groups for Malawi are those linked to the National Association of Smallholder Farmers Malawi (NASFAM) whereas those for Tanzania are linked to the Agricultural Seed Agency (ASA). Another successful foundation seed provision scheme in Malawi is the seed revolving fund scheme run by ICRISAT (Figure 2). This was initiated by ICRISAT in 2001 through a one-time financial grant from USAID and is still running with further support from Irish Aid. The scheme has since grown and is supported by an alliance of seed producers that now accounts for 54% in total of legume seed produced in Malawi. Since its inception, the scheme has delivered more than 1,200 tons foundation seed and more than 200 tons breeder seed. Currently, the scheme produces

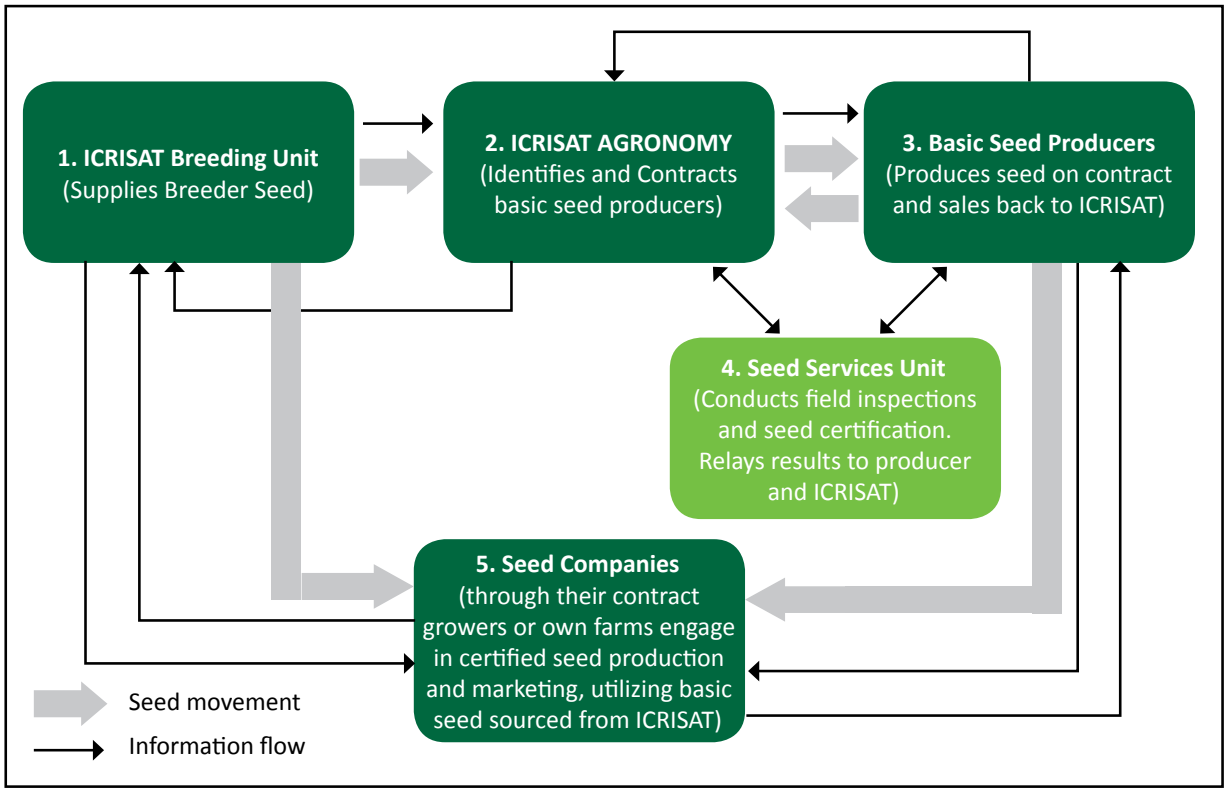


Figure 2. The Malawi model of the seed revolving fund.

about 200 tons foundation seed and 50 tons of breeder seed annually. By 2011, the scheme was able to supply the seed requirements of 156,250 farmers. Taking cognizance of the fact that the groundnut farmers obtain a majority of seeds from other farmers, this reach can easily be multiplied five-folds.

The scheme is funded through a revolving fund that grows based on the sale proceeds of the foundation seed to selected local seed companies and a few NGOs working on food security, who in turn produce and sell certified seed to the government and farmers. The fund has been growing and expanding to other orphaned crops.

3. Certified seed. TL II partnered with farmer organizations like NASFAM in Malawi and farmer cooperatives in Tanzania for commercial production of certified seed. The seed from farmers' field is used either directly by the farmer organizations or feeds directly into Government programs such as the government input subsidy programs of Malawi. This model is now replicated in Zambia. In order to ensure sustainability, the private seed sector is slowly getting involved. In Malawi, the demand created by the Government input subsidy program has attracted SEEDCo, one of the largest seed companies in the region, into groundnut seed production and marketing. Recently, Tanzania has found apparent involvement of certified seed marketing agencies, such as the ASA that sells about 100 tons of certified seeds per year.

4. Alternative seed production, distribution and marketing arrangements. In order to improve the reach of new varieties, TL II explored alternative seed production systems that depend on farmer level but research supported seed production. A combination of farmer groups and farmer field schools were engaged in seed production. In 2013, the Tanzanian farmer groups produced 17,542 tons of seed, followed by 16,253 tons produced by Malawi, about 363 tons by Uganda and 66 tons by Mozambique. In Malawi, more than 450 farmers were involved who were linked to the NGO named as CARE, 233 farmers were linked to NASFAM, and 73 linked to the Millennium Villages project. Similar approaches are being used in Uganda with NASAARI partnering with Government Programs (District Farm Offices or National Agricultural Advisory Services), local companies and civil society such as Plan International, VECO, for seed production and making it available to the farmers.

1. **Strengthening diffusion, marketing and institutional arrangements for seed**. In order to improve the diffusion of technologies, the TL II harnessed complementary investments in all anchor countries and successfully built upon earlier lessons that were learnt while working with the farmer groups.

    - **Tanzania experience**. Farmer-marketing groups were established in districts of Tanzania – Mpeta, Mnanje B and Likokona – while seed production groups have been established in three districts of Malawi – Mchinji (19), Nkhotakota (28) and Zomba (3). In addition to the supply of the required variety and class of seed to the growers and traders, they were supported by capacity building and farmer-friendly literature in vernacular on Integrated Crop Management and seed production, processing, storage and marketing skills (especially for the traders and seed entrepreneurs). Seed marketing is handled by ASA in Tanzania. These agencies offer smallholder farmers seed production contracts to produce certified seed, which is then bought back by these agencies. The national seed services of each participating country do independent inspections for quality assurance.
    - **Malawi experience**. In collaboration with NASFAM and Millennium Village Project and other complementary projects (McKnight Foundation supported), there are now about 200 seed production groups with community seed banks in Mchinji, Kasungu, Mzimba Nkhotakota Dedza and Zomba. The groups in Mchinji are already mature and are regularly producing seed on contract for ICRISAT and other interested NGOs and private sector. Others are still at seed production level and dependent on project-based support market to sell their produce as seed,

otherwise, they sell most of what they produce as grain. In addition, 150 farmers in Kasungu from Traditional Authorities (TAs) Kaomba, Mwase and Njobwa in collaboration with ICRISAT and CARE were issued with groundnut breeder seed of ICGV-SM 90704 and ICGV-SM 99568 to produce foundation seed under the formal contract. Around 135 smallholder contract growers produced each 0.5 ha seed but organized themselves into a farmer cooperative in order to take care of the costs involved in delivery of a contract.

- **Uganda experience**. A multi-pronged approach is being used in Uganda involving community-based organizations that already have farmer groups such as Soroti Catholic Diocese Development Organization (SOCADIDO); farmer self help groups such as Patongo women's group as well as through Government supported rural interventions that require collective action through the National Agricultural Advisory Services (NAADS). The TL II trained community organization extension agents provide seed and complementary training to produce it by NASAARI. These are generally being contracted to produce seed for government, private sector or distribution within the community.

2. Improving capacity to produce, deliver, store and market seed. A number of activities have been conducted to improve production, delivery and marketing**.**

- **Production**. By 2010, 527 officers, farmers and seed producers, 57 technicians, 141 extension officers and 46 farmer research group leaders were trained in seed production in Tanzania and Malawi. In addition, a groundnut seed production manual for Malawi was produced while a similar manual for Tanzania is available in Swahili. In Uganda, a similar document has been produced. In each anchor country, at least 1,000 – 3,000 information leaflets are distributed during each growing season. In addition, over 6,000 farmers (3,635 women and 2,365 men) have been trained towards the use of improved technologies (improved varieties and integrated crop management – time of plantation, plant population, weed management, harvesting and post-harvest technologies including storage and management of aflatoxin contamination).
- **Engaging private sector**. In Malawi, under the umbrella of Malawi Seed Alliance Trust (registered in 2014), an alliance of local seed producers and marketers, created to sustain availability and increased uptake of legume foundation seeds by local seed companies and entrepreneurs. The current membership of MASA endorses 14 small seed companies and smallholder producer groups. MASA provides branding that allows the seed to be marketed commercially in Malawi. MASA brands are packaged as small seed packets of 5 and 10 kg suitable for the smallholder farmers. In Uganda and Tanzania, the seed companies are being engaged albeit at ad-hoc basis because of the weak demand from the seed companies to engage in legume seed. A similar scenario exists in Mozambique.

3. Local-level awareness of released varieties (demand creation). A number of activities to popularize the released varieties were implemented in all anchor countries. These are highlighted below.

- **Annual farmer field schools, farmer field days and seed fairs.** In Malawi, 20–50 farmers' field days are conducted annually by NARS and ICRISAT with partners since 2007 for skill upgradation of the farmers and stakeholders on improved varieties and integrated crop management while soliciting feedback to improve focus of the breeding program. The farmer field schools have also become an important tool for technological awareness. There are over 400 active farmer field schools in the project sites of Malawi. In Tanzania, the field days (19 per season), open days and seed fairs (two per site per season) and farmer field schools (80 in Tanzania) became tools for regular project monitoring of activities. In Tanzania, for example, over 100 extension officers and policy makers (40 women and 60 men) have been exposed to improved groundnut varieties. Seed fairs have been organized in Tanzania creating awareness for about 2,000 farmers per fair. Furthermore, in Tanzania, more than 3,000 booklets describing good agronomic practices and

methods for good quality seed production were produced and disseminated. In Uganda and Mozambique, open days and field days were also implemented. In 2012, season field days were implemented at project action sites (Acholi bur), national agricultural show and seed fair.

- **Publicity**. Flyers for crop production, aflatoxin management and seed production were developed and translated into vernacular in Tanzania, Malawi, Uganda and Mozambique (at least 4,000 flyers were distributed annually during the field days). These flyers carried messages on description of released varieties, new promising materials under farmer evaluation and results of participatory variety selection from previous seasons. Television and radio broadcasts with live interviews and newspaper articles about the new varieties were also used. The access to benefits by partner communication platforms, such as NASFAM, MASA, etc, increases the reach of information flow. Complementary newsletters became a norm throughout the project sites in Malawi and Tanzania.

Adoption and impacts

Household adoption tracking. Household surveys were conducted in Malawi; based on three rounds (2008, 2010 and 2013) of surveys covering the project areas, progress in adoption is clearly emerging. The adoption rates showed a steady increase, starting from 31% to more than 40% for CG7 (Table 4). Furthermore, the share of the low yielding but formerly widely popular local variety *Chalimbana,* which used to be grown by more than half of the farmers in Malawi, was down to 22% in 2013, showing a good progress in replacing old material in farmers' fields. Partnering with TL II, in-depth studies have also found profound indications of impact achieved on households' incomes, poverty reduction and gender equity attributable to groundnut research in Malawi.

Table 4. Progress of groundnut adoption in Malawi.

	Total		
Crop varieties grown by the farmer	2008	2010	2013
	% of farmers planting		
CG 7	31	39	42
JL 24 (Kakoma)	1	0	4
Chalimbana 2005	11	4	15
Chalimbana	44	34	19
ICGV-90704 (Nsinjiro)	2	17	17
Kalisere	6	3	1
Manipintar	5	3	2

Testing modern ICT tools – Technology for outreach or information. With modern technology penetrating the rural areas, new modes of communication with farmers are made available. Therefore, one of these new avenues was tested in phase II of the project. To raise awareness on aflatoxin contamination among groundnut farmers, ICRISAT's Dr Samuel MC Njoroge, went on Kenya's highly popular farming TV show, *Shamba Shape Up*, in the second episode of the TV show's fourth season titled 'Healthy Groundnuts'. Dr Njoroge advised the farmers on groundnut production and also suggested improvements that will not only result in higher yields, but also reduce aflatoxin exposure.

With over seven million viewers across the three countries in Africa, *Shamba Shape Up* is a widely viewed channel by the smallholder farmers. For farmers in Kenya, the TV show offers additional support by providing free-of-charge information flyers that can be requested by sending a text message. The farmers can also pose queries through text messages to which the experts would respond in less than

48 hours. Aiming at rapidly growing rural audience of East Africa, the makeover style TV show focuses to give both the farmers and audience the tools they need to improve productivity and income on their farms. The show's team visits a farm each week in different areas of the country and involves experts from partner organizations who specialize in the topics covered in the episode. A team from ICRISAT ESA worked with Dr. Njoroge and the show's production company, mediae.org, on planning the episode's content and messaging. The program with Dr Njoroge can also be viewed online at: http://youtu.be/X8H9ETNeieA. The data generated from this exercise is helping the ICRISAT team to further improve aflatoxin-related messaging.

The program was sponsored by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) with funding support from Tropical Legumes-II project. The features parts of an animation were produced by the Innovative Communication Media and Methods project, funded by the McKnight Foundation. This highlights the synergetic effects of various projects for wider spread of the results. Besides its initial release in Kenya, the program will also be aired in Tanzania and Uganda in both English and Swahili.

Strengthening of groundnut breeding pipelines

Participatory variety selection underpinning variety relevance and adoption

Methods. Under TL II project, the FPVS is being used to improve the adoption of new variety by the farmers. FPVS is being used to: (i) identify local and market selection criteria for candidate groundnut varieties; (ii) determine the performance of promising varieties for release and (iii) identify farmer and market-preferred material from the pool of candidate lines for variety release. In general, about 10 candidate varieties, each of mainly Spanish and Virginia groups are being used. In all anchor countries, the methodology used to elicit farmer selection criteria is the same though the number of varieties used varies. The entries were selected based on seed yield and a multiple of other desirable agronomic traits, such as seed color, size, shape and maturity range from trials planted on-farm during agreed upon days (Appendix 2). FPVS were set up following the mother-baby approach in which the researcher-managed trial (the mother plot) and farmer-managed plots (baby plots) were taken into consideration. The number of mother plots contained all test lines including a local check while the baby trials usually contained three test lines. The mother trials varied according to the number of villages while the baby plots were determined by the farmers willing to test lines and seed availability. The pair-wise comparisons and matrix ranking techniques were used to elicit variety preferences by the farmers based on identified local evaluative criteria. In addition, the farmers were given the opportunity to select materials according to their own composite of preferred traits and criteria to gain better understanding of the farmer selection criterion.

Main achievements

1. **Tanzania**. Using this approach the new lines, ICGV-SM 99555 and ICGV-SM 99557, were confirmed as better material than Pendo released prior to TL II. The output traits, such as confectionary market demands as determined by pod filling, grain size and attractiveness of grain were identified and used to inform breeding activities. In the recent past (2012 – 2013) cropping season, 25 farmer research groups (FRGs) comprising 20 farmers each of 25 selected villages (total 12,500 farmers) participated in paired comparisons of three released varieties (Pendo, Mangaka and Mnanje) against a local variety in project districts of Southern (Masasi, Nanyumbu, Tandahimba and Tunduru), Central (Bahi Kondoa and Manyoni), Western (Nzega) and Lake Zone (Bukombe). In addition, 40 new candidate varieties were put under PVS, which involved 8,000 farmers in all the above project action districts of Tanzania. These PVS will lead to the release of next generation of new varieties for Tanzania.

2. **Malawi.** PVS is being implemented now as a routine part of the breeding program. During the 2012 – 2013 season, for example, a total of 25 PVS trials were conducted in over 20 sites in 10 districts (Lilongwe, Kasungu, Mzuzu, Salima, Machinga, Blantyre and Shire Valley Agricultural Development Divisions (ADDs), including new districts of Lilongwe and Mzimba). FPVS involved trials comprised six advanced (Spanish and Virginia) lines in each set tested against two popular varieties (CG7, Nsinjiro or Chalimbana 2005 for Virginia and Kakoma or Chitala for Spanish) in each case in paired comparisons as mother trials. FPVS trial results revealed that the farmers were excited with the new advanced lines due to the various attributes provided by the promising lines. The preferred attributes ranged from high yield, heavy pod load, resistance to diseases (rosette and leafspots), early maturity and good pod filling under limited moisture conditions. Chalimbana 2005 was the most promising variety alongside the older varieties, such as CG7 and Nsinjiro, particularly for export market qualities. The groundnut traders and processors cited the roundish wedge-shaped nuts and uniform grain shape characteristic of Nsinjiro as the reason for preference due to anticipated ease of blanching. PVS top ranked materials, ICGV-SM 96714 and ICGV-SM 99537, have been recommended for release whilst others (four Spanish (ICGV-SM 96714, 99567, 99537, 01514) and three Virginia (ICGV-SM 01708, 01728 and 01711) were identified for their superior performance. These farmer-preferred materials have now been pipelined for National Performance trials and subsequent variety release.
3. **Mozambique.** In Mozambique, FPVS trials were conducted in Nampula, Zambezia and Inhambane and five varieties each of Spanish and Virginia-type were identified. Through PVS, farmers' view points on candidate groundnut varieties were solicited. The current focus of the work is to popularize the released materials, such as ICGV-SM 99568, ICGV-SM 01513, ICGV-SM 01514, CG 7 and JL 24 as well as the new materials.
4. **Uganda.** FPVS has been implemented in various agro-ecologies (major groundnut producing zones), parts with a major focus in the eastern and northern parts of the country. The test materials include nine sets with a total of 35 entries from ICRISAT and eight sets NARO initiated efforts to improve a susceptible ICRISAT derived material S1 or CG 7 (ICGV-SM 83708) using another ICRISAT derived material ICGV-SM 91707. Other materials under PVS include ICGV-SM 06525, ICGV-SM 06629, ICGV-SM 06637, ICGV-SM 08528, ICGV-SM 08556, Baka and Kakoma. These new options will expand the repertoire of improved groundnut materials for use in diverse agro-ecologies of the country and region.
5. **Spill over to other countries.** The approach has also been tried in spill over countries, such as Zambia, where five new candidate lines have now entered national performance trials following successful FPVS. The varieties for release were also identified in Malawi – which should be released before the end of fourth year of the project.

Fast-tracked release of *'on-the-shelf'* varieties expands options for farmers

Prior to the TL II period, variety release was slow with many of the released material unavailable to the farming communities in some cases. More than 148 groundnut mother trials and 440 baby trials in the first four years of the program in Malawi; 60 mother trials and 300 baby trials in Tanzania and 48 mother trials and 162 baby trials in Mozambique underpinned variety release (Table 5). In comparison to the pre-TL II period in the selected countries, (anchor and spill over countries) the program has supported the release of 22 new varieties.

Stronger capacity of the regional program to breed for common needs

Regional operations. ICRISAT maintains a regional groundnut improvement centre at its Lilongwe Station that is based at Chitedze Research Station in Malawi. ICRISAT takes leadership in the development of new populations that underpin the extensive variety selection currently being implemented in all anchor countries. A major contribution of TL II to the regional groundnut breeding efforts has been

strengthening of breeding pipelines in anchor countries in the short term via breeding line access and medium to longer term via sharing of material for use by NARS breeding programs.

Table 5. Trends in groundnut variety releases prior to and during the seven seasons of TL II.

Country	Breeding line/Germplasm	Released name	Year of release
Malawi	ICGV-SM 83708 (ICGMS 42)	CG 7	1990
	ICGV-SM 99568	Chitala	2005
	ICGV-SM 90704	(Nsinjiro)	2000
	ICG 12991	(Baka)	2001
		Chalimbana 2005	2005
	Chalimbana	Chalimbana	1968
	ICGV-SM 08501		2014
	ICGV-SM 08503		2014
	ICGV-SM 01731		2014
	ICGV-SM 01724		2014
	ICGV-SM 99551		2014
	ICGV-SM 99556		2014
	ICGV-SM 01514		2014
Mozambique		Babianco Branco	
	ICG 12991	Nematil	2002
	ICGV-SM 90704	Mamane	2002
	ICGV-SM 01513		2011
	ICGV-SM 01514		2011
	ICGV-SM 99541		2011
	ICGV-SM 99568		2011
	CG 7		2011
Tanzania	Robut 33-1 selection	Johari	1985
	ICGMS 33	Pendo	1998
	ICGV-SM 99555	Naliendele 09	2009
	ICGV-SM 99557	Mangaka 09	2009
	ICGV-SM 01711	Nachingwea 09	2009
	ICGV-SM 01721	Masasi 09	2009
	ICGV-SM 83708 (ICGMS 42)	Mnanje	2009
Uganda	ICGV-SM 83708 (ICGMS 42)	Serenut 1R	1999
	ICGV-SM 90704 (Igola-2)	Serenut 2 /Igola 2	2002
	ICG 12991 (Igola-1)	Serenut 4T	2002
	ICGV-SM 93535	Serenut 5R	2010
	ICGV-SM 99566	Serenut 6	2010
	[a]SGV-S1R x S2	Serenut 7T-14R	2011

[a]These are derivatives from the cross involving ICGV-SM 83708 (CG7) and ICVG-SM 90704.

Strengthened capacity at ICRISAT. The main focus of the R4D work in Malawi is variety development, germplasm sharing and management and support to developmental partners. The highlights of the major impacts include:

(i). **Input traits: Stress tolerance breeding.** Breeding populations ranging from $F_2 – F_7$ are currently being evaluated. Most of these populations were generated from crosses between adapted Malawian, Tanzanian, Zambian, Zimbabwean, Nigerien, Malian and Senegalese varieties and disease resistant accessions or elite ICGV-SMs lines. There are currently 12 populations for ELS ranging from $F_2 – F_7$, 13 populations for rust resistance ranging from $F_2 – F_7$, 10 populations for GRV ranging from $F_2 – F_7$, nine populations for aphid resistance (F_6) and six populations for aflatoxin (F_2). The program currently maintains more than 3,500 progenies for rust, 1,500 for ELS and 400 for rosette from segregating populations ($F_3 – F_6$) developed for variety improvement through pedigree breeding.

(ii). **Output trait: Oil content and confectionery traits**. Other populations being evaluated were derived from crosses between high yielding genotypes, high oil content (CG 7) and bold seeded genotypes (Chalimbana). The details of populations developed are presented in Appendix 3.

New sources of traits identified under TL I are being used for further hybridization and quantitative trait locus (QTL) mapping. They are presented below:

- **Sources of rust resistance**: 92R/70-4, ICGV 94114, ICGV-SM 86021 and ICGV-SM 02536 that combines rust and ELS. Additional rust resistant lines found from the germplasm reference set includes: ICGV 02194, ICG 11426, ICGV 01276 and ICGV 02286.
- **Sources of rosette resistance**: ICG 14705, ICG 15405, ICG 13099, and ICG 9449 identified from the groundnut reference set.
- **Sources of ELS resistance**: ICG 5663, ICG 4156, ICG 721 and ICG 9905.
- **Sources of drought resistance**: ICG 14390, ICG 14778, ICGV SM 00537 and ICGV SM 03535 identified from field trials.

Germplasm transfers. Over the past seven seasons of TL II, about 2,500 new breeding lines have been availed to NARS in the anchor countries, Tanzania, Malawi, Mozambique and Uganda as well as spill over countries (non anchor countries – Sudan, DR Congo, South Africa and Zambia). The trial sets usually include: Elite short-duration groundnut variety trials (25 genotypes), Elite Virginia bunch drought resistant groundnut variety trial (20 genotypes), Elite Spanish bunch rosette resistant groundnut variety trial (25 genotypes), Elite Spanish bunch drought resistant groundnut variety trial (20 genotypes) and Elite rust resistant groundnut variety trial (16 genotypes), etc. For Malawi, these trials are established at Chitedze, Chitala, Kasinthula and Ngabu. In Mozambique, trials are usually conducted from Nampula, Zambesia, Chokwe and Inhacoongo (Inhambane); whereas in Tanzania trials are conducted at Naliendele, Nachingwea, Hombolo, Makutopora, Bihawana and Tumbi Research Stations. The trials are jointly monitored by ICRISAT and concerned NARS and data reported in appropriate annual planning and review meetings for the project. For the entire period, over 450 international/regional trial sets including varieties and advanced/elite lines were distributed. In addition, the groundnut reference set (259 varieties) and recombinant inbred lines (RILs) (300 varieties) were distributed for drought and disease phenotyping in Malawi and Tanzania in conjunction under TL I. The performance of some of the trial sets selected from the partner research stations has been highlighted in Appendix 4.

Capacity building

There has been infrastructure development in all participating countries for the active breeding program. In Tanzania, greenhouse facilities now exist for disease screening, refrigeration of samples (seed and disease), rainout shelter and a Leaf Area meter for drought screening and Spad meter for chlorophyll measurements in drought screening trials. In Malawi, the NARS have similarly been equipped with a rainout shelter, two glasshouses, one portable weather station and irrigation pump to help them maintain offseason breeding nurseries. Two collaborators from Malawi (Mr Wilson Chafutsa) and Tanzania (Juma Mfaume) were trained at MSc level. Wilson is now in-charge of the seed certification lab of Malawi while Juma is a breeder at Naliendele Research Institute. Training on groundnuts hybridization techniques, design of experiments and statistical data analysis, disease screening and use of the infector row technique benefited seven research technicians from Malawi (3), Tanzania (2) and Mozambique (2). Three scientists, one from each of the partner countries, attended the statistical data analysis training conducted at ICRISAT Malawi.

Lessons learned

Groundnut improvement

1. **Improving R4D efficiency**. Scientist-farmer partnership in agricultural research and development is crucial in bringing about desired changes in the agricultural research and production scenario in the country. There is a need for faster varietal testing and release systems to enhance the spectrum of varieties available to the farmers.
2. **Targeting and adoption**. Advocacy of new varieties and technology by the farmers is essential to bring about changes in the existing policies and large-scale adoption.
3. **Impact orientation**. Sustained seed support is essential for large area coverage by FPVs and resultant enhanced productivity in groundnut.
4. **High performing genotypes could be targeted for regional release**. Many of high performing genotypes are generally good performers across the region. There is need to develop a mechanism if possible, for regional release to overcome or at least minimize “slowdown” due to national institutional challenges.
5. **Strengthening capacity via mentorship**. Each of the countries is unique in their right in terms of capacity and throughput. Exploring opportunity for mentorship amongst regional scientists over and beyond the planning meetings is worth considering, especially supporting development of leadership skills, which are needed to push things through government systems. Tanzania, which is one of the high-flying project partners, is successful because the country’s focal point has good leadership qualities, which is used to mentor other younger scientists.

Seed systems

1. **Marketing-related issues.** The input and output markets continue to emerge as a challenge to full utilization of the potential of legumes by smallholder farmers.
2. **Impact orientation**. The project interventions that focused on pro-poor seed production and delivery systems have a better chance of surviving beyond the lifespan of the project.
3. **Catalyzing seed production**. The contract seed production is profit-motivated as farmers look at seed production as an enterprise; sustainable seed production by smallholders stand a better chance of success if complemented by functional seed and product markets for the legumes.
4. **Limited capacity a challenge**. Limited number of research and seed technicians available in ESA hampers progress of seed dissemination.
5. **Smallholder seed entrepreneurs**. The business-oriented smallholder farmers performed better in seed production, seed storage and seed dissemination than food security-oriented farmers. Hence, efforts should be made for inclusion of such groups into the seed systems.

Appendixes

Appendix 1. Participating districts, wards and villages implementing TL II activities in Tanzania.

District	Ward	Participating Villages
Masasi	Chiungutwa	Chiungutwa, Mpeta and Maugura
	Lisekese	Sululu
	Chigugu	Nangose
	Lukuledi	Chigugu and Mandiwa
		Chikowete and Namichi
Nanyumbu	Mangaka	Likokona
	Maratani	Mnanje-B
	Mikangaula	Mikangaula
	Likokona	Nanyumbu
		Nahawala
Tunduru	Mlingoti Mashariki	Sisi kwa Sisi
	Mlingoti Magharibi	Mkwajuni and Kangomba
	Namasakata	Amani and Mchenga
	Kidodoma	Legeza
	Ligunga	Ligunga
	Mbesa	Mbesa
	Nandembo	Naluwale
	Nakapanya	Rwanda
Mtwara	Naliendele	Naliendele
	Ufukoni	Mbaye and Mbawala chini
	Mkangala	Mji mwema
	Mikindani	Ziwani
	Ziwani	Mkwajuni and Kangomba
		Amani and Mchenga
		Legeza
		Ligunga
Chamwino	Muungano	Muungano
	Buigiri	Buigiri
	Mvumi Makulu	Mvumi makulu
	Mvumi Iringa	Mvumi Iringa
	Msanga	Msanga
	Idandu	Ndembwe
	Msamalo	Chinangali
Bahi	Bahi	Bahi
Kondoa	Mondo	Mondo

Appendix 2. Farmer participatory selection and demonstration sites across various agroecologies of Uganda during the 2013 growing season.

Location	Region	PVS/Multiplication	Demo	Intention
Bukedea	Eastern Uganda	Serenut 5R and Serenut 6T	Serenuts 1-14 series	Demonstration, PVS, yield stability; multiplication
Isingiro	South Western	Gweri red; Serenut 3 and Serenut 5R	Serenut 1-14 series	PVS, demonstration of rosette and leafspot resistant technologies
Patongo		Serenut 5R and Serenut 6T	Serenut 1-14 series	Wide adaptability; yield stability; multiplication
Lyantonde	South Western	Gweri red and Gweri tan; SGV 99046; Serenut 3 and Serenut 5R	Serenut 1-14 series	Demonstrate leafspot and rosette resistant technologies
Maraca	South Western	Serenut 5R, Serenest 7-14	Serenest 1-14 series	Demonstrate leafspot and rosette resistant technologies
Hoima	Western			Wide adaptability; yield stability
Mukono	Central Uganda			Wide adaptability; yield stability
Rubirizi	South Western Uganda	Gweri red and Gweri tan (4 entries); Serenut 5R and S3	Serenuts 1-14 series	Demonstrate leafspot and rosette resistant technologies
Pajule	Northern Uganda	Gweri red and Gweri tan (4 entries); Serenut 5R and S3		Wide adaptability; yield stability; Demonstration
Prison Masindi	Western Uganda	Gweri red	Serenuts1-14 series;	Wide adaptability; yield stability; Demonstration
Acholibur	Northern Uganda	Gweri red and Gweri tan (4 entries); Serenut 5R and S3		Wide adaptability; yield stability; PVS, Demonstration
Alito	Northern Uganda	Gweri red and Gweri tan (4 entries); Serenut 5R and S3		Demonstrate leafspot and rosette resistant technologies
Aduku	Northern Uganda		Serenuts S1-14 series	Demonstrate leafspot and rosette resistant technologies
Nakabango	Eastern Uganda			Rosette disease resistance confirmation at this hot spot in addition to yield stability
Abi	North Western Uganda		Serenuts S1-14 series	Wide adaptability, yield stability; Demonstration
Ikulwe	Eastern Uganda		Serenuts S1-14 series	Demonstration; Wide adaptability; yield stability
Kuju	Eastern Uganda			Wide adaptability; drought tolerance; yield stability
Ngetta	Northern Uganda			Wide adaptability; drought tolerance; yield stability
ZOA	Northern Uganda		Serenuts S1-14 series; Gweri red and tan; Serenuts 5R and 6T	Demonstrate groundnut technologies; PVS; Multiplication

Appendix 3. Populations developed being evaluated at different stages at ICRISAT Malawi.

Priority stress	Generation	Remark
Early leafspot	F_7	Introgressed to Zimbabwe variety
	F_7	Introgressed to Indian variety
	F_6	Introgressed to Malawian variety
	F_6	Introgressed to Tanzanian variety
	F_6	Introgressed to Tanzanian variety
	F_6	Introgressed to Tanzanian variety
	F_6	Introgressed to Nigerian and Senegalese variety
	F_6	Introgressed to Nigerian variety
	F_6	Introgressed to Malian and Senegalese variety
	F_2	Introgressed to Zambian variety
	F_2	Introgressed to Zambian variety
	F_2	Introgressed to Zambian variety
Rust	F_7	Introgressed to Zimbabwean variety
	F_7	Introgressed to Malawian, Zambian variety
	F_7	Introgressed to Malawian, Zambiam variety
	F_6	Introgressed to Senegalese variety
	F_6	Introgressed to Nigerian variety
	F_6	Introgressed to Nigerian variety
	F_6	Introgressed to Tanzanian variety
	F_6	Introgressed to Malawian variety
	F_2	Introgressed to Zambian variety
GRV	F_7	Introgressed to Malawian variety
	F_6	Introgressed to Tanzanian variety
	F_6	Introgressed to Nigerian variety
	F_6	Introgressed to Malian and Senegalese Variety
	F_6	Introgressed to Senegalese variety
	F_2	Introgressed to Zambian varieties
Aphid	F_6	Introgressed to Tanzanian varieties
	F_6	Introgressed to West African varieties
Aflatoxin	F_2	Introgressed to Zambian varieties other regional varieties

Appendix 4. Performance of Elite groundnut varieties at select Research Stations (Tanzania 2009 – 2010).

Cultivar	Naliendele	Nachingwea	Ilonga	Hombolo
CG 7	532	510	1,880	654
ICGV 90087	720	280	1,133	416
ICGV 90092	481	225	573	375
ICGV 94114	720	582	867	561
ICGV-SM 01711	627	422	1,000	765
ICGV-SM 02501	626	623	633	558
ICGV-SM 03701	683	370	900	526
ICGV-SM 86201	700	148	1,500	620
ICGV-SM 90704	692	582	967	512
ICGV-SM 99568	600	175	1,300	383
PENDO	723	718	2,533	763
Mean	646	421	1,208	557
CV%	24.7	35.7	37.6	28.5
LSD	272	256.1	978.6	270
$P \leq 0.05$	NS	**	*	NS

Appendix 5. Seed delivery plan, 2014 – to cover the required area (20% of national area under groundnut for Malawi).

Summary			Area to be covered (20% adoption)		Seed Production (tons)					
					Breeder seed 2012		Foundation seed 2013		Certified seed 2014	
Ecology (Zone)	Demand (ha)	Promising Varieties	Total (ha)	Per variety (ha)	Area (ha)	Production (kg)	Area (ha)	Production (tons)	Area (ha)	Production (tons)
Mid Altitude	216,000	CG7	216,000	129,600	155	139,648	29	26,054	20	18,000
		Nsinjiro		64,800	6	5,000	21	18,737	18	16,000
		Chalimbana 2005		10,800	13	11,848	9	8,000	3	3,000
		ICGV-SM 01711		10,800	6	5,000	3	3,000	3	3,000
Lowland	54,000	Kakoma	54000	27,000	0	400	1	1,250	0	400
		Chitala		27,000	16	13,970	9	8,000	3	3,000
Total	270,000		270,000	270,000	195	175,866	72	65,041	48	43,400