Annual Progress Report
September 2012 – August 2013

Groundnut Varieties Improvement for Yield and Adaptation, Human Health, and Nutrition

Submitted to
The McKnight Foundation

ICRISAT
Science with a human face
International Crops Research Institute for the Semi-Arid Tropics

ANNUAL PROGRESS REPORT

1. NARRATIVE

(I) Overview

Development of this project: Groundnut is a major component in the livelihood strategies of many farming communities in humid to semi-arid tropics. The focal countries for this project are Tanzania and Malawi, in which the crop covers about 316,000 hectares, serving more than 300,000 households. The potential area for the crops is however only 780,000 ha, indicative of the opportunity to double production by expanding crop area and productivity (output per unit). This project is one of the efforts made by ICRISAT and its partners to improve productivity and competitiveness of groundnut as a livelihood strategy for farming communities in the semi-arid tropics. The aim of this project, now at the end of its third year, is to contribute to "reduction of poverty in target countries by improving incomes, food and nutrition security through investments that improve groundnut yield, reduce the incidence of aflatoxin contamination in Malawi and Tanzania, and its effects on human health, designing and implementing strategies for contamination reduction". This goal is underpinned by the fact that the crop has high protein (12-36%), high oil content (36-54%)), thrives under low rainfall and poor soil fertility conditions but can fix nitrogen leaving positive residual effects, and can therefore be grown with limited capital investment. Increase in groundnut production requires a shift to intensification of the cropping system to ensure increased production without negative consequences to the environment. A major focus of CCRP is agro-ecological intensification and in the case of this project the supply of groundnut varieties along with attendant technologies and knowledge that fit agro-ecological contexts is our entry point.

Research problem: Major constraints to groundnut production in lowland and mid-altitude areas of Malawi and Tanzania include biotic (diseases/pests and aflatoxin contamination), abiotic (drought), socio-economic, and institutional challenges that affect functionality of the market and value chains. Biotic and abiotic stresses cause considerable yield losses, with the current yield gap being about two-fold less than is expected (ICRISAT 2013 - Impact studies in Malawi). These challenges can be grouped as input traits (related yield enhancing) and output traits (related to end use). The most challenging output trait is aflatoxin contamination that poses a threat to both human and livestock health and growth, especially among children. The introduction of improved groundnut varieties coupled with proven technologies for the management of aflatoxin contamination could have an especially important impact on women farmers' children and other vulnerable community members, who have in many cases been excluded from the traditional cash crop economy.

Moreover, groundnut is a nutrient dense crop with several nutritional advantages including enhancement of vitamin A absorption due to its high oil content. Groundnuts can thus help ameliorate severe nutrition deficiencies reported in the two countries where more than 49% (Malawi) and 40% (Tanzania) of children under five in the rural areas are malnourished to such a degree that their development is retarded. In fact, child mortality rate is as high as 189 and 141 per 1000 live births in Malawi and Tanzania, respectively. This severe malnutrition has several causes. Firstly, the rural poor do not produce enough food to feed themselves, but also, the diet of the vast majority of farmers lack protein, oil and vitamins. Mycotoxin contamination in groundnuts, especially aflatoxin, can however counteract the nutrition benefits from groundnuts. The R4D purpose of this project is to develop groundnut genotypes with requisite input and output traits for intensification of groundnut production in mid-altitude and lowland areas of Malawi and Tanzania. To address this issue requires development of groundnut genotypes that provide a suitable "fit" for the targeted agro-ecologies and farming systems within the context of the project development goal. The R4D strategy being used to support intensification efforts is presented below and involves breeding, diagnosis and surveillance, experimentation with target communities and knowledge transfer.

Research strategy: The consortium implementing this project consists of institutions with comparative advantage to generate technologies, disseminate them and support the development of an appropriate policy. ICRISAT is the lead institution working with national institutions in agricultural research, health and nutrition, universities and development agencies, leveraging strengths and opportunities of the consortium to improve delivery of project results. ICRISAT will generate novel groundnut varieties around which various productivity enhancement, aflatoxin and nutrition amelioration technologies and knowledge will be developed. The other partners are: Naliendele Agricultural Research Institute, Sokoine University of Agriculture-Tanzania, National Smallholder Farmers' Association of Malawi for outreach, and Kamuzu Central Hospital-Malawi for pilot work on aflatoxin diagnosis, surveillance and management. These partners collectively will generate four outputs that will contribute to the overall project goal namely,

1. High yielding farmer and market-acceptable groundnut varieties with resistance to foliar/viral diseases and aflatoxin contamination developed;
2. Nutritional status, dietary diversity, human health and mycotoxin contamination problem spatially characterized;
3. Adoption rates of improved farmer and market-acceptable varieties and production technologies enhanced;
4. Capacity of partners for management of mycotoxins in food, variety development and enabling policy environment enhanced.

These outputs address issues that are related to development and deployment of groundnuts as a livelihoods strategy-strengthening crop for the targeted communities. Specifically, through new resilient varieties we will: (i) Improve groundnut productivity, contributing to food and nutrition security as well as household incomes when the surplus crop is sold; (ii) Improve soil fertility being a legume and thereby reduce farming costs, a requirement for sustainable intensification; (iii) The use of aflatoxin free groundnuts in diets of communities will improve their nutrition and health; and (iv) scale up knowledge transfer and utilization for improving productivity and thus ensure health benefits within target communities and beyond.

B) Project Activities by Objective (1 September 2012 – 31 August 2013)

The project theory of change proposes that intensification of groundnut production in the lowland and mid-altitude areas requires development and deployment of high yielding, stress resilient, farmer- and market-preferred groundnut varieties as the basic intervention around which food safety, nutrition and other market-penetration innovations and knowledge can be built. High yielding and resilient groundnut varieties increase crop surplus, addressing food security and incomes when sold. Aflatoxin management and formulation of toxin-free groundnut-based diets especially for children can improve the nutritional health and well-being of households. The net benefit will be healthier and productive communities that can harness their natural resources in a sustainable way to address livelihoods. This narrative highlights achievements related to delivering key results during Year 3, in Phase II.

Objective 1: High yielding farmer- and market-acceptable groundnut varieties with resistance to foliar/viral diseases and aflatoxin contamination

Activities 1.1. Identify and introgress germplasm for yield components, farmer/market preferences and adaptation to biotic and abiotic (drought) traits

Two major activities were undertaken to develop and characterize new sources of resistance to Groundnut Rosette Disease (GRD). In the first study interspecies crosses were made involving two designated wild *Arachis* species (ISATGR 72B and ISATR 265 5A) with cultivated groundnuts JL-24 and ICGV-SM 99568 (Chitala). F1 progeny from these crosses are being multiplied and advanced under greenhouse conditions. In the second study, characterization of resistance in new sources (ICGV-SMs 08503, 08501, 01709, 06518, 01721, 01731, 01514, ICGV 14705 and ICG 9449), to the GRD viral complex (GRV, GARV and satRNA) through grafting experiments is being done. Preliminary results from the experiment show that the genotypes ICGV-SMs 08503, 01709, 01514 and 03710 resist GRD by eliminating either GRV or satRNA. Further studies are ongoing.

Activity 1.2. Develop diverse groundnuts breeding lines and populations while developing capacity to screen for GRD and foliar disease resistance in Tanzania

Backcross populations for farmer-preferred but susceptible resistant sources have been developed and advanced to BC2F3. Through evaluation in Tanzania and Malawi, the genotypes ICGV-SMs 01514, 08501, 08503, 03572, 03576, 01728, 01724 and 01731 with superior market and yield enhancing traits have been identified.

Activity 1.3. Develop advanced breeding lines and varieties of groundnut with special emphasis on resistance to aflatoxin contamination

Crosses to improve resistance in elite material (ICGV-SM s 01711, 01721, 99555, 01724, 01731 and 99557) to aflatoxin contamination have been made generating 200 lines. Additionally, farmer- and market-preferred varieties CG 7, JL 24 and Nsinjiro for Malawi and Pendo for Tanzania have been crossed with low aflatoxin genotypes J11, Ah 7223, 55-437 and ICGV 95494. The progeny are being advanced.

Objective 2: Nutritional status, dietary diversity, human health and mycotoxin contamination problem spatially characterized

Activity 2.1. Define the scale of the Mycotoxin contamination problem and identify the hotspots depicting pockets of the populations where Mycotoxin occurrence is higher

This activity was a follow-up to an earlier study on complete surveillance of the aflatoxin problem in Tanzania. Nine hundred and thirty-six grain samples from Central Tanzania (Dodoma) and 174 grain samples from Southern Tanzania (Nanyumbu) were collected from groundnut, maize, bambara nut, sunflower, millet, sorghum and bean for analysis of aflatoxin contamination. The samples were collected from the field and household (freshly harvested grain). Enzyme Linked Immuno Sorbent

Assay (ELISA) was used to detect aflatoxin. The Thin Layer Chromatography (TLC) technique was used to confirm toxin presence. Soil samples were also collected from the same fields from which crop samples had been collected to determine the population dynamics of *Aspergillus* species, the source of aflatoxins. Preliminary results show very high aflatoxin content of 70% and 100% in samples from households and markets, respectively, having up to 4000 ppb, beyond the 4ppb recommended threshold.

Activity 2.2. Assess the relative exposure of humans to Mycotoxin contamination of food in drought prone regions and other vulnerable areas and nutritional benefits from aflatoxin free foods

Seven hundred and ninety-three blood samples were collected from five districts of Malawi including Kazungu, Mzimba, Nkhotakota, Salima and Chikwawa to analyze for the aflatoxin biomarker, an indicator exposure to aflatoxins. Sixty-four percent of individuals had aflatoxin biomarker ranging from 5-600 pg mg of albumin, indicative of a very high level of exposure. Secondary data from our partner, Kamuzu Central Hospital, in Lilongwe, show that most liver patients come from aflatoxin hotspots previously reported, suggesting a link between aflatoxin exposure and liver disease incidence.

Activity 2.3. Assess aflatoxin load in exposed populations and relationships to health-related ailments

Individuals from hotspots whose blood samples were collected to analyze aflatoxin biomarker were also used to analyze Hepatitis B and Hepatitis C status. 3.4% of individuals were positive for Hepatitis B virus and 2.8 % were positive for Hepatitis C virus. These two viruses when linked to aflatoxin exposure increase risk for liver cancer. In 2013-2014 studies on linkages to health will be done.

Activity 2.4. Assess aflatoxin load in exposed populations and relationships to nutrition as determined by body mass index (BMI)

This activity, being implemented by Sokoine University of Agriculture, followed 40 children (below 5 years) who were being fed with a groundnut-based complementary food. The work is being done in Muungano and Mundemu villages of Chamwino and Bahi districts of Dodoma region. Groundnuts were analyzed for aflatoxin using the RomerAgraStrip Total Aflatoxin Test Kit with a detection cutoff level of 20 ppb. Baselines on height and weight of the child study cohort were established and their mothers taught to prepare complementary groundnut-based foods for feeding them. Measurements of height and weight are ongoing, with analysis for determinants of the nutritional status to be completed after Year 1.

Objective 3: Adoption rates of improved farmer and market-acceptable varieties and production technologies enhanced

Activity 3.1. Conduct participatory adaptive trials to assess Mycotoxin management practices relating to crop production in pre- / post-harvest operations, and demonstrations for post-harvest handling, food processing methods, consumption patterns and diets

Results from management practices for aflatoxin were not as prominent as the 2011-12 season in which management practices (box ridges and time of planting) had a three-fold reduction. Contamination in the various treatments ranged from 1.4 to 1.558 ppb. However, results were able to show that early planting (1.4 ppb) and use of box ridges (1.4 ppb) have the potential to minimize contamination. Both late planting and use of box ridges had contamination above 1.45 ppb. The variation in the results may be attributed to erratic rains that influenced the treatments. Most farmers planted in January when the average rainfall was very low and there wasn't much difference between early and late planting

Activity 3.2. Conduct field days, agricultural shows & rural seed fairs with farmers, researchers & market players to promote improved Mycotoxin management including testing of resistant cultivars

New varieties*:* Twenty trials each for Virginia and Spanish genotypes were established in 20 research groups in Malawi – each consisting of 20 members. The most-preferred traits were identified as yield ability, drought tolerance, resistance to disease, earliness of maturity, taste, and ease of shelling. The Spanish varieties, ICGV-SMs 99551, 99556, 01514 were ranked as best genotypes by men and women farmers. The men selected ICGV-SM 99551 as the best genotype due to its high yield (>1600kg/ha), while women selected ICGV-SM 99556 for its good taste, resistance to drought and good yield. In Tanzania, Virginia genotypes, ICGV-SMs 08503, 01731 were evaluated in Chikoweti, Luanda and Nawaje. The genotypes ICGV-SMs 08501 and 08503 were selected yielding 2033.3 kg/ha and 1916.7 kg/ha, respectively. The farmer-preferred traits were pod filling, yield, maturity duration, disease resistance, pod size and kernel size. ICGV-SM 08501 was ranked as the best genotype across sites. These materials have been tested for 3 years and are now being released in the two countries.

Field Days: Three Field Days were conducted in Tanzania to demonstrate the importance of field hygiene and variety selection. In Malawi 12 Field Days were conducted for variety selection and to show production technologies for the management of aflatoxin and groundnut rosette disease. The activity attracted a total of 374 (men 164, women 210) participants in Tanzania. In Malawi 727 participants (farmers, Extension Staff from NASFAM and Ministry of Agriculture, and local traders) attended the field days. In Tanzania, 3 radio and 4 TV programs were produced and are currently being aired on National Radio and TV Stations.

Activity 3.3. Market players to promote improved Mycotoxin management including testing of resistant cultivars

Our partner, the Department of Agriculture and Nutrition at Ekwendeni Hospital Malawi provided aflatoxin mitigation messages to 9,000 families. The second partner, Mzimba South NASFAM Association provided aflatoxin mitigation technologies to farmers and Field Officers. Through this effort, some farmers reported yield increase from 700 to 1300 kg/ha. A limited survey involving (15 farms per district) showed that 75% of the farmers had planted early and used correct spacing while 50% had used box ridges.

Activity 3.4. Enhance institutional innovations to improve access of the poor to good quality seeds of improved high yielding adapted varieties

The focus in this activity is to strengthen the ability for technology delivery for farm households and other stakeholders.

Malawi: Fifty-two tons of certified seed was produced, out of which 12.23 tons were distributed increasing the total number of seed banks to 174 (up from 80), serving 1623 farmers (up from 566) in 2011. To date, beneficiary farmers have at least 1 hectare under improved varieties and each has been able to sell extra seed to at least 2 members of their community, thereby improving the research reach of the institutions.

Tanzania: The project provided 500 kg of improved seed of variety Pendo to new Farmer Research Groups in Naluwale, Nandembo, Sisi kwa sisi (Tunduru), Nangomba, Mnanje (Nanyumbu district), and Ilindi (Bahi district). Each group received 100 kg of seed.

Objective 4: Capacity of partners for management of mycotoxins in food, variety development and enabling policy environment enhanced

Activity 4.1. Conduct training workshops for NARES staff

In Malawi, on 2 November, a total of 7 NASFAM Field officers and 3 Technicians from Chitedze Agriculture Research Station were trained on principles of plant breeding, experimentation and data collection, groundnut production practices and leadership skills.

Activity 4.2. Degree training program to MSc to develop regional capacity for pathology work including screening of commodities for aflatoxin contamination

Ms Ethel Chilumpha from Malawi has been admitted for MSc in Plant Pathology at Lilongwe University of Agriculture and Natural Resources. Athanas Minja from Naliendele Agricultural Research Institute completed his MSc studies at Sokoine University of Agriculture.

Activity 4.3. Conduct sensitization workshop for Policy makers, NARES/ NGO/ Private sector

This activity will be conducted during the next reporting period and will target critical stakeholders for management of aflatoxin. We will leverage support from the communication project that will meet stakeholders in October 2013 in Malawi.

Activity 4.3.1. Linkages with the health and other sectors will be developed and maintained for future collaboration

In Malawi, the project partner in the Ministry of Health is Kamuzu Central Hospital whose role is to collect human blood samples from aflatoxin hotspot areas for exposure studies.

Activity 4.3.2. Develop and share project reports, policy briefs and journal articles

Between 14 and 22 September, 2012 a project progress report on management of aflatoxin and groundnut Rosette Disease was presented to 77 participants (extension workers, lead farmers and traders) of Mikundi, Champhira, Ekwendeni and Linga in the districts of Mchinji, Mzimba and Nkhotakota, respectively. One thousand five hundred flyers on improved groundnut varieties and practices were distributed to various stakeholders. Nine posters on production technologies and seed systems were presented in various forums including field days.

4.4. Establish strategy and time frame for impact monitoring and reporting

The project is using a three-stage system to monitor progress. First a pre-season meeting is held with stakeholders to review past season progress. This is followed by within season monitoring and subsequently end-of-season monitoring. Evaluation studies for monitoring progress within our theory of change will be done this year, setting baselines for a final post project evaluation.

Lessons learned and strategy for improvement

- **Partnerships –** Project success has depended on partnerships with stakeholders who work with farmers and are able to scale-out demonstrations, seed production and engage in farmer-based research and knowledge dissemination. We will maintain these partnerships to support results delivery.
- **Technology delivery** – Community seed banks are effective for improving access to improved variety seed by resource poor farmers but require good group organization and training as an important component for improving farmer organization. We are leveraging the expertise of NASFAM for this purpose as well as lessons for scaling-out this approach
- **Farming context affects technology adoption –** Adoption of technologies in places where groundnut follows tobacco is a challenge as farmers are reluctant to adjust ridge spacing. Exploring the method of planting double rows per ridge may improve farmer's yields per unit area.
- **Engaging policy makers is needed to enact policy –** Politicians, especially in Tanzania, are becoming aware of groundnut technologies and aflatoxin problem. This is an opportunity platform for influencing policy. We will explore this approach in Malawi as well.
- **Lack of incentives for producing aflatoxin free groundnuts hindering the progress –** There is need to conduct an awareness campaign to sensitize stakeholders in the groundnut value chain on the importance of producing and consuming aflatoxin-free nuts and rewarding farmers for their efforts.

(III). ANNUAL WORKPLAN FOR YEAR 1 (September 2013 - August 2014)

The project will involve four main components: breeding, variety testing, aflatoxin diagnosis, knowledge dissemination and capacity building. As appropriate, relevant stakeholders are engaged in implementation to ensure relevance and ultimate delivery of knowledge generated and technologies to the final beneficiaries – smallholder farmers. The detailed work plan guided by this principle is presented below.

Detailed work plan

Year	Quarter	Activity number	Type of milestone	Description of Milestone	Time due*	Means of verification
1 1 1	1 3 4	1.1.1	Activity	• Breeding objectives incorporates knowledge and skills of smallholder farmers through PVS thereby improving breeding effectiveness from Year 1 of Phase II (2010) • Additional sources of resistance to foliar diseases and or aflatoxin contamination identified from the groundnuts through multi-location trials from reference set, core collections, local and wild germplasm (2010 – 2014) • Farmer-preferred varieties with local adaptation identified and hybridization (including back crosses) initiated for introgression of resistance to aflatoxin, GRD and foliar fungal disease resistances (2011-14)	May 2014 May 2013 Sept 2014	• List of farmer/ researcher groups in the two countries. Training reports • Documentation of sources of resistance for hybridization • List of varieties with farmer- / market-preferred traits • List of backcross populations developed
3	1	1.1.2	Activity	• Disease screening capacity developed in Tanzania and NARS scientists routinely use the infector row technique (2010 – 2014)	May 2014	• Training reports • Infector row technique established in Tanzania • List of genotypes

Year	Quarter	Activity number	Type of milestone	Description of Milestone	Time due*	Means of verification
						developed through infector row technique
3 3	3 4	1.1.3	Activity Activity	• Advanced breeding lines and breeder seed of improved groundnut varieties available to NARS and NGOs in ESA on an annual basis (2010 – 2014) • Sick plots for resistance to aflatoxin contamination and drought resistance developed and screening and testing activities initiated	May 2014 May 2014	• Seed requests/ signed MTAs • List and quantities of germplasm distribution by country • List of entries screened and report of performance
2	4	2.2.1	Activity	• Aflatoxin disease survey implemented in Tanzania May 2014	May 2014	• Survey report
	4	2.2.1	Activity	• Aflatoxin testing of survey samples from Tanzania (Oct 2010; June 2013)	Aug 2013	• Report of aflatoxin levels
	4		Activity	• *A. flavus* testing of soil and grain samples from Tanzania (Oct 2010; Jun 2014)	Aug 2014	• Report of *A.flavus* abundance and map
	4	2.2.3	Activity	• Aflatoxin testing of human samples from Malawi (Oct 2010; Oct 2012-13)	Oct 2013	• Report of aflatoxin load in tested samples
3	4	2.3.4	Activity	• Nutrition survey implemented in Tanzania (Jul 2011 – June 2014) link with post-harvest project	May 2014	• Survey report
3	4	3.1.1	Activity	• Varieties for wide scale on-farm adaptive testing with farmer participation (2010 – 2014)	May 2014	• List of new varieties for on-farm testing in PVS in each country • List of varieties preferred by farmers
3	4	3.2.1	Activity	• Field days, demonstrations, agricultural shows and seed fairs conducted at select farmer field school sites annually (2010 – 2014)	Aug 2014	• Number of field days, number and type and stakeholders participating • Number of demonstrations

Year	Quarter	Activity number	Type of milestone	Description of Milestone	Time due*	Means of verification
						mounted • List of traders and others involved in g/nut trading • Number of farmers demonstrating at seed fairs and list of varieties preferred by farmers & market • Survey report on impact
3	1	3.3.1	Activity	• Engagement with at least two non-governmental organizations for community seed supply of improved groundnut varieties (2010 - 14)	August 2014	• Number of seed delivery innovations operational • Quantity of seed produced and sold • Publications
3 3	1 4 4	4.2.2	Activity	• Training partners in disease screening • Training partners in aflatoxin detection • Training new technicians on hybridization techniques	May 2014 May 2014 Sept 2014	• Number of partner Institutions trained • Training report • Training report • Training report
3	4	4.5.1	Activity	• Project Annual Review for internal monitoring established and functioning (2010 - 2014)	August 2013	• M&E plan • Progress reviews and annual work plans

V. APPENDICES

Appendix A. Research Report

The second phase of the project has come to the end of its third year of implementation (2010-2014) and will be expected to deliver four main outputs by the end of its four-year period in Malawi and Tanzania:

- High yielding farmer- and market-acceptable groundnut varieties with resistance to foliar/viral diseases and aflatoxin contamination developed;
- Nutritional status, dietary diversity, human health and mycotoxin contamination problem spatially characterized;
- Adoption rates of improved farmer- and market-acceptable varieties and production technologies enhanced;
- Capacity of partners for management of mycotoxins in food, variety development and enabling policy environment enhanced.

Activities undertaken during the reporting period between September 2012 and August 2013 have been compiled by objective. For each, a brief statement of the problem is followed by a summary of activities undertaken and findings; followed by short comments on implications of the research findings for the next stage of research, for suggested development activities and for policy where applicable.

Objective 1: High yielding farmer- and market-acceptable groundnut varieties with resistance to foliar/viral diseases and aflatoxin contamination

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Statement of the problem
The majority of smallholder farmers in sub-Saharan Africa (SSA), including Malawi and Tanzania, strive to attain their nutritional well-being from the meager harvests of their main staples. Staple diets in this region are usually cereal-based (maize, sorghum, millets) and legumes (groundnut, beans, pigeonpea) with significant dependence on root crops, particularly cassava and sweet potato. Groundnut (*Arachis hypogaea* L.) is rich in digestible protein (25-34%), oil (44-56%), amino acids, and vitamins. It is an important food and cash crop and a major source of dietary oil for both urban

and subsistence dwellers. But groundnut yields are severely constrained by fungal foliar and viral diseases. In addition to maize, cassava and other commodities, groundnuts also have been found to accumulate aflatoxins which are known to suppress the human immuno-response system. This affects the HIV and AIDS infected members of the community because groundnut is consumed widely. Through previous efforts, ICRISAT has identified germplasm from ICRISAT groundnut collection with resistance to drought and diseases (rosette, rust and leaf spots), with special focus on resistance to *Aspergillus spp*. While continuing with the efforts, a few of these materials have already provided the much needed resistance for introgression into farmer/market preferred varieties.

Summary of activities

The following activities were undertaken in the two countries during the reporting period of September 2012 to August 2013:

1.1. Identify and introgress germplasm for yield components farmer/market preferences and adaptation to biotic and abiotic (drought) traits;
1.2. Develop diverse groundnut breeding lines and populations while developing capacity to screen for GRD and foliar disease resistance in Tanzania;
1.3. Develop advanced breeding lines and varieties of groundnut with special emphasis on resistance to aflatoxin contamination.

Progress during the reporting period

1.1. Identify and introgress germplasm for yield components farmer/market preferences and adaptation to biotic and abiotic (drought) traits.

1.1.1. Additional sources of resistance to foliar diseases and aflatoxin identified from core collection, local germplasm and wild germplasm

In search for more sources of resistance to diseases, 10 wild species were designed for crossing with released varieties in Malawi and Tanzania. Due to irregular flowering displayed by the wild germplasm, only two species ISATGR-72B and ISATR-265-5A were crossed with JL 24 and ICGV-SM (Chitala), respectively. F1 progenies have been harvested which is waiting for seed multiplication as few seeds have been realized. Figure 1 shows JL 24 which is susceptible to GRD grafted on the test plant. Preliminary results from grafting experiment show that ICGV-SMs 08503, 01709, 01514 and 03710 are resistant to GRD. The molecular diagnostics show that resistance is due to elimination of GRV and satRNA and not to GRAV. Further evaluation is under progress to prove resistance and its inheritance of resistance.

Figure 1.1. Susceptible JL 24 grafted on a test plant during the GRD transmission studies for characterisation of resistance reaction of candidate sources of resistance to the disease.

1.2. Develop diverse groundnut breeding lines and populations while developing capacity to screen for GRD and foliar disease resistance in Tanzania

Breeding work in Malawi

For the 2012-2013 season, the project continued to screen populations emanating from the good by-crosses. For GRD populations (CG 7 x ICGV-SM 90704 and Chalimbana x ICGV-SM 90704), about 2000 progeny lines for each were exposed to rosette high disease pressure using the infector row technique. Selection is in progress. CG 7 is a new farmer-preferred variety, it is high yielding reaching up to 2.5 tons/ha, red in color and medium-seeded, but very susceptible to rosette. Similarly, Chalimbana is a popular Malawi variety for its seed size but susceptible to rosette too, while ICGV-SM 90704 was used as a resistant.

Figure 1.2. CG 7 x ICGV-SM 90704 population

Four backcross populations for the good x good crosses currently at BC3F2 have been developed. These are populations involving farmer-preferred varieties (CG 7, Chalimbana, JL 24 and Pendo) in Malawi and Tanzania using ICGV-SM 90704 and ICG 12991 as sources of rosette resistance. Additionally, backcross populations – 6 for GRD, six for Rust, and 7 for Aflatoxin – in which new sources of resistances were involved have also been developed.

For the regional trials, materials coming through the first phase of the project are currently being evaluated by the Malawi National Program for possible release. These include ICGV-SMs 01514, 03572, 03576, 99556, 99551, 99557, 99772, 01708, 01731, 01724, and 01728. Additionally, three (3) new materials that have been tested and chosen by farmers for the past three years (2010-13) will be recommended to the National Program for further action. These include ICGV-SM 08503, 08501 and 99567. On-station trials have confirmed superiority of these genotypes over and above the two popular checks (ICGV-SM 90704 and JL 24). Both ICGV-SMs 08501 and 08503 gave yields >1700kg/ha compared to 1292kg/ha for ICGV-SM 90704 used as a check, while ICGV-SM 99567 a Spanish, yielded above JL 24, 1290kg/ha and 1160kg/ha, respectively (Table 1.1). The other two high-yielding Spanish genotypes chosen by farmers (ICGV-SM 01514 and 99556) are already in the National trials.

Breeding work in Tanzania

Screening activities in Tanzania have provided about 20 high yielding, disease and drought tolerant materials. Nine of these materials are in the National Testing Program. Figure 3 shows three of the promising genotypes proposed for release: ICGV-SMs 02724, 01731 and 10149. This effort is in addition to 5 varieties already released by the Department through the project. For this reporting period, a total of 19 promising Spanish genotypes were tested at Makutupora, Naliendele and Nachingwea in Tanzania. No significant differences, p=0.05 were observed in genotypes for yield (Table 1.2). Four genotypes – ICGV-SMs 01514, 06737, 07517 and 05738 – performed consistently well across the three sites. These materials require further evaluation to confirm stability. Naliendele had the highest average yields as it was the most suitable environment, unlike Makutupora. Another set of 19 genotypes under regional drought was evaluated at Makutupora and Naliendele Research Stations. Significant differences were observed, p=0.05 between genotypes for yield (Table 1.3). Three genotypes, ICG 00331, ICGV-SMs 01514 and 03530, showed a lot of promise with yields above 1800kg/ha at both sites compared to JL 24 (check) yielding 1184 and 1469 kg/ha at Makutupora and Naliendele, respectively.

Table 1.1 Genotype performance across three sites; Chitedze, Chitala and Ngabu in Malawi

Genotype: Virginia	**Kernel yield kg/ha**	**Genotype: Spanish**	**Kernel yield kg/ha**
Chalimbana 2005	1038	ICGV-SM 01514	1277
ICGV-SM 01708	1726	ICGV-SM 99551	1165
ICGV-SM 01724	1321	ICGV-SM 99556	1506
ICGV-SM 01728	1544	ICGV-SM 99567	1290
ICGV-SM 01731	1348	ICGV-SM 99568	1251
ICGV-SM 08501	1931	ICGV-SM 99772	1267
ICGV-SM 08503	1935	JL 24	1160
ICGV-SM 90704	1292		
Mean	1517	**Mean**	1274
Fpr	<0.001	**Fpr**	0.275
sed	139.2	**SED**	141.8
CV	26	**CV**	19.3

1.2.1. Germplasm exchange between Malawi, Tanzania, Mozambique and other partners

a) Nuclear seed of elite lines produced annually for testing and breeder seed production

A total of 80 lines most of which are in the advanced testing stage responding to various constraints have been multiplied ranging from 2 to 40 kgs. This effort will reinforce support to NARS and other programs requiring such materials for breeding purposes.

Figure 1.3. Some of the candidate varieties proposed for release in Tanzania

Table 1.2 Performance of Spanish genotypes across sites: Makutupora, Nachingwea and Naliendele in Tanzania

Cultivar name	**Makutupora**	**Nachingwea**	**Naliendele**	**Mean kg/ha**
ICGV-SM 00537	852	1875	1272	1333
ICGV-SM 01514	1386	1125	1882	1464
ICGV-SM 05738	1020	1062	1561	1214
ICGV-SM 06519	826	1875	1148	1283

Cultivar name	Makutupora	Nachingwea	Naliendele	Mean kg/ha
ICGV-SM 06525	479	2000	1460	1313
ICGV-SM 06637	891	1250	1255	1132
ICGV-SM 06737	1364	1250	1390	1335
ICGV-SM 07517	1098	1625	1039	1254
ICGV-SM 07540	727	1625	1571	1308
ICGV-SM 07544	966	1500	1421	1296
ICGV-SM 07553	455	1250	1882	1196
ICGV-SM 08572	979	1625	1525	1376
ICGV-SM 08577	737	2125	1508	1457
ICGV-SM 08583	988	1750	1695	1478
ICGV-SM 08586	921	1625	1278	1275
ICGV-SM 99537	794	875	1566	1078
ICGV-SM 99551	779	2125	1119	1341
ICGV-SM 99566	971	1375	1212	1186
ICGV-SM 99568	750	1375	1365	1163
JL 24	736	1500	1416	1217
Mean				1285
CV%				21
LSD				316
P=0.05				NS

b) Breeder seed of improved groundnut varieties available to NARS and NGOs in the region on an annual basis

Various quantities of breeder seed amounting to 14,222 kg were produced in Malawi in this reporting period. Three thousand three hundred and forty kg of GRD resistant variety ICGV-SM 90704; 1,760 kg of aphid resistant ICG 12991; 4,980 kg of high yielding CG 7; 2,820 kg of early maturing JL 24; and 1,100 kg of Chalimbana were produced. Similar efforts were underway in Tanzania where a total of 21.87 tons of breeder seed for Pendo (20 tons), Mnanje (945 kg), Mangaka (525 kg), Nachingwea (300 kg), Masasi (10 kg), were produced at the Naliendele Research Station. This will ensure sustainable support to partners and farmer research groups, especially where new ones are being formed.

Table 1.3 Regional drought groundnut variety trials in Tanzania

Cultivar name	Makutupora	Naliendele	MEAN Kg/ha
ICG 12991	972	1502	1237
ICG 14788	1096	1876	1486
ICGV 00331	2120	1822	1971
ICGV-SM 01514	2049	2732	2391
ICGV-SM 03519	1396	1774	1585
ICGV-SM 03520	1365	1861	1613
ICGV-SM 03530	2126	2146	2136
ICGV-SM 05650	1287	1720	1504
ICGV-SM 05666	1184	1655	1420
ICGV-SM 05723	1027	1366	1197

Cultivar name	Makutupora	Naliendele	MEAN Kg/ha
ICGV-SM 08503	460	2166	1313
ICGV-SM 08528	1130	1466	1298
ICGV-SM 08533	942	1692	1317
ICGV-SM 08538	1236	1635	1436
ICGV-SM 08540	961	1465	1213
ICGV-SM 08547	1312	1825	1569
ICGV-SM 08556	1142	2065	1604
ICGV-SM 08565	890	1829	1360
ICGV-SM 99568	1524	1365	1445
JL 24	1184	1469	1327
Mean			1521
CV%			30
LSD			662
P=0.05			*

c) Germplasm exchange

To facilitate breeding activities by different NARS programs, the project supplied a total of 59 sets of elite materials for Regional testing to Malawi (20), Mozambique (20), and Tanzania (19). These included materials for GRD, Rust, Early and Late Leaf Spot, Drought and Short duration, each containing about 20 lines. A total of 75 sets of on-farm trials were also distributed to the three countries.

1.3. Develop advanced breeding lines and varieties of groundnut with special emphasis on resistance to aflatoxin contamination.

Efforts to improve resistance to *Aspergillus spp* contamination of promising breeding lines yielded a total of 200 crosses. Target materials included ICGV-SM s 01711, 01721, 99555, 01724, 01731 and 99557, some of which are newly released varieties in Tanzania and others in National breeding trials in Malawi. Farmer-preferred varieties that included CG 7, JL 24 and ICGV-SM 90704 for Malawi and Pendo for Tanzania were also targets for improvement. Sources of resistance to these materials are products of an extensive screening process undertaken by the project at Chitedze Reseaerch Station since 2009. Four promising lines that included J11, Ah 7223, 55-437 and ICGV 95494 were used. These materials are going through generation advance and will be evaluated in the 2013/14 season.

Implication of research findings

Development of diverse breeding lines responding to various constraints including aflatoxin coupled with improved breeding capacity for National Programs will be an important milestone for the region where foliar diseases, drought and aflatoxin are still a major challenge.

Objective 2: Nutritional status, dietary diversity, human health and mycotoxin contamination problem spatially characterized

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Statement of the problem

Dietary aflatoxin, produced by the fungi *Aspergillus flavus/ A. parasiticus,* has been reported to retard growth and productivity in both humans and animals. Aflatoxins also cause immuno-suppression due to the reactivity of aflatoxins with T-cells, decrease in Vitamin K activities and decrease in phagocytic activity in macrophages, and strong synergy has been shown between aflatoxin and diseases such as Hepatic Cellular Carcinoma and Human Immune Deficiency Syndrome (AIDS). Further, poor nutrition usually attributed to food insecurity which may be exacerbated by exposure to aflatoxins, can increase prevalence of such diseases. Exposure to aflatoxins can aggravate the already delicate condition in smallholder populations, such as those in many areas of Malawi and Tanzania, who subsist on legume and cereal-based diets and on milk from their livestock. The aim of this objective is to generate information that will inform policy on relevant national initiatives that target food safety in the two countries for development of appropriate standards and / or regulatory frameworks.

Summary of activities

2.1. Define the scale of the mycotoxin contamination problem and identify the hotspots depicting pockets of the populations where mycotoxin occurrence is higher;
2.2. Assess the relative exposure of humans to mycotoxin contamination of food in drought prone regions and other vulnerable areas and nutritional benefits from aflatoxin-free foods;
2.3. Assess aflatoxin load in exposed populations and relationships to health related ailments;
2.4. Assess aflatoxin load in exposed populations and relationships to nutrition as determined by body mass index (BMI).

Progress during the reporting period

2.1. Define the scale of the mycotoxin contamination problem and identify the hotspots depicting pockets of the populations where mycotoxin occurrence is higher

The result shows that 70% of household groundnut had a contamination level up to 4000 ppb and 100% of the market samples had aflatoxin contamination level up to 504 ppb. Interestingly 43.5% of Bambara nut samples had a contamination level up to 411 ppb in Central Tanzania. The aflatoxin level in Bambara nuts from Southern Tanzania is only up to 20 ppb. The aflatoxin level in Bambara nuts was higher in Central Tanzania than Southern Tanzania. The result gives a clue that better management practices like grading the grains in Southern Tanzania may be a reason for reduced aflatoxin contamination when compared to Central Tanzania where the grains are not generally graded based on quality but on size.

2.2. Assess the relative exposure of humans to mycotoxin contamination of food in drought prone regions and other vulnerable areas and nutritional benefits from aflatoxin-free foods

In total 793 blood samples were collected from five districts of Malawi, which were analyzed for aflatoxin biomarker level. Sixty-four percent of individuals were found to be having aflatoxin biomarkers ranging from 5 to 600 pg mg of albumin. This indicates a high level of exposure to aflatoxins.

2.3. Assess aflatoxin load in exposed populations and relationship to health-related ailments

Sixty-four percent of individuals have aflatoxin exposure ranging from 5-600 pg mg of albumin. 3.4% of individuals are positive for HBV and 2.8% of individuals are positive for HCV. And most of the individuals coming to KCH with liver disease are from these hotspot regions which show that there is a significant link between aflatoxin exposure and liver disease.

2.4. Assess aflatoxin load in exposed populations and relationship to nutrition as determined by body mass index (BMI)

The data obtained so far shows that the growth of targeted children is increasing with time, corresponding to feeding with the formulated complementary food based on groundnuts. The assessment on nutritional status of children was based on the standard indices of physical growth that are: Height-for-age (stunting), Weight-for-height (wasting), and Weight-for-age (underweight). Each of the three nutritional indicators is expressed in standard deviations (Z-scores) from the mean of the reference population. Deviations of the indicators between -2 and -3 standard deviations (SD) indicate that the children are moderately affected, while deviations below -3 SD indicate that the children are severely affected. The trend of Weight-for-Age (Figure 2.1) shows that the weight of children fed on the developed complementary food based on groundnuts increased thus: -5.8 Z-Scores to +0.52 Z-Scores. Before feeding started, most children were moderately underweight but after feeding most of the children moved away from the underweight region. A separate study (results not included) showed that children who were not fed the complementary food based on groundnuts remained underweight over time.

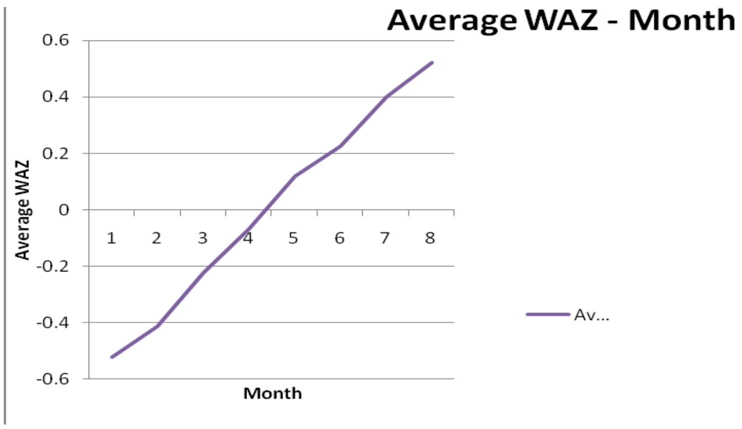

Figure 2.1. Mean weight-for-age Z-Scores of targeted children

The height trend of the targeted children also increased in response to feeding of the formulated complementary groundnut-based food. According to Figure 2.2, the trend of Height-for-Age Z-Scores increased although at a lower rate compared to Weight-for-Age Z-Scores, (remained less than 0 Z-Score which is reference point).

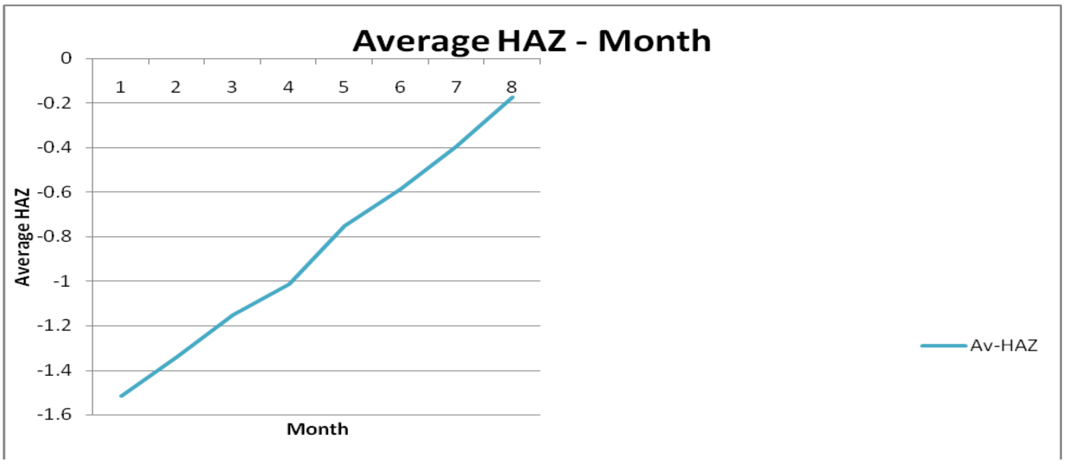

Figure 2.2 Mean Height-for-Age Z-Scores of targeted children

Trend for Weight-for-height Z - score is above zero suggesting that there are no wasting incidences (Figure 2.3).

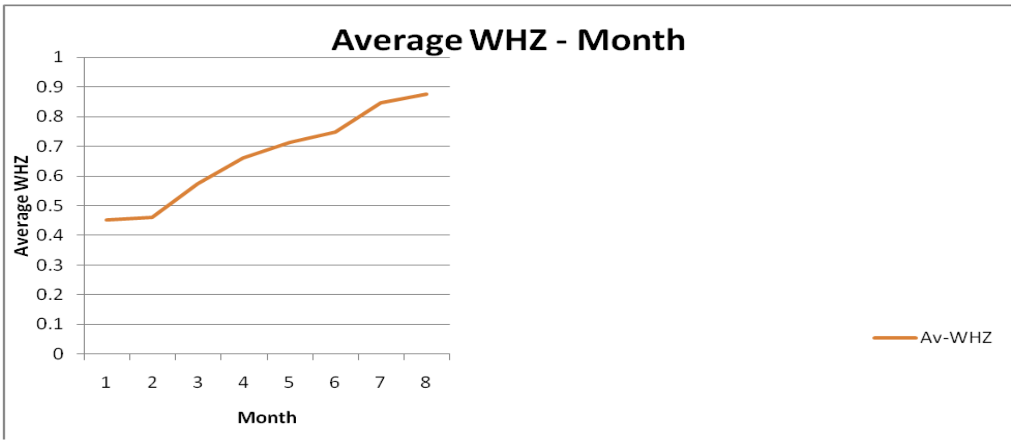

Figure 2.3 Mean Weight-for-Height Z-Scores of targeted children

Implication of research findings
Based on the Malawi experience, defining the scale of Mycotoxin contamination as well as assessing aflatoxin loads in exposed populations in Tanzania will help in planning appropriate sensitization campaigns as well as in developing inclusive approaches for management of aflatoxin contamination in food in the country leading to food and safety policy advocacy. Policy will be impacted through information sharing to facilitate decision making. Policy guidelines and direction will be positively impacted through maintaining standards, e.g. allowable levels of mycotoxins in food and feed, acceptable nutritional status. This will also strengthen health laboratories to include aflatoxin capacity.

Objective 3: Adoption rates of improved farmer- and market-acceptable varieties and production technologies enhanced

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Problem Statement

In spite of a wide range of available technologies (including groundnut varieties), adoption rates by small scale farmers remain low chiefly because farmers are not aware of their availability. Thus continued development and strengthening of the already existing platforms and/or communication mechanisms is vital for an effective and efficient technology dissemination program. Such will create project's islands of success and contribute to meaningful adoption of technologies by farmers. The multi-disciplinary partnership approach used in the first phase has again been employed to deal with this multifaceted problem and so far farmers, community leaders, researchers, extension agents, traders and processors have been engaged in this to achieve wide scale adoption of best practices for pre- and post-harvest management of aflatoxins. Conducting demonstrations of improved technologies on farmers' fields will improve their understanding of the problem (learning by doing) and enhance adoption of such technologies and also offer a forum for selecting and promoting preferred varieties and best-bet resource management interventions. Aflatoxins also continue to be a major limitation to trade in groundnuts from Malawi as 42% (by volume) of Malawi's exports were rejected by the EU market in 2005. Thus, any improvement in management of contamination at farm level would potentially result in increased trade with regional and international partners. Providing better information on the distribution of aflatoxins and underlying factors will support efforts to manage contamination at the farm level.

Summary of activities

3.1. Conduct participatory adaptive trials to assess mycotoxin management practices relating to crop production in pre- / post-harvest operations, and demonstrations for post-harvest handling, food processing methods, consumption patterns and diets;
3.2. Conduct field days, agricultural shows & rural seed fairs with farmers, researchers and market players to promote improved mycotoxin management including testing of resistant cultivars;
3.3. Market players to promote improved mycotoxin management including testing of resistant cultivars;
3.4. Enhance institutional innovations to improve access of the poor to good quality seeds of improved high yielding adapted varieties.

Progress of outputs

3.1. Conduct participatory adaptive trials to assess mycotoxin management practices relating to crop production in pre- / post-harvest operations, and demonstrations for post-harvest handling, food processing methods, consumption patterns and diets

a) Demonstrate technologies for the reduction of aflatoxin contamination in smallholder conditions
The objective of the demonstration was to validate and promote options for the management of aflatoxin contamination of groundnuts on farmers' fields especially in new project sites. Even though aflatoxin contamination could occur at any point in the groundnut value chain, the main starting point of the problem is at pre-harvest; therefore technologies that would minimize contamination of groundnuts in farmers' fields are best options for arresting the problem.

In Malawi, a total of 20 demonstration plots were mounted on farmers' fields in three districts of Mchinji, Mzimba and Nkhotakota. One variety (ICGV-SM 99568) was demonstrated to evaluate the effect of time of planting and use of box ridges. The demonstration contained four plots each, with four 10 m rows spaced at 60 cm and 10 cm between plants. Rows were tied every 2 m for box ridged treatments. Important data collected included stand count and pod weight. Ten plants to be analyzed for aflatoxin contamination were randomly harvested from each plot. Groundnuts samples were transported to Chitedze Research Station for further processing. The remaining net plot was also harvested to act as a control. A 100 g sample was collected from each sample and subjected to aflatoxin analysis using Enzyme Linked Immuno Sorbent Assay (ELISA) to evaluate levels of aflatoxin contamination in various treatments. For the 2012-13 season, unlike other previous seasons results show very low levels of aflatoxin contamination in the various treatments ranging from 1.4 to 1.558 ppb (Fig 3.1a). No significant differences p=0.05, for aflatoxin contamination were observed between treatments; however, early planting and use of box ridges recorded 1.4 and 1.41 ppb respectively compared to late planting and use of open ridges, all of which recorded more than 1.45 ppb. The small variation in the results may be attributed to erratic rains which had an influence on the effects of the treatments as observed from rainfall data for Mchinji district (Fig 3.1b). Most farmers planted in January when the average rainfall was very low and there wasn't much difference between early and late planting.

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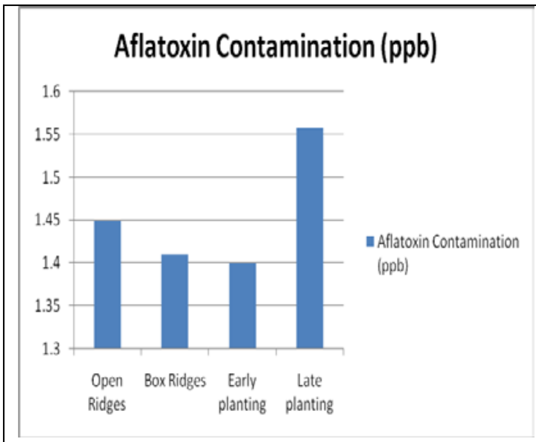
<td>
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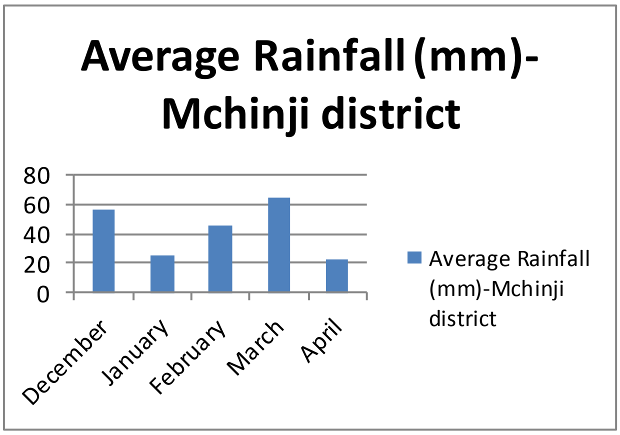
<td>
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<tr>
<td>Figure 3.1a Effect of different treatments on aflatoxin contamination of groundnuts</td>
<td>Figure 3.1b Average rainfall (mm) for Mchinji district</td>
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b) Demonstrate technologies for the reduction of GRD in smallholder conditions

The demonstration aimed at popularizing available and common disease management technologies amongst smallholder farmers, validate best cultural practices with a specific improved variety and help small scale farmers improve food security and incomes through reduction of GRD. The demonstrations were mounted on 20 farmers' fields in the three districts. A total of 300 farmers were directly involved in the implementation of the activity.

Two varieties, namely ICGV-SM 90704 (resistant) and Chalimbana (susceptible), were used to assess the effect of time of planting (early vs late [3 weeks late]) and plant density (high vs low). Plots contained 4 rows, each 10m long with ridges spaced at 75cm and 60cm with 30cm and 10 cm between plants for low and high population density, respectively. Important data collected included stand count and rosette count.

Results showed significant differences, p=0.05 between treatments for rosette incidence. There were high rosette incidences on late planted and low density treatments (Figure 3.2). Additionally, the susceptible variety had generally a higher rosette incidence than the resistant genotype. There were no significant differences, p=0.05, in rosette incidence between districts as well as between chapters. Results were able to demonstrate that early planting, use of optimum plant population and resistant varieties have the potential to minimize rosette incidence in farmers' fields. For the susceptible variety, planting early had a more than 2-fold disease reduction in rosette incidence, using late planting as the basis for comparison.

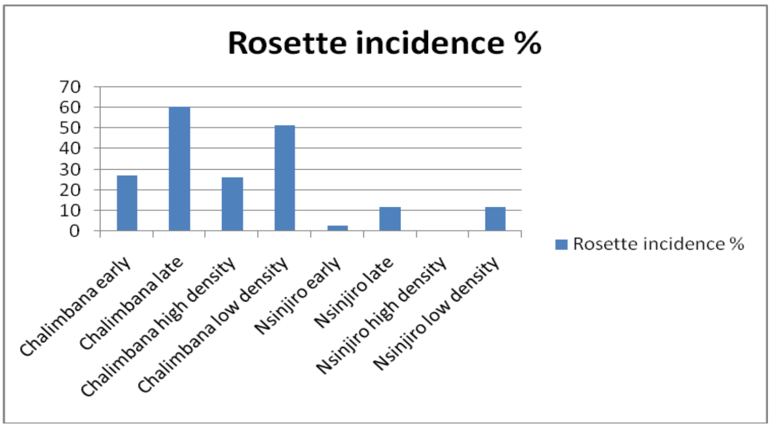

Figure 3.2 Effect of different treatments on rosette incidence of g/nuts

c) Participatory variety evaluation

In Malawi, 700 collaborating and non-collaborating farmers, 10 traders and 15 NGOs were engaged in order to elicit more views on variety selection in all project areas covering the three agro-ecological zones including low, medium and high altitude groundnut growing regions. A total of 20 trials each for Virginia and Spanish genotypes were established in 20 groups. Each group consisted of about 20 members giving a total of at least 400 farmers involved in the implementation of the activity.

The genotypes used originated from preliminary screening activities at Chitedze Research Station out of which, promising materials were selected for farmers to evaluate. A total of 6 test lines each for Virginia and Spanish were provided for evaluation. Each group was evaluated alongside 2 controls comprising farmer preferred varieties. For Spanish, lines included ICGV-SMs 01514, 999551, 99556, 99557, 99555 as test lines and 99568 (Chitala) and JL 24 (Kakoma) as controls. While for Virginia, materials included ICGV-SMs 01708, 01731, 08501, 08503, 01724, 01728 as test lines and ICGV-SM 90704 (Nsinjiro) and Chalimbana 2005 as controls. All test lines were chosen mainly for their performance against major diseases such as Groundnut Rosette (GRD), Early Leaf Spot (ELS) as well as Rust.

Trait selection by farmers

The most common traits outlined by farmers are yielding ability, disease resistance (rosette), drought tolerance, taste and maturity duration, ease of shelling, seed color, seed size, pod filling, fresh seed dormancy, growth habit, cooking quality, number of seeds per pod, seed weight and oil content. Out of these traits, farmers ranked 8 best traits that were then used during the selection process.
Yield potential was the most important trait for men followed by maturity duration. Female farmers chose ease of shelling as the most important trait followed by yielding ability. There was no significant difference observed ($p = 0.5$) between yield and maturity duration, resistance to pest and diseases and resistances to drought which was ranked by male farmers indicating that male farmers put equal weight on these four traits. For women, the top four included ease of shelling, yielding ability, taste and maturity duration (Table 3.1).

Results from ranking done by women, show the importance of including gender in the variety development process and have implications on adoption of materials. Apart from yield potential women were also interested in consumption and ease of processing. It, therefore, may be inferred that groundnut processing is largely a woman's activity, at the same time if the underlying objective is food security, women's views are of vital importance in the variety development process.

Table 3.1 PVS in Mchinji, Mzimba and Nkhotakota segregated by gender

Male Selection		**Female Selection**	
Trait	**Mean**	**Trait**	**Mean**
Yielding	44.75 a	Shelling	30 a
Maturity	37.25 ab	Yielding	25.5 ab
P/d resistance	36 ab	Taste	23.75 abc
Drought Resistance	33.5 abc	Maturity	20 abcd
Pod filling	26.5 bcd	Drought Resistance	17 bcd
Taste	22.75 cde	P/d resistance	16.75 bcd
Shelling	17.5 de	Seed size	15 bcd
Seed size	13.75 e	Pod filling	13 cd
Color	13.25 e	Color	9 d

Genotype ranking segregated by gender based on eight important traits -Virginia
Based on farmer chosen criteria, the eight most important traits were used by participants to select varieties. Significant differences were observed between varieties selected by both male and female farmers, implying that genotype performance was varied (Table 3.2). Even though the two groups ranked the genotypes differently, both had ICGV-SMs 08503, 01731 and 01728 ranked as the top three genotypes. Most genotypes were ranked ahead of checks: Chalimbana 2005 and ICGV-SM 90704.

Table 3.2 Genotype ranking segregated by gender

Variety	Total preference scores (Males)	Rank	Variety	Total preference scores (Females)	Rank
Chalimbana 2005	15.15	7	Chalimbana 2005	15.54	8
ICGV-SM 01721	14.23	6	ICGV-SM 01721	14.08	7
ICGV-SM 01724	13.38	4	ICGV-SM 01724	13.92	5
ICGV-SM 01728	12.38	3	ICGV-SM 01728	12.69	3
ICGV-SM 01731	12.08	2	ICGV-SM 01731	12.08	1
ICGV-SM 08501	14	5	ICGV-SM 08501	13.77	4
ICGV-SM 08503	11.85	1	ICGV-SM 08503	12.15	2
ICGV-SM 90704	13.38	4	ICGV-SM 90704	13.92	5
Mean	13.308			13.52	
Fpr	<.001			<.001	
S.E.D.	0.3752			0.442	
CV	7.2			8.33	

Genotype ranking by gender based on six most important traits - Spanish

Spanish genotypes were also evaluated based on the six traits chosen by farmers. Significant differences, p=0.05, were observed in the selection for both male and female farmers, implying that genotypes varied considerably as traits of interest. ICGV-SMs 99551, 99556, 01514 were all ranked in the top three by both groups. For males, ICGV-SM 99551 was the best genotype preferred for its high yielding ability while female farmers chose ICGV-SM 99556 as the best genotype for its high yield, good taste and resistance to drought (Table 3.3). Results also indicate that yield is the main focus for male farmers while females had taste as an additional key trait in all the three selected genotypes.

Table 3.3 Genotype ranking segregated by gender - Spanish

Genotype	Total preference scores (Males)	Rank	Genotype	Total preference score (Females)	Rank
ICGV-SM 01514	13.69	2	ICGV-SM 01514	14.23	3
ICGV-SM 99551	12.46	1	ICGV-SM 99551	13.54	2
ICGV-SM 99556	13.85	3	ICGV-SM 99556	13.92	1
ICGV-SM 99567	16.15	4	ICGV-SM 99567	16.23	7
ICGV-SM 99568	15.23	5	ICGV-SM 99568	15.15	4
ICGV-SM 99772	15.69	7	ICGV-SM 99772	16	6
JL 24	15.46	6	JL 24	15.85	5
Mean	14.648		Mean	14.989	
Fpr	<.001		Fpr	<.001	
S.E.D	0.3674		s.e.d	0.3533	
CV	6.4		cv	6	

Participatory variety selection in Tanzania

In Tanzania, on farm trials for variety selection were conducted in 3 villages of Chikoweti, Luanda and Nawaje. Seven genotypes were tested against two popular checks: Mnanje and Pendo. There were no significant differences, p=0.05, in the yield performances between genotypes across all the three sites. ICGV-SMs 08501 and 08503 were, however, the most outstanding genotypes yielding 2033.3 kg/ha and 1916.7 kg/ha respectively, compared to Pendo a local check that gave 1708.3 kg/ha (Table 3.4). Farmer chosen traits for selection of genotypes included pod filling, yield, maturity duration, disease resistance, pod size and kernel size. Ranking was based on the number of times a given genotype was chosen as best by farmers. ICGV-SM 08501 was ranked best genotype (Table 3.5) in all the three villages while ICGV 13338 and ICGV 14778 were rejected for poor pod filling and seed size.

Table 3.4 Performance of genotypes under on-farm testing in Tanzania

Genotype	Chikoweti	Luanda	Nawaje	Mean
ICGV-SM 08503	1250.0	2250.0	2250.0	1916.7
ICGV-SM 13338	1750.0	1000.0	2050.0	1600.0
ICGV-SM 05562	1500.0	1500.0	1500.0	1500.0
ICGV-SM 14778	1950.0	1500.0	1950.0	1800.0
ICGV-SM 08501	1900.0	1950.0	2250.0	2033.3
ICGV-SM 08556	1500.0	2250.0	1650.0	1800.0
ICGV-SM 07544	2000.0	1650.0	2050.0	1900.0
MNANJE	1800.0	2050.0	1500.0	1783.3
PENDO	1500.0	1500.0	2125.0	1708.3
Mean	1683.3	1738.9	1925.0	1782.4
CV%				19.8
LSD				610.7

Table 3.5 Variety ranking in Tanzania

Genotypes	LUANDA	CHIKOWETI	NAWAJE	Total	Mean	Rank
ICGV-SM 08503	8	5	9	22	7	2
ICGV-SM 13338	0	1	7	8	3	7.5
ICGV-SM 05562	2	2	5	9	3	7.5
ICGV-SM 14778	3	2	3	8	3	7.5
ICGV-SM 08501	9	8	7	24	8	1
ICGV-SM 08556	7	1	3	11	4	6
ICGV-SM 07544	4	9	4	17	6	3.5
MNANJE	5	7	5	17	6	3.5
PENDO	6	5	8	19	6	3.5

3.2. Conduct field days, agricultural shows & rural seed fairs with farmers, researchers and market players to promote improved mycotoxin management including testing of resistant cultivars

Field days and seed fairs continue to be an important platform for engaging various stakeholders to enhance and/or to promote groundnut production technologies especially on issues of mycotoxin management. The interaction amongst various players in the groundnut value chain presents an opportunity for effective variety selection and technology transfer. They also provide a platform for researchers to provide scientific backstopping to farmers and other stakeholders. Three field days were conducted in Tanzania during the vegetative growth stage to demonstrate on-field hygiene and during harvest for variety selection. It attracted a total of 374 participants (men: 164, women: 210). Following media participation during field days, 3 radio and 4 TV programs were produced and are currently being aired on the National Radio and TV Stations. In Malawi, a total of 12 field days were conducted attracting a total of 727 participants that included collaborating and non-collaborating farmers, Extension Staff from NASFAM and Ministry of Agriculture, and local traders (Table 3.6).

The field days focused on community seed production, disease management especially aflatoxin and GRD, participatory variety selection and post-harvest handling. The project team continues to use ***"improving income, nutrition and health of farmers through improved groundnut production technologies"*** as the theme for the field days.

Table 3.6 Participation at Field Days in Malawi

District	No. of Field Days	No. of Ext Workers	No. of Traders	Female Farmers	Male Farmers	Total participation
Mchinji	4	7	2	80	84	173
Nkhotakota	3	4	0	53	55	112
Mzimba South	2	13	2	151	159	325
Mzimba North	3	5	1	36	63	105
	12	**29**	**5**	**320**	**361**	**715**

3.3. Market players to promote improved mycotoxin management including testing of resistant cultivars

The Department of Agriculture and Nutrition at Ekwendeni Hospital, which works with 9,000 farming families, continues to be engaged in propagating project messages with main focus on aflatoxin mitigation. The Department has marketing as one of the most important components in its programs and issues of aflatoxin are critical to gain rewarding markets. Similarly, Mzimba South NASFAM Association is a new project site which has also been engaged for the second year running to promote these technologies through training of both farmers and Association Field Officers. This Association works with over 10,000 farming families where groundnut is a huge emerging cash crop. Through these collaborative efforts, more farmers are now aware of the dangers of aflatoxin and methods for mitigating the problem. A visit made to a few farmers' gardens (15 per district) showed that 75% of the farmers had planted early, used correct spacing and 50% had used box ridges. Additionally most farmers' yield averaged 1300kg per hectare. Even though these yields are still low compared to potential yields, the increase is a positive step towards improving farmers' incomes, nutrition and health.

3.4. Enhance institutional innovations to improve access of the poor to good quality seeds of improved high yielding adapted varieties

Community seed banks

One major problem for most farmers in Malawi and Tanzania is difficulty in accessing seed of improved varieties coupled with the fact that the seed systems for groundnuts in the two countries are weak. In a bid to ease the problem, the project is using community seed multiplication as a way of reaching communities with such difficulties. Through Naliendele Research Station, the project provided 500 kg of improved seed of Pendo variety to new Farmer Research Groups in five villages of Naluwale, Nandembo, Sisi kwa sisi (Tunduru), Nangomba, Mnanje (Nanyumbu district), and Ilindi (Bahi district). Each group received 100 kg of seed.

In Malawi, NASFAM and the Department of Agriculture at Ekwendeni Hospital distributed seed of improved groundnut varieties (Nsinjiro and Chitala) to farmers of Mchinji, Mzimba and Nkhotakota. From the initial 6.5 tons seed investment in the 2011-2012 season, a total of 80 seed banks were formed and 566 farmers were reached (Table 3.7). For the 2012-2013 season, farmers under this program produced a total of 52 tons out of which 12.23 tons was collected as seed recovery. This resulted in the formation of 94 new seed banks making a total of 174 seed banks. The project has now a total of 1623 farmers under community seed multiplication in the new project sites. Seed recovery (pay back) ranged from 85-100%. Elangeni in Mzimba South NASFAM Association recorded 100% recovery rate and had a total of 4.98 tons of seed in the seed bank.

Table 3.7 Progress of community seed banks in new project sites

Year	Seed investment (tons)	Amount produced by farmers (tons)	Recovered for seed banks (tons)	No. of seed banks	No. of beneficiaries
2011-12	6.5	52	12.23	80	566
2012-13	12.23	115	26	174	1623
2013-14	26				

Implication of research findings

On-farm demonstrations were able to validate the effectiveness of improved practices on the management of aflatoxin contamination and GRD disease. Such findings have the potential to change people's perception on the extent of the problems (aflatoxin and GRD) that may result in adoption of technologies. Farmers' access to seed of improved varieties has had huge success in project sites. There is enormous evidence that the use of the pass-on program through community seed banks is an important tool to bridge the gap between seed producers and the rural poor.

Objective 4: Capacity of partners for management of mycotoxins in food, variety development and enabling policy environment enhanced

Authors

Malawi
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Dickson Mbughi, Project Research Technician, NASFAM

Statement of the problem

Engaging stakeholders on every level of project activities will enhance information flow and knowledge on critical issues of mycotoxin as well as instill a collective approach towards mitigating the problem, which is lacking in the region. This is an essential component of the project as it will ensure policy is informed about the problem and result in formulation of appropriate regulatory framework on products especially for the local markets that do not have any. Increased knowledge will also help partners to carry out future projects in a more focused approach and have appropriate harmonization of conventional breeding and farmer participatory approaches. Training offered to farmers on the use of best-bet technologies for managing aflatoxin will improve adoption of the practices and this would stay in the communities with a multiplicative effect beyond the project period.

Summary of activities

4.1. Stakeholders project start-up/planning workshop to agree on project components for promotion, pilot areas and mode of operation;
4.2. Conduct training workshops for NARES staff;
4.3. Degree training program to MSc students to develop regional capacity for pathology work including screening of commodities for aflatoxin contamination;
4.4. Conduct sensitization workshop for Policy makers, NARES/ NGO/ Private sector

4.4.1. Through a national level workshop, recommended policy options will be advocated to decision-makers at the national level by end of project. Preliminary findings will be shared with stakeholders;
4.4.2. Linkages with health and other sectors will be developed and maintained for future collaboration;
4.4.3. Develop and share project reports, policy briefs and journal articles;
4.5. Establish strategy and time frame for impact.

Project outputs

4.1. Stakeholders project start-up/planning workshop to agree on project components for promotion, pilot areas and mode of operation

A meeting was organized for all project partners to review the 2012-13 season to identify project's islands of successes, areas requiring improvement, and map the way forward for the 2013-14 growing season. The review critically examined progress on the breeding activities, strides made on mapping aflatoxin distribution in the two countries as well as efforts made on the nutritional component of the project in Tanzania. The meeting was attended by Omari Mponda, Yasinta Muzanila, Anitha Seetha, Patrick Okori and Wills Munthali. The team also developed work plans for the different components for the 2013-14 season. The review meeting took place at Cross Roads Hotel in Lilongwe, Malawi from 9-10 September 2013.

4.2. Conduct training workshops for NARES staff and other stakeholders
In Malawi, a total of seven NASFAM Association Field Officers and three Technicians from Chitedze Agriculture Research Station were trained on principles of plant breeding, experimentation and data collection, groundnut production practices, and leadership skills. These modules were facilitated by Scientist and Scientific Officers from ICRISAT, Malawi. The activity took place on 2 November 2012 in Louis Mughogho Conference Room - ICRISAT Malawi.

4.3. Degree training program to MSc students to develop regional capacity for pathology work including screening of commodities for aflatoxin contamination

Ms Ethel Chilumpha from Malawi has been identified to pursue MSc training in Pathology at Lilongwe University of Agriculture and Natural Resources (LUANAR) - Bunda College of Agriculture. Ethel is a Senior Research Technician at ICRISAT with expertise in aflatoxin detection from crop and human samples. Athanas Minja from Naliendele Agricultural Research Institute in Tanzania (previously identified) finished his MSc course work at Sokoine University of Agriculture. He conducted field research work at Naliendele and is currently writing his dissertation at SUA. His major focus is on mapping the alleles responsible for groundnut rosette disease resistance.

4.4. Conduct sensitization workshop for Policy makers, NARES/ NGO/ Private sector

4.4.1. Through a national level workshop, recommended policy options will be advocated to decision-makers at national level by end of project. Preliminary findings will be shared with stakeholders

The project team has set targets for the 2013-14 season for all the components so as to engage critical stakeholders through various forums to share major project findings or messages that could enhance policy on important aspects affecting communities in the two countries. Target stakeholders include Ministry of Health for the nutritional component in Tanzania, politicians especially Members of Parliament in Tanzania, and stakeholders along the groundnut value chain in Malawi, for aflatoxin awareness and seed policy in Tanzania. Policy briefs will be developed and shared in the 2013-14 calendar year. The Project through Naliendele Research Station has already produced 500 flyers (Figure 4.1) to be distributed to all Members of Parliament in Tanzania.

4.4.2. Linkages with the health and other sectors will be developed and maintained for future collaboration

In Malawi, the project has engaged the Ministry of Health through Kamuzu Central Hospital (KCH) to deal with health-related components of the project. Specifically KCH is helping in the collection of human blood samples from aflatoxin hotspot areas. This will help in finding connections with health ailments. The activity is currently in its second year of operation. The link person is Dr Judith Mkwaila who has replaced Dr Madinda. Similar efforts are underway in Tanzania to ensure a mapping survey that was conducted in the project sites.

4.4.3. Develop and share project reports, policy briefs and journal articles

The project also conducted a review exercise between 14 and 22 September, 2012 specifically to share project results with our collaborators. Results shared included outcomes from demonstrations for the management of Aflatoxin and groundnut Rosette Disease and also feedback on the aflatoxin survey conducted in Malawi. The activity was conducted in Mikundi, Champhira, Ekwendeni and Linga in the districts of Mchinji, Mzimba and Nkhotakota respectively. The target was extension workers, lead farmers and traders. A total of 77 participants including lead farmers and extension workers attended these review sessions. The activity was undertaken by ICRISAT Scientific Officer, Mr Wills Munthali. One thousand five hundred (1500) flyers on improved groundnut varieties and practices were distributed to various stakeholders that included farmers, traders and NGOs in the groundnut value chain. Nine posters with messages ranging from production technologies to seed systems were also produced and presented during field days.

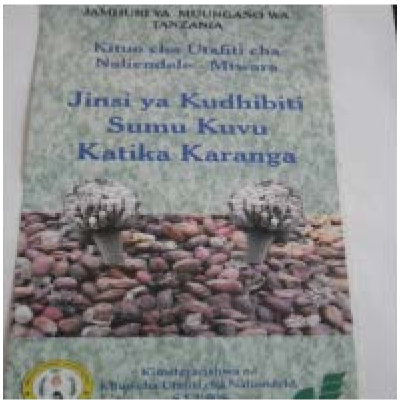

Figure 4.1 Flyer on aflatoxin - Naliendele

4.5. Establish strategy and time frame for impact monitoring and reporting

Following a series of interventions through the project, ICRISAT staff conducted a monitoring and evaluation exercise in order to document various impacts the project has had on farmers in the project sites. The activity which ran from 15 to 25 January 2013 was conducted by Wills Munthali (SO Groundnut Breeding), Harry Msere (ICRISAT SO Social Economics) and Dickson Mbughi (Project Technician). The team visited farmers and their fields and also recorded assets emanating from their involvement in community seed production.

Farmers visited expressed gratitude as the project activities have transformed their lives beyond expectation. Most farmers were able to show the assets they have accumulated through the sales arising from use of improved varieties supplied by the project. They cited participation in community seed production and use of the technical know-how learnt through training and demonstrations mounted by the project in their respective communities as catalysts of their well-being.

Many farmers in the project sites have been able to access seed of improved varieties (Nsinjiro or Chitala). Clubs were started with 25-30 members in which only 10 were the first beneficiaries. But by the end of the second year all in the club had received seed and even formed baby clubs. Most indicated having sufficient money for school fees, medical bills, and domestic needs in addition to accumulation of assets. Figures 4.2 and 4.3 show women in Elangeni in Mzimba selling their excess seed and another women in Katonda showing off one of her goats bought after selling groundnut seeds.

	
Figure 4.2 Women in Elangeni selling excess production	**Figure 4.3** A farmer in Katonda shows off one of her goats (bought from proceeds of her sale)

Drs Charlie Riches and Prudence Kaijage, visited ICRISAT Malawi to have an understanding of the activities being implemented and map a way forward. Dr Riches took advantage of the trip to introduce Prudence, the new Regional Representative, to project members. The team was briefed on progress of the McKnight Project in Malawi that included aflatoxin testing at ICRISAT Laboratory and on-farm activities especially the community seed bank program that has recorded much success. They were also shown groundnut breeding efforts especially GRD populations and nurseries under regional testing. The activity took place on 4 April 2013. Based on success of community seed banks, Dr Riches linked the project team to the Bambara project for the latter to explore possibilities of implementing a similar approach for community seed production.

Appendix B. Publication Summary

Papers submitted:
Anitha S, Monyo ES and Okori P. 2013. Simultaneous detection of Groundnut rosette assistor virus (GARV), Groundnut rosette virus (GRV) and satellite RNA (satRNA) in groundnuts using multiplex RT-PCR**.**

Flyer published:
Charlie Harvey and Munthali Wills. 2013. Improved groundnut varieties released through ICRISAT and NARS collaboration. ICRISAT, Malawi.

Training manuals developed.
Munthali Wills, Charlie Harvey, Guwela Veronica and Okori Patrick. 2013. Post-harvest handling of groundnuts – A manual. ICRISAT, Malawi.

Posters:

1. Improving quality of groundnut grain through improved crop management practices. Wills Munthali, Harvey Charlie, Veronica Guwela and Patrick Okori. ICRISAT, Malawi, 2013.
2. Delivering high quality seed to improve productivity, food security and incomes of farmers. Felix Sichali, Wills Munthali, Harvey Charlie, Veronica Guwela and Patrick Okori. ICRISAT, Malawi, 2013.

Appendix C. Training and outreach

The project trained a total of 105 lead farmers on leadership skills, realizing that running community seed banks needed not just technical ability to produce seed but also organizational ability. Providing such capacity is expected to enhance the ability to implement project activities as well as sustainability beyond project life. The activity was conducted in all the project sites between 25 November and 3 December 2012. See table below.

Participation, segregated by gender

Mzimba	Chapter	Male	Female	Total
Mchinji	Mikundi	11	4	15
Mzimba South	Elangeni and Jenda	14	8	22
Mzimba North	Bwabwa and Thimalala	12	13	25
	Thimalala	6	11	17
Nkhotakota	Linga	9	17	26
	Total	**52**	**53**	**105**