COLLABORATIVE CROP RESEARCH PROGRAM

THE McKNIGHT FOUNDATION

New Frontiers in Legume Research

Case Studies of Ten Years of Research in Malawi

CCRP Southern Africa Community of Practice




Preface

The McKnight Foundation deeply believes that inspired and sustainable change comes from the leadership and vision of those closest to the issue. The Collaborative Crop Research Program (CCRP) strives to support that leadership, as exemplified in the efforts documented here.

CCRP has funded agricultural research and development in Malawi, Mozambique, and Tanzania since 2006, supporting a group of projects that form the Southern Africa Community of Practice (CoP). The region faces many food security challenges, but there are also many opportunities that have the potential to benefit smallholder farmers. One opportunity is the wide range of edible legume crops that are grown in the region, such as common and climbing bean, soya bean, cowpea, groundnut, Bambara groundnut, and pigeon pea. CCRP supports research to enhance legume crop productivity and other ecosystem benefits within sustainable cereal-based agricultural systems. Bringing together teams of scientists, civil society organizations, farmer groups and other stakeholders, the CoP shares complementary expertise and mutual purpose. This enables them to share good practices, to inspire each other, to learn from each other's experiences, and to use all this to inform implementation on the ground.

In Malawi, CRRP support has targeted improvement of selected legume crops, development of seed systems, improved agronomic practices, mechanization to reduce drudgery and increase efficiency, and stimulating inclusive markets. In all cases, an overarching aim has been to research how agroecological intensification can contribute to more sustainable agricultural systems. Participatory approaches have been used since the start of the program, but increasing attention is being given to the central role that farmers can play in the research process. The CoP recognizes farmers' diverse needs and the importance of identifying options that are best suited to their particular contexts.

The tenth annual Southern Africa Community of Practice (CoP) meeting is being held in October 2016 in Malawi. To mark this occasion, this brochure features results and outcomes of four CCRP projects led by organizations in Malawi. These stories exemplify the kinds of transformative efforts driven by the broader grantee cohort of CCRP's Southern Africa CoP. We are proud to share these stories with you.

Jane Maland Cady *(International Program Director, The McKnight Foundation)*
Rebecca Nelson *(CCRP Scientific Director)*
Prudence Kaijage *(Southern Africa Regional Representative)*
Tim Chancellor *(Southern Africa Liaison Scientist)*

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Formation of brochure ideas and structure:

Tim Chancellor, *Southern Africa Liaison Scientist for CCRP, Natural Resources Institute, University of Greenwich, Chatham, UK*
t.chancellor@gre.ac.uk

Prudence Kaijage, *Regional Representative for CCRP in Southern Africa, Arusha, Tanzania*
prudencecrp@gmail.com

Writers:
Tim Chancellor and Geoffrey Chilombo

Layout and Print:
Perfect Printers Ltd. - Arusha, Tanzania
sales@perfectprinters.co.tz

About

THE McKNIGHT FOUNDATION

The McKnight Foundation, a Minnesota-based family foundation, seeks to improve the quality of life for present and future generations. Program interests include regional economic and community development, Minnesota's arts and artists, early literacy, youth development, Midwest climate and energy, Mississippi River water quality, neuroscience research, international crop research, and rural livelihoods. Through grantmaking, collaboration, and encouragement of strategic policy reform, the Foundation uses its resources to attend, unite, and empower those it serves (www.mcknight.org).

About the Collaborative Crop Research Program

The McKnight Foundation's Collaborative Crop Research Program (CCRP) funds collaborative research between smallholder farmers, leading local and international researchers, and development practitioners to explore solutions for sustainable, local food systems.

CCRP seeks to contribute to a world where all have access to nutritious food that is sustainably produced by local people. We do this through collaborative agroecological systems research and knowledge-sharing that strengthen the capacities of smallholder farmers, research institutions and development organizations.

The program has its roots in the plant biology program that began in 1983. CCRP began in 1993 and has undergone several changes since then. At present, CCRP works in four regions, 12 countries, and funds a total of approximately 65 research projects. The McKnight Foundation's commitments to the CCRP represent over $100 million and include more than $74 million in grants, as well as non-grant assistance (such as support for convenings, technical assistance, capacity building, and monitoring and evaluation). These investments have led to profound impacts, including new solutions, technologies, ideas, policies, adaptations, and innovations in the agricultural research and development field.

CCRP in Southern Africa

The CCRP Southern Africa Community of Practice (CoP) focuses on improving food security and nutrition for smallholder farming families in Malawi, Mozambique, and Tanzania. All three countries have high levels of poverty,

with large numbers of malnourished and food insecure people. These countries rely heavily on agriculture for employment and economic growth, and research can make a substantial contribution to enhancing agricultural performance and improving the livelihoods of rural households. Grain legumes offer a solution to the problems of low soil fertility and lack of diversity in people's diet. They also enhance system productivity in a sustainable manner. Since the CCRP-funded projects began in 2006 researchers have worked with farmers and other stakeholders to develop legume technologies that support agroecological intensification. As the CoP has evolved, farmer-centered approaches are increasingly being used to ensure the relevance and impact of the research.

Cover photos: Tim Chancellor

For more information about the CCRP in Southern Africa, visit www.ccrp.org/southern-africa

MAIZE-LEGUME ROTATIONS IMPROVE SOIL HEALTH AND CROP PRODUCTIVITY

Background

Maize is the most widely grown food crop in Malawi and is crucial for food security in a country whose economy is mainly based on agriculture. However, average maize yields are low and are declining in some areas. This is partly due to limited adoption by smallholder farmers of improved varieties but also because the fertility of the soil is declining. Inorganic fertilisers can increase maize yields in the short run, but are expensive to buy and are not always available to smallholder farmers. To maintain longer-term soil health, it is important to build organic matter to ensure efficient nutrient cycling and to enhance water-holding capacity. The Malawian government has sought to support farmers and boost the economy by subsidising seeds and fertilizers through the Farm Input Subsidy Programme (FISP). The programme has delivered positive outcomes but resource constraints mean that not all farmers can be reached. Also, it is evident that subsidies are not sustainable in the longer term.

The average farm size of farmers in Malawi is around 0.8 hectares. There is little new land available to bring under cultivation and so the only opportunity to increase the output of maize and other food crops is by intensifying production on the existing land area. One way to increase productivity on small land holdings, while diversifying diets, is to intercrop or rotate different crops. Grain legumes intercropped with maize provide multiple benefits. Legumes fix atmospheric nitrogen and their residues provide soil carbon, so they help to maintain or restore soil health and fertility. The grains are a rich source of proteins and oils, and the inclusion of legumes in the cropping system helps to diversify the diet and contribute to improved nutrition of farm families. The heavy dependency on maize in Malawi restricts the choice of food in the diet and this is a particular problem for women and young children.

CCRP response

The Collaborative Crop Research Program (CCRP) of The McKnight Foundation promotes the principles and practices of agro-ecological environments, which aims to improve the performance of agriculture systems by integrating ecological principles into farm management. Improved performance can be associated with various factors including increased productivity, enhanced use of local resources, improve livelihoods and more diverse diets. To investigate how maize-based cropping systems in Malawi could function more sustainably, the CRRP commissioned a research project led by Bunda College of Agriculture. The 'Best Bets' project began in 2006 and is led by Professor George Kanyama-Phiri, who has been conducting research on agroecological issues for smallholder farmers in Malawi for over two decades.

A 'doubled-up' legume system: a groundnut-pigeonpea intercrop

Research aims and approach

The Best Bets project is now in a third phase and aims at sustainably enhancing the productivity of smallholder farming systems in different agroecological environments in Malawi. It also aims to improve nutritional diversity of farm families, particularly for children under five years of age and for pregnant women. The project seeks to achieve these aims through strengthening innovation based on farmer-led priorities and farmer evaluated technologies. "It aims at improving crop productivity and soil health through integration of grain legumes in maize based systems. The project is promoting sole and doubled-up legumes involving pigeonpea, groundnut, soybean and cowpea. Doubled-up legumes involves intercropping two legumes with complementary growth habits. These legumes are rotated with crops such as maize to take advantage of the fertility left behind by the legumes," says Professor Kanyama- Phiri. "Since a lot of smallholder farmers are poor and unable to afford the high price of inorganic fertilizer, the project will help farmers to achieve multiple benefits of improved soil fertility, enhanced crop productivity, and better family nutrition," he adds.

The project is working in Kasungu and Ntcheu districts in the central region of Malawi and Mzimba district in the northern region. The sites have differing rainfall patterns and soil types. "The idea is to identify the technology options that will be most suited to that particular niche or environment in order to improve the agricultural production and livelihood in a sustainable manner" Professor Kanyama-Phiri says. At the start of the project, which initially focused on Kasungu district and the Ekwendeni area of Mzimba district, the project team engaged with lead farmers and government extension officers to jointly identify key research issues. Participatory research was then conducted with farmers in which 'mother' trials were used to demonstrate technologies and 'baby' trials enabled farmers to try out selected practices in their own fields. Field days and farmer feedback workshops were conducted to discuss experiences and share results.

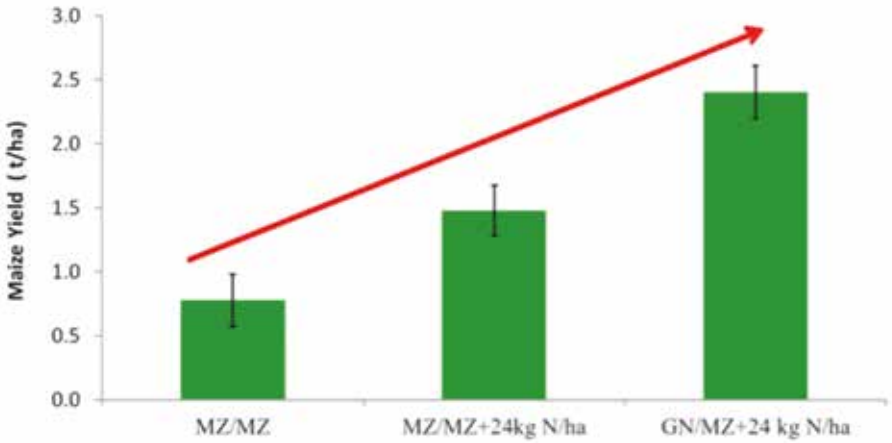


Figure 1: Maize yield under continuous maize (MZ/MZ) with and without inorganic nitrogen fertiliser and a groundnut/maize (GN/MZ) rotation with inorganic nitrogen fertiliser in northern Malawi. Bars indicate standard errors (Mhango et al., 2011).

Legumes bring benefits

Results from the first four-year phase of research confirmed that continuous sole cropped unfertilised maize produced low yields of less than one tonne per hectare on average. Integrated soil fertility management involving a legume in a rotation and adding a low dose of inorganic nitrogen fertiliser (24 kg N/ha) gave higher maize yields than a continuous sole cropped maize with a similar amount of fertiliser (see Figure 1). The doubled up legume technology, pigeonpea intercropped with soybean or groundnut and then rotated with maize, produced the best returns to land and labour invested. It also led to very high fertilizer use efficiency. On sandy soils in Kasungu, the pigeonpea-groundnut intercrop fixed 83 kg N/ha compared to 56 kg N/ha and 54 kg N/ha for a sole crop of groundnut and pigeonpea, respectively.

Over two seasons of evaluation, over 80% of the farmers involved in farmer research groups at the Ekwendeni research site indicated that they would like to grow more of the doubled-up legume technology. Twenty percent of farmers expressed interest in growing a maize-pigeonpea intercrop. Similar responses were provided by farmers in Kasungu. Consequently, during a second phase of the research, the project sought to extend the benefits of legume diversification through expanded legume knowledge and use. There was a special focus on households affected by HIV-AIDS and the project worked in collaboration with Ekwendeni hospital's Soils, Food and Healthy Communities initiative (SFHC) to conduct participatory trials, hold field days and provide nutrition education. Legume recipes were included in the nutrition education and both men and women took part in the training.

Sisiwe Luhana with her maize crop grown after groundnut and applying 24 kg N/ha of inorganic nitrogen fertilizer

Malibase Botha from Bwengu Extension Planning Area (EPA) in Mzimba has noticed that her legume crops have boosted the fertility of the soils on her farm. "The good thing about planting legumes is that you don't apply fertiliser when you rotate with maize. This is helping us save on inputs", she says. Sisiwe Luhana is also happy that she now has to buy less fertilizer as the legume residues in her crop rotation adds nitrogen and organic matter to the soil. She observes that the residues help to retain moisture during dry spells. This is something the project team has investigated through a modelling approach. Their findings suggested that both intercrops and rotations are likely to perform better than monoculture maize under conditions of increasing temperature and more varied rainfall. This was true for the majority of locations and soil types in the simulated conditions.

Differences in response to legumes

One of the challenges identified during the research is that the performance of legume systems varies between and within locations. This is thought to be due to a combination of biophysical and socioeconomic factors, but the way that these factors influence system performance is not well understood. On-farm trials were carried out in Kandeu and Manjawira EPA in Ntcheu district in which maize response to different interventions was investigated. The interventions included different legume crops, inorganic nitrogen and compost. Some fields seemed to respond to each intervention, whereas other fields seemed not to respond much to any intervention. Similarly, considerable variation between farms in maize yield following doubled-up legumes was observed in Kasungu. Figure 2 shows that on some farms there was a large increment in maize yield following legumes whereas there was little difference in yield on others. The project team is currently conducting research to investigate the factors that cause the wide variation in benefits that farmers obtain from the technology. It is known that soils with critically low levels of organic matter are non-responsive, and there may be other factors that also contribute to poor intervention responses.

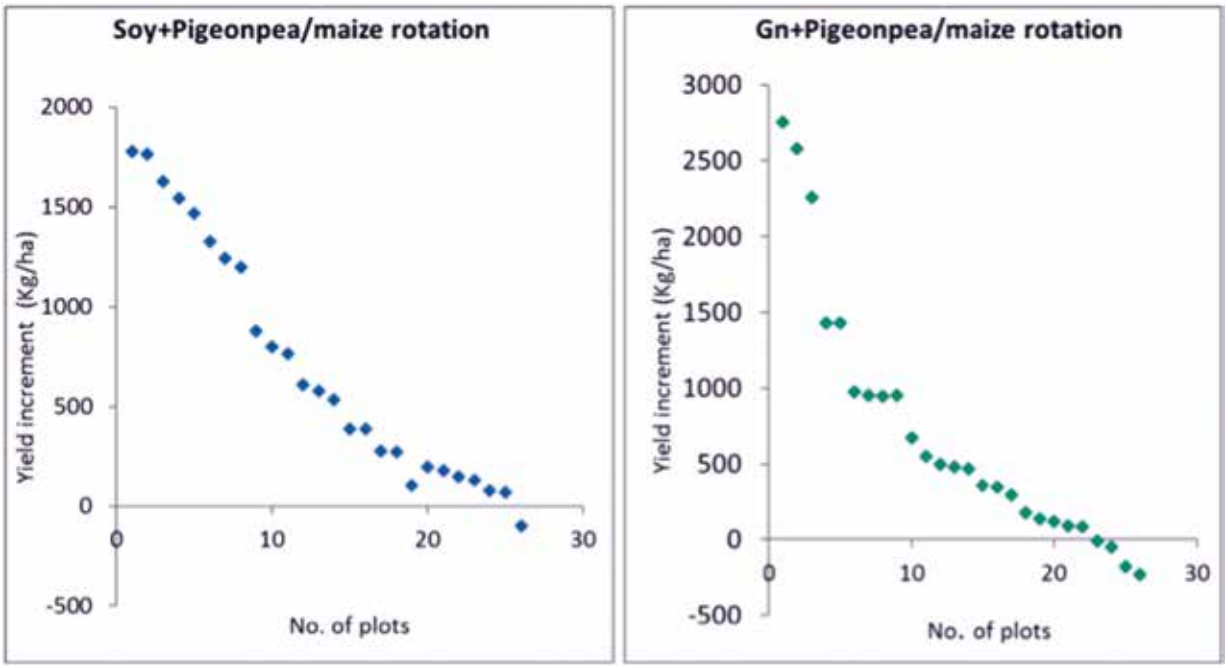


Figure 2: Maize yield increment following legumes versus continuous maize in Kasungu district

Project team members Kate Wellard, Wezi Mhango and Prof. Kanyama-Phiri meet with farmer collaborators in Ntcheu District

Dr Wezi Mhango, soil scientist at LUANAR and co-Principal Investigator of the project, explains the approach being used. "We are using multi-environment trials (MET) to develop a better understanding of the factors influencing variability in the performance of maize-legume cropping systems in Malawi", she says. One of the factors under consideration is the effect of variation in farm management on crop performance. Dr Mhango has developed a MET protocol to assess the impact of factors such as planting date, time and frequency of weeding, control measures for pests and diseases. The findings should help to explain why farmers like Linely Chavula, a lead farmer from Zombwe EPA in Mzimba district, did not obtain yield benefit from pigeonpea and soya in her system.

Lead farmers involved in on-farm trials in Ntcheu district

As with previous on-farm trials in the project, the MET are being conducted with lead farmers. Each lead farmer has about 20 follower farmers who take part in the trials and try out the technologies on their own farms. A new development in some locations in the project is the linking of farmers, researchers, extension officers and other stakeholders in farmer research networks (FRN). FRN is a new approach through which farmers are engaged as equal partners of scientists, development agents and other relevant stakeholders in generating, adapting and scaling out innovations. The project is investigating the potential of the FRN model to facilitate building the capacity of smallholder farmers to engage in the innovation process within the maize legume farming system. The research is being conducted by a PhD student from LUANAR, Frank Tchuwa, under the direction of Dr Daimon Kambewa (Extension Department, LUANAR) and Dr Kate Wellard (Social scientist at the University of Greenwich in the UK).

So far there has been a positive response from farmers to the participatory research being conducted in the MET. In Ntcheu district, the Lipangwe Organic Manure Demonstration Farm (LOMADEF), a partner organization in the project since 2010, has seen improvements in yield resulting from project activities. Thomics Lupenga, LOMADEF Executive Director, says that the project has helped farmers in the area to improve their soils and they like the technologies the project is promoting. "Instead of making manure, which is laborious work, LOMADEF farmers have embraced the technologies of crop diversification of legumes and cereals that the project is promoting," he says. Similar reactions from farmers have been observed in other project locations. However, some challenges remain. Patrick Kanyika, Agriculture Extension Development Coordinator in Bwengu, says soil fertility in his area has been a concern for years and crop yields have dropped sharply. Consequently, farmers are receptive to new ideas but still need to be convinced. "Most farmers are interested and what is needed is to increase size for plots where trials are being conducted. When we use small plots some farmers fail to appreciate the impact," says Kanyika.

Influencing policy processes

The project has generated a considerable amount of evidence on the advantage of including legume crops in maize-based systems (see Box 1). However, the full benefits of the research will not be felt unless there is support among decision-makers and practitioners for the promotion of the improved practices. Accordingly, the project team has prepared policy briefs and held workshops to which government officials are invited and briefed on the new technologies. Parliamentarians have also been engaged through a link with the Parliamentary Committee on Agriculture. These efforts have borne fruit with the adoption by the Ministry of Agriculture, Irrigation and Water Development of doubled-up legumes as one of the technologies it is promoting.

Next steps

The project will continue to explore factors affecting the heterogeneity of response in individual farms from integrating legumes into maize-based cropping systems in Malawi. Further multi-environment trial activities will be conducted at the three project sites in Mzimba, Kasungu and Ntcheu districts and these will make use of the innovative work with low-cost sensors to measure soil and plant characteristics. The research is expected to help farmers to understand what practices work best for them in their own situation and the MET approach will be evaluated to see how it can contribute to scaling out the adoption of legume technologies.

Joint farmer-researcher experimentation is at the heart of the MET approach. The project will assess the potential for farmer research networks to build farmers' capacities to engage in agricultural innovation and generate maize-legume practices that enhance the productivity of their farms in a sustainable way whilst improving their livelihoods.

Box 1

Achievements of the project

- Farmers at the project sites are now obtaining **maize yields of up to 1.5 t/ha** compared to 0.5 t/ha before.
- The significant contribution of legumes to **soil nitrogen reserves** has been documented.
- Results have shown an **increase in soil organic matter** when legumes are included in the cropping system.
- Crop modelling studies have shown that with climate change, integration of legumes in maize based systems **can reduce the risk of failure** compared to continuous maize with or without fertiliser
- The **doubled-up legume** technology involving groundnut and pigeonpea is being promoted by the Ministry of Agriculture Irrigation and Water Development.
- A **PhD student and several Masters students** have graduated successfully and made important contributions to the research.

Lessons

The project has shown that it is possible to enhance the productivity of maize-based systems without relying heavily on inorganic fertilisers which are expensive, not universally available and do not contribute to the maintenance of soil fertility. Through incorporating legumes into a rotation, system productivity may be increased and soil health and fertility can be maintained or enhanced.

Integrating legumes into maize-based cropping systems is a sustainable solution but how this is done depends on local contexts. Locations vary in biophysical characteristics such as soil type and climate. They also differ in social and economic factors such as attitudes and perceptions of farmers and their access to input and output markets. Consequently, recommendations on the choice of crops and how to manage them need to be tailored to the local context.

Multi-environment trials (MET) enable researchers, farmers and agricultural extension staff to jointly identify and test locally adapted solutions across a range of socio-ecological environments. MET need careful planning to ensure that all parties endorse the purpose and approach and understand their roles in data collection and analysis. Communication and data gathering in MET can be facilitated by the use of information and communication technologies and the project team is gaining useful experience in experimenting with low cost sensors and open source software.

The project has made an important contribution to policy change in Malawi. This has been achieved by generating evidence from a series of well-planned trials and engaging effectively with policy makers.

Project team members

LUANAR: George Kanyama-Phiri, Wezi Mhango, Daimon Kambewa, M. NyaManda, Frank Tchuwa, Helen Mwale, Kareem Longwe

LOMADEF: Thomics Lupenga

Ministry of Agriculture Irrigation and Water Development: Annily Mustafa Msukwa, Jackson Mkombezi, Albert Tembo

Ekwendeni Mission Hospital: Lizzie Shumba

Michigan State University: Sieglinde Snapp, Anne Ferguson

University of Greenwich: Kate Wellard

For further information contact Dr Wezi Mhango at wezzi2002@yahoo.com

NEW GROUNDNUT VARIETIES BRING HOPE TO FARMERS

Background

Productivity of groundnut cultivation in Malawi is for the most part low as farmers face multiple challenges. They have limited access to good quality seed and other inputs such as fertilizers. The crop is generally produced on land that is deficient in key nutrients such as phosphorus, potassium and calcium. Farmers sometimes planted their groundnut crops later than the recommended date and this increases the risk of exposure to drought. Groundnut is well adapted to semi-arid environments but it does require adequate moisture at critical periods of plant growth, especially when the pods are developing. A prolonged dry spell can lead to substantial reduction in yield and also predisposes the crops to pests such as termites and diseases such as groundnut rosette and aflatoxin contamination resulting from aspergilus infection. Too much rain, on the other hand, increases the vulnerability of groundnut plants to fungal pathogens such as early and late leaf spot.

In spite of these challenges groundnut remains an important crop in Malawi and the cultivated area is expanding. Groundnut is highly nutritious and is used as a relish and ingredient in complementary food formulations for infants and under five-year old children. The crop has high economic value to farmers by generating income for many households as well as meeting other household needs such as cooking oil, confectionery and peanut butter. There is strong demand for groundnut in local markets, but few farmers are able to produce a surplus for cash sale so they cannot take full advantage of the opportunities. Access to regional and international markets is restricted by the difficulty of meeting quality standards; notably minimum levels of aflatoxin, a toxic substance produced by a fungus that occurs in the soil and attacks groundnuts pods when the crop is grown under stressed conditions. High levels of aflatoxin can cause acute poisoning and lead to liver cancer or death. There is also evidence that exposure to aflatoxin contributes to stunted growth in young children and rates of stunting in Malawi remain very high. This is a major threat especially due to chronic exposure toxicity. Notwithstanding these challenges, the Malawi government sees the crop as an alternative to diversify the country's economy and improve its terms of trade. Groundnut has thus been prioritized as an export growth alternative in the Malawi National Export Strategy being implemented by the Malawi Investment and Trade Centre.

Support through the Collaborative Crop Research Program

Productivity of groundnut could be greatly enhanced if farmers were able to grow high-yielding varieties and use appropriate cropping practices to unlock the full potential of improved varieties. This approach would also reduce the risk of pests and diseases, including aflatoxin contamination. To catalyse this change, the Collaborative Crop Research Program (CCRP) commissioned a four-year project in 2006 to develop improved groundnut varieties which are adapted to different agroecologies in Malawi. The project is led by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in collaboration with the National Smallholder Farmers Association of Malawi (NASFAM), and the Department of Agriculture, Ekwendeni Mission Hospital. The aim of this crop improvement investment is to strengthen resistance breeding for foliar diseases in Malawi and to build capacity in Tanzania to select and deploy resistant material while engaging farmers in the process. To strengthen informal seed systems, a community based seed system was piloted by NASFAM and Department of Agriculture, Ekwendeni Mission Hospital in Malawi and by the Naliendele Agricultural Research Institute working with NGOs and farmer groups in Tanzania. These activities were continued in a second phase of the research between 2010-14. In order to inform planning for aflatoxin contamination management, geographical distribution and severity of aflatoxin contamination sites in groundnut production areas was mapped in both countries. On-farm trials were also conducted to evaluate pre- and post-harvest practices to reduce the risk of aflatoxin contamination.

Box 1

Outputs from the groundnut breeding project (2010-14)

- 5 and 7 new groundnut varieties released in Tanzania and Malawi, respectively.
- Genotypes with low susceptibility to aflatoxin contamination identified and used to improve other materials.
- Incidence of the mycotoxin producing fungi *Aspergillus flavus* mapped in Tanzania and Malawi.
- Exposure to aflatoxin using biomarker studies quantified in Malawi.
- Farmer research groups established in Malawi and Tanzania and conducting participatory varietal selection and on-farm trials.
- Seed networks set up and producing 7 tonnes a year in Malawi and 30 tonnes a year in Tanzania.

By the end of the second phase of the research in 2014 significant progress had been made in developing improved groundnut lines and varieties (Box 1). Farmer groups were actively involved in selecting materials adapted to their cropping and seed systems. Detailed studies revealed the extent of the aflatoxin challenge. Results from a survey carried out in Malawi showed that 46% and 23% of the total samples from 2008 and 2009, respectively, had aflatoxin B1 contamination levels greater than 4 ppb, the maximum permissible level for groundnut in the European Union. Subsequent surveys using an aflatoxin urinary biomarker revealed that 45% and 85%, respectively, of children tested in Malawi and Tanzania were exposed to aflatoxin.

A new phase of research

These disturbing figures on the scale of exposure to aflatoxins justified a continued focus on addressing the challenge under a third phase of the research (2014-18). The project objectives in the current phase continue to emphasise high yields and disease resistance. But additional objectives include breeding of groundnut varieties that are drought tolerant and resistant to aspergilus infection and low aflatoxin contamination. In related work a system for evaluating groundnut test lines under water stressed conditions in aspergilus inoculated soil has been established at ICRISAT-Malawi and is used to support the new breeding objectives.

The current phase of the project is also seeking to improve nutrition of people living in rural communities. The joint efforts of the first two phases of research and other initiatives such as the Tropical Legumes II project led to a 300 per cent increase in productivity of groundnut in Malawi – from 400 kg per hectare to 1200 kg. This was accompanied by an increase in per capita consumption of groundnut from 1.2 kg to 9 kg. These are significant achievements and Dr Patrick Okori, Principal Investigator of the project, now highlights a new frontier in groundnut research. "The project is building from previous successes by increasing the levels of specific nutrients. The new varieties will have all the qualities of the previous varieties plus new ones we are adding such as zinc and iron." These minerals, which are especially important for pregnant women and young children, are also found in meat products. But providing extra zinc and iron in the diet through nutrient dense groundnuts is a more affordable option for rural households. Increasing the oleate content will prevent rancidity and lengthen the shelf life of peanut butter thus increasing the consumption of safe products.

To get the best out of the improved varieties the research team is working with farmers to understand how they fit best into different cropping systems. For example, groundnut is often grown as an intercrop with maize or sorghum or even with another legume such as soya bean which is a common practice in Mchinji District in Central Malawi. The team wants to help farmers to optimize their agronomic practices so that they get the maximum yield possible from their crop. The researchers know that there are large variations between the yield obtained by farmers and the potential yield. Sometimes low yields may be due to factors that are largely beyond the control of the farmer, such as highly degraded soils or drought. But according to Dr Okori, "farmers sometimes complain about low yield and the effects of climate change yet the problem could be poor management of the crop grown. Some farmers take groundnuts as a third crop. As a result, they plant it one month after the rains have already started. That means when it is being planted the crop has already lost at least 20 days of moisture and with the duration of 120 days yield is compromised."

New groundnut varieties released in Malawi

This highlights the importance of matching the variety to the environment. Dr Justus Chintu, a groundnut breeder in the Department of Agricultural Services in Malawi acknowledges the value of the long-term collaboration between his organization and ICRISAT. The support from the McKnight Foundation and other funding agencies has led to the recent release of seven new groundnut varieties in Malawi. These are named CG8 to CG14 and Dr Chintu states that they are an improvement on older varieties such as CG7. Three of the varieties are early duration (90-110 days) small-medium seeded types, with some tolerance to drought and a yield of 1.5 to 2.0 tonnes per hectare. The other four varieties are medium duration (120-130 days) with medium-large seed size and yields in excess of 2.5 tonnes per hectare. Commenting on the contribution of the CCRP support to the development and release of the varieties Dr Chintu says "Almost all the on-farm trials to evaluate the varieties before their release were carried out under the McKnight project. Maintenance of breeding lines and varieties and promotion of new varieties has also been done with McKnight Foundation support."

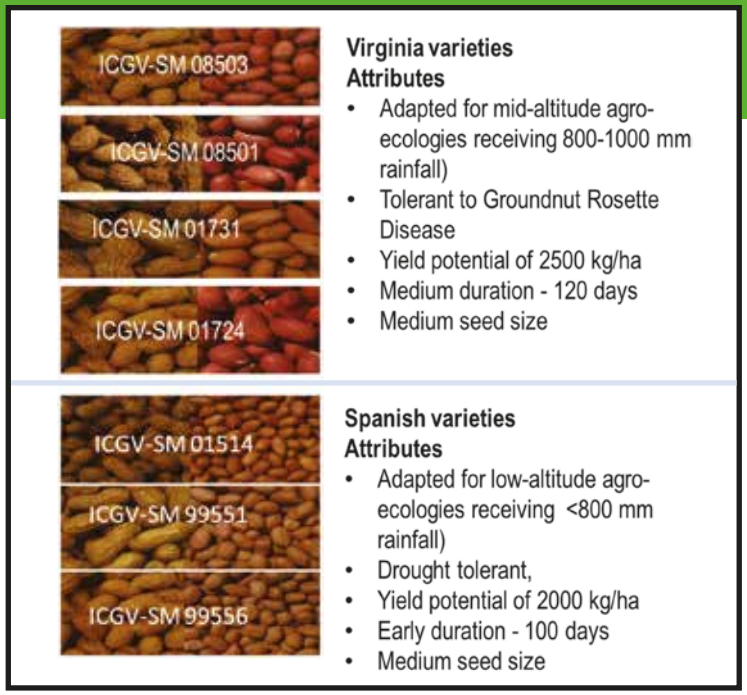
Box 2

Anita Chitaya, of Mayipi village in Mzimba District has been cultivating groundnuts for ten years. She used to keep all her harvest for home consumption as the yield from the local varieties was very low. When she took part in on-farm trials she chose a new variety with similar characteristics to CG7 (CG8). She says she is now able to produce enough groundnuts for home consumption and sell the surplus to generate income to meet her various needs. On one acre she harvests at least 15 bags (unshelled and packed in 50 kg branded sacks) whereas in the past when she was getting less than 6 bags from the same area. From last year's harvest, she bought a goat and fertilizer but also used part of the money to support her children's education.

A participatory varietal selection activity in Malawi

In Mzimba North more than 100 farmers have participated in on-farm trials in the current phase of the research. Community promoter Paul Nkhonjera of Malawi Farmer to Farmer Agroecology (MAFA) which coordinates the trials reports that farmers selected medium duration varieties such as Nsinjiro. "Unlike early maturing varieties such as Chitala, Nsinjiro adapts to prolonged rainfall. The early maturing varieties either germinate or rot when the rains are persistent," his colleague Zacharia Nkhonya explains. Anita Chitaya is one such farmer who is impressed by the improved medium-duration varieties (see Box 1). "I have benefited a lot from the new variety which yields more than the local varieties" she says. "This year I harvested 15 bags and in the past I was getting only six bags." This year she intends to grow the crop on three acres and is also encouraging her son to grow on one acre so that they produce more and let others learn from her.

By contrast, many of the farmers in the two project sites in Mchinji District, Kalulu and Mikundi, chose short duration varieties as they consider these to be better suited to the unstable weather patterns in the area. NASFAM's field officer for Kalulu, Ester Kabinda recalls how 16 varieties were given to farmers in her area to evaluate when the trials started in 2013. Farmers selected seven of these and tested them again in their field plots. Chitala and Nsinjiro were the most popular varieties with farmers due to their market demand, high yield and, in the case of Chitala, early maturity. Ester Kabinda notes that the farmers responded very positively to the participatory approach that was used. "Farmers were able to observe the progress and compare the harvest in demonstration plots. They were convinced by the performance of Chitala and Nsinjiro," she explains.



Improved groundnut varieties released in Malawi with project support

Box 3

James Phiri from Nyoka Village in Mchinji started cultivating tobacco in 1988 but ventured into groundnuts in 2011 when the tobacco price began to fall. However, he found he was getting low yields from the local varieties of groundnuts he cultivated. When the CCRP project started he acted as one of the lead farmers in the on-farm trials. He selected the variety Chitala as he says "Chitala matures quickly, resists drought and has high yield." Today, he produces more than 8 bags of 50 kg on the same piece of land he used to harvest 3 bags of 50 kg using the local variety of Chalimbana. In the 2014-15 growing season he raised MK 200,000 from groundnut sales and used the proceeds to buy five pigs. This additional income is also helping him to meet other expenses such as paying for his daughter's school fees.

James Phiri from Nyoka Village in in Mchinji is one of many smallholder farmers whose lives have been transformed by the project in Mchinji (see Box 3). Fellow villagers Joseph and Liveness Mateche have also made good use of the opportunities presented by the new varieties. From 40 kilograms of Chitala seed they produced 65 bags of 50 kg unshelled groundnuts. They echo James Phiri's enthusiasm about the high yield, disease and drought resistance and quality seeds of Chitala. They have so far spent about MK 66,600 to procure a solar panel, an inverter, a battery and lighting bulbs from the profits of Chitala. They also paid MK 7,000 in school fees for their daughter Naomi. According to Liveness Mateche "Things have improved in our family because of the groundnuts."

Mr and Mrs Phiri grading groundnut seed before selling in the local market

Joseph and Liveness Mateche with the solar panel they bought after selling their harvest of cv. Chitala

These farmers have also leveraged investments under the ICRISAT led Malawi Seed Industry Development Project to link them to formal grain markets managed by the Auction Holdings Limited. Through NASFAM, these farmers also produce grain for export under fair trade arrangements for lucrative markets in Europe.

Looking to the future

The production and market prospects for groundnut are good but can only be achieved if prerequisite production and productivity is attained. New varieties can unlock productivity but improved agronomy and mechanisation is needed to expand production area and reduce drudgery. With CCRP support new drudgery reducing equipment was released in 2015 and models for scaling out the equipment are being tested to inform further investments (see the chapter 'Mechanization Reduces Drudgery for Groundnut Farmers'). The threat from aflatoxin exposure will remain but this will be minimized by better management and the use of a recently launched diagnostic kit.

Lessons

- Long-term support to the groundnut breeding programs in Malawi and Tanzania has generated improved varieties and delivered benefits to farmers.
- Involving farmers in the research in a participatory manner from an early stage has increased the relevance and benefits of the research.
- Giving blanket recommendations to farmers without considering wide differences in local conditions has proven to be unsuccessful. The approach of the project in tailoring varieties and crop management options to the local context has paid dividends.
- The project has generated evidence which shows that the aflatoxin challenge is widespread, serious and needs to be addressed. This has stimulated investments by other donor agencies in aflatoxin research.

Project team members

Wills Munthali (ICRISAT)
Dr Omari Mponda (ARI- Naliendele)
Dr Betty Chinyamunyamu (NASFAM)
Ms Lizzie Shumba (Ekwendeni Mission Hospital)
Dr Chifundo Kajombo (Kamuze Central Hospital)
DR Hendrix Kazembe (DARS- Malawi)
Dr Anitha Seetha (ICRISAT)
Dr Emmanual Monyo (ICRISAT)
Dr Moses Siambi (ICRISAT)
Dr Takuji Tsusaka (ICRISAT)
Ms Bupe Mwakasungula (CTA)
Dr Alexandra Spieldoch (CTA)
Dr Patrick Okori (ICRISAT)

For further information contact Dr Patrick Okori at p.okori@cgiar.org

BAMBARA GROUNDNUT FOR ENHANCED FOOD SECURITY AND NUTRITION

Background

The current El Niño climatic event has caused the most serious drought in over three decades in several countries in Southern Africa, including Malawi. Rains in the region normally fall between October and April, but in many places in 2015-16 the rains only started in late February. This has led to calls for more drought-resistant seed of the main staple crops such as maize and sorghum. Whilst these technologies can help to mitigate the effects of water stress, there are other traditional, drought-tolerant crops that have been largely overlooked. One such crop is Bambara groundnut, which is well adapted to hot and dry conditions and often produces a harvest when other crops fail.

Bambara groundnut (Vigna subterranea) is a grain legume that grows well in light, free-draining soils. The grain contains high levels of protein (19%) and carbohydrates (63%) and has higher dietary energy content (367-414 Kcal/100g) than that of many pulses. It is also rich in minerals and vitamins and so the crop is a useful addition to the diet of rural families whose main source of food is cereals like maize, millet and sorghum. In common with other legumes, Bambara groundnut fixes atmospheric nitrogen in the soil and so helps to maintain the fertility of soils which are often deficient in this important nutrient. Like other legumes, Bambara groundnut residues can also be used to build soil organic matter, which can improve nutrient cycling and improve the soil's ability to hold water.

In spite of these advantages, Bambara groundnut is a neglected and underutilized crop. It is grown mainly by women on relatively small areas of land and most of the grain harvested is for home consumption. Since Bambara groundnut is not considered a priority crop, there are few improved varieties and farmers generally grow landraces that only yield about 400 kg/ha. The low productivity is also due to a lack of knowledge about agronomic practices that would increase yields. Markets for Bambara groundnut are not well developed and so there is little incentive for farmers to increase their production.

CCRP response

Bambara groundnut was identified by the McKnight Foundation's Collaborative Crop Research Program (CCRP) as a potentially important crop for semi-arid environments in its target countries in southern Africa: Malawi, Mozambique and Tanzania. In 2009, CCRP funded Bunda College in Malawi, now part of the Lilongwe University of Agriculture and Natural Resources (LUANAR), to lead a scoping study on Bambara groundnut and to establish a partnership of research and development organizations. The results of the scoping study showed that on average 80% of the crop at the survey sites in the three countries is produced for domestic consumption while the remaining 20% is sold. However, the average rural household is only able to consume Bambara groundnut during the first four months after harvest. Farmers have limited land, so an increase in productivity is needed to extend the period in which they can consume Bambara groundnuts or produce a surplus for sale. A value chain analysis carried out in the three target countries and in the international market showed that there is currently more demand than supply for Bambara locally, regionally and internationally. For example, it was established that in Tanzania a number of potential buyers exist but they require guaranteed quantities that are difficult for farmers to provide with the limited availability of Bambara seeds.

Increasing the productivity of Bambara groundnut

Following the scoping study, a project was commissioned with the aim of improving yield of Bambara groundnut through the introduction of new varieties and by improving agronomic practices. The project is also researching how utilization of Bambara groundnut at the household level can be enhanced and is investigating the potential for market development. The Naliendele Agricultural Research Institute (NARI) in Southern Tanzania is leading the development of new varieties, whilst the National Agricultural Research Institute in Mozambique (IIAM) is conducting complementary research on crop management practices. LUANAR is coordinating activities on household utilization and nutrition and the Natural Resources Institute of the University of Greenwich in the UK is heading the work on market development.

Varietal development

Bambara groundnut accessions were collected from Tanzania, Malawi, Burkina Faso and were also received from the genebank of the International Institute for Tropical Agriculture (IITA) in Nigeria. Participatory varietal selection of the most promising lines was done with groups of farmers in Malawi, Mozambique and

Tanzania. Farmers assessed the lines based on their yield potential, maturity, drought tolerance, pest and disease resistance, size of pods and seeds, number of pods per plant, vigour and taste. The lines they selected were entered in national variety evaluation trials in different locations in the countries. As a result, four Bambara groundnut selections were approved for release as new varieties in Tanzania (Box 1). Dr Agnes Mwangwela, Principal Investigator of the project at LUANAR, says that new varieties will soon be released in Malawi. "At the moment there are three varieties that are due for release in the country. One of the varieties is local and the other two are varieties that were released in Tanzania. Official names have not been assigned but currently the local variety is referred to as Khaki and the two varieties released in Tanzania are known as Nalbam 3 and Nalbam 4."

Dr Agnes Mwangwela assesses Bambara groundnut lines on the research station farm at LUANAR

Box 1

New Bambara groundnut varieties

Four Bambara groundnut varieties have been released in Tanzania and three will soon be released in Malawi. The varieties released in Tanzania are named Nalbam 3, Nalbam 4, Nalbam 6 and Myao and these have different seed color and seed size (see photos). Nalbam 3 has high levels of protein (27%) and zinc (44 mg/kg) and Nalbam 4 has a high iron content of 30 mg/kg. The varieties have maturity periods ranging from 100-115 days and they each produce yields of between 1.5 and 2.0 t/ha. These are a major advance on the landraces that are currently available and the project is working with farmers to multiply the seed and enhance farmer access to the new varieties.

The project team recognises the importance of making Bambara groundnut seed available to farmers. This will enable farmers to increase their productivity and at the same time stimulate market development. Over 5 tonnes of breeder seed of the new varieties were produced in 2014-15 and the project is working with farmer groups to multiply seed of both the new varieties and preferred local varieties. The rate of seed multiplication for Bambara groundnut is slow and so the process of bulking up seed takes time. However, 2-3 tonnes of seed have been produced by farmers in Malawi each year since the 2013-14 season. This is gradually increasing the production area of the crop in Mzimba South and Ntchisi districts.

Four Bambara groundnut varieties released through the project in Tanzania. The variety in the unlabelled photo is Nalbam 4. The released name for TANBAM 2013 is Myao.

Improved crop management practices

Before the project started, farmers had limited information on the best ways of cultivating Bambara groundnut as little research had been done on how to grow the crop. The project team designed field trials in different locations in Mozambique, focusing particularly on when to plant and the plant density that should be used. One of the key findings was that planting date had a large effect on grain yield at each location. The yield of crops planted in late January was significantly lower than crops planted in December and early January. Plant density also had a significant effect on grain yield (Figure). Grain yield increased with increasing plant density and so high seed rates gave the highest yields per unit area of land. However, the response to density was not so strong in the less productive environments (data not shown) so a farmer working in a lower-potential environment should select a density below the maximum tested. High plant density was also associated with smaller seed size and a relatively low yield per seed planted. So if seed size is an important consideration for farmers or if the amount of seed they have to plant is constrained, lower densities may be more appropriate. These findings reveal that farmers need to take account of when to plant and at what density. But specific recommendations for a particular site should be based on local experimentation as conditions often vary considerably among locations.

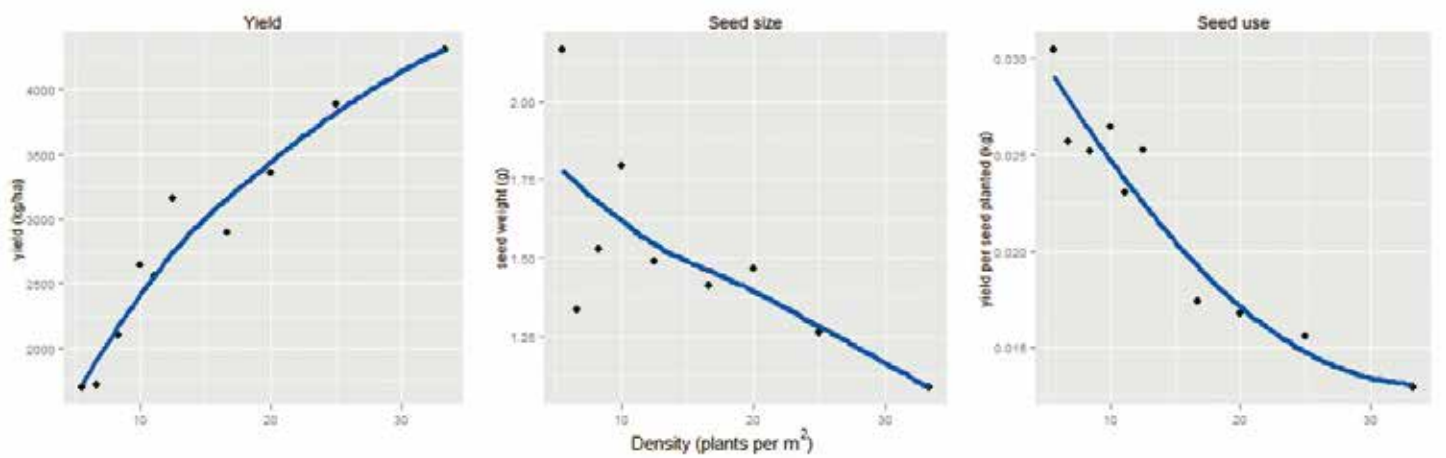


Figure: Relationship between Bambara grain yield and grain density in field trials at three locations in Mozambique

Enhancing nutrition through diversifying diets

A study carried out by the project team in Mzimba South and Ntchisi districts in Malawi revealed that Bambara groundnuts are consumed in rural households but less often than other more common grain legumes. On average, Bambara was consumed 1.5 times per week during the period it was available. This compared with a consumption frequency of 2.6 and 4.5 times per week for common beans and groundnuts, respectively. The low consumption rate was likely to be partly due to a lack of awareness of how Bambara can be used in meal preparations. Almost 96% of respondents said that they consumed Bambara groundnuts in the form of a stew but few of them consumed them in other ways. In order to raise awareness of other options the project team identified and tested local recipes for Bambara. The recipes are being promoted in the project's target areas and restaurant owners have been trained in how to use them. Farmers are also receiving training in making Bambara groundnut preparations. This is being done as part of a wider approach to inform them of the nutritional value of legumes, the importance of good hygiene and good practice in infant feeding.

These activities have had a clear effect on farming households at the project sites. Farmers in Mzimba South use Bambara as a relish and as an ingredient in their main meal. They also make flour from some varieties and use it to cook porridge and bake cakes. The NGO World Relief in Ntchisi, one of the project partners, is using flour from Bambara nuts to prepare porridge in its Community Based Child Care Centres (CBCC). Kester Kambani, a World Relief staff member in Nsonga zone, explains that "With the coming of the project, the organization has switched from soya bean to Bambara nuts when it comes to cooking porridge for its CBCCs in the area. The crop is nutritious and cheaper than the soya bean flour we used for making porridge".

Members of Kanthu Nkhama Farmer group in Mzimba South with some of the Bambara groundnuts they harvested in 2016

Box 2

Vickness Nyirenda, a lead farmer from Mbawa Extension Planning Area (EPA) in Mzimba, started growing Bambara groundnut in 2014. In the first season she sowed 5 kg of seed. After noting that the crop was high yielding and that it served the family in various ways, she increased this to 20 kg of seed. "I use the nuts for relish and I make flour which I use for cooking porridge and baking cakes. I am able to sell what we do not consume at home," she says. Next season she intends to sow 30 kg of seed, divided equally between the varieties Khaki, Mazila ampheta and Chikope cha nyani. "My family is living a happy life after I started growing the crop," she adds.

Market opportunities for Bambara

Farmers in the project's study sites in Malawi say that they have difficulty selling their surplus Bambara groundnuts. The only available outlet that is available to most farmers is to sell to local vendors. The price they receive for the produce is too low to encourage them to expand the area of Bambara groundnuts they cultivate. Saina Phiri is the chairperson of the Katuwtuwa farmer group in Mzimba South. He grows the Bambara groundnut varieties Khaki and Chikope cha nyani. This season he harvested about 80 kg of Chikope cha nyani from 5 kg of seed. However, he says that he does not make much profit from selling his Bambara groundnuts as he has to take the harvest to a trading centre that is 55 kilometres from his farm. "I take the produce to Jenda but to reach there I need MK 1,500 for my transport (one way) and produce is also charged depending on the quantity," says Phiri.

The project is trying to stimulate the development of local markets by supporting seed multiplication activities. The hypothesis is that the current limited supply of Bambara groundnuts is insufficient to attract traders to purchase produce from farmers. By engaging more farmers in the seed multiplication process, it is expected that traders will find it worthwhile to purchase the larger quantities of Bambara groundnuts that become available. Early signs are encouraging but it is not yet clear whether this approach will be successful.

Another opportunity for Bambara groundnut growers is to sell their produce to traders who supply regional markets. A market study carried out by the project identified that there is a market for Bambara groundnuts in South Africa, especially in the Zulu-speaking regions. In addition to dry Bambara groundnuts, there is a demand for canned and fresh products that meet the changing needs of consumers, especially for reduced cooking time and 'eating on the move'. However, the market study also identified constraints that needed to be addressed in order to facilitate access to the market in South Africa. One key problem is limited storage capacity; another is susceptibility of stored seed to weevil damage, in both the producer countries and South Africa. The project is now investigating the potential for developing improved storage systems so that larger amounts of Bambara groundnuts can be stored with lower levels of weevil damage. The high cost of transport is also a constraint, as are the time-consuming procedures for exports to South Africa.

Next steps

The project team is continuing to support the release of the new Bambara groundnut varieties in Malawi and Tanzania by generating additional data from trials conducted on-station and in farmer's fields. With larger quantities of improved seed made available through varietal release and continued support for seed multiplication, the project will be seeking ways to facilitate private sector involvement in Bambara processing, packaging and distribution for local urban markets.

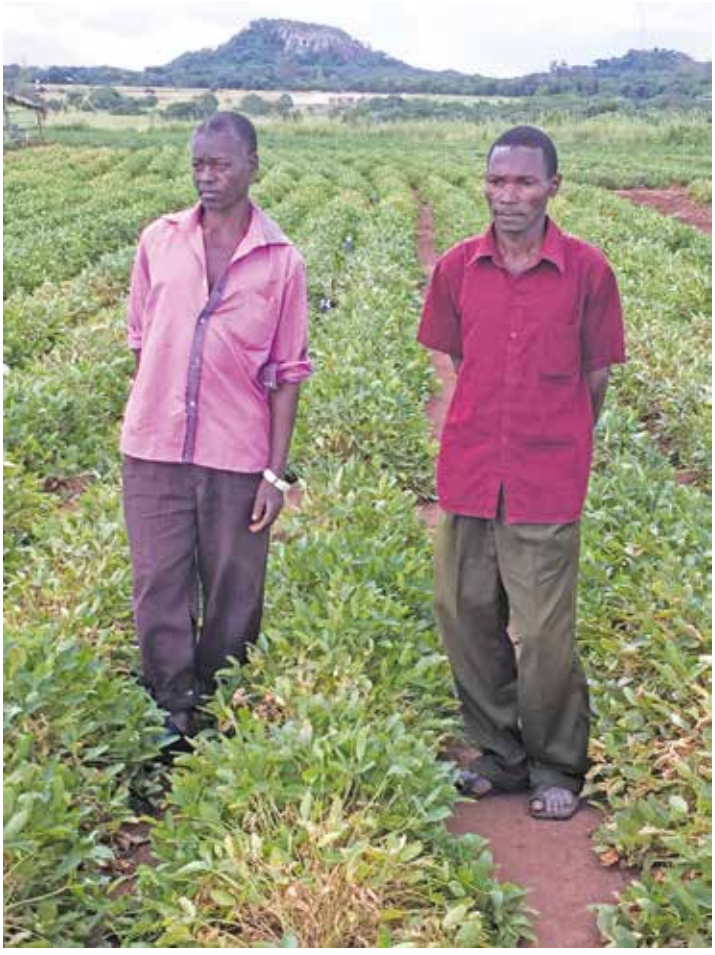
Data from a survey on farmer methods of storing Bambara groundnuts are being analysed with a view to making recommendations for improved practices. Improved storage practices would help to extend the storage period and enable farmers to take advantage of higher prices outside the main production season. This could stimulate increased production as off-season prices can be very high. Better storage would also produce more viable seeds and this would enhance productivity.

Recent surveys in Malawi and Tanzania have identified that some Bambara groundnuts stored in households and sold in markets are contaminated with aflatoxin. The project team is working to identify interventions that will lower the risk of aflatoxin contamination occurring. This includes the establishment of on-farm trials to test agronomic practices that are expected to reduce aflatoxin risk.

Lessons

Through a participatory varietal selection process, improved high-yield varieties of an under-utilized crop such as Bambara groundnut can be developed and made available to farmers without embarking on a major breeding program. However, for sustained impact to be achieved, it is necessary for long-term support to be provided through national agricultural research systems. The project has shown that such investment is justified for Bambara groundnut as farmers have obtained high yields of this drought-tolerant and highly nutritious crop.

The evidence suggests that there is a demand for the crop and that farmers in Malawi, Mozambique and Tanzania should be able to access suitable local markets for their produce once sufficient seed is available to increase the overall supply. There are also opportunities to export Bambara groundnuts to South Africa, but this will require engagement with the private sector to develop new added-value products and overcome the logistical constraints that currently hinder the cross-border trade.



Farmer collaborators in on-farm Bambara groundnut trials in central Malawi

Project team members
LUANAR: Agnes Mwangwela (Principal Investigator), Alice Kilembe
Naliendele: Omari Mponda
IIAM: Amade Muitia
World Relief: Dumisani Mambiya
University of Greenwich: Ben Bennett
For further information contact Dr Agnes Mwangwela at agnesmwangwela@yahoo.com

MECHANIZATION REDUCES DRUDGERY FOR GROUNDNUT FARMERS

Background

Groundnut is an important crop in Malawi and is grown on approximately 300,000 hectares, mainly by smallholder farmers. The crop is quite tolerant to drought and can be cultivated in areas with annual rainfall as low as 450-500 mm, provided this is distributed fairly evenly throughout the growing period. Average crop yield is 800 kg per hectare—considerably below what could be achieved with the use of improved varieties and good management practices. There is a good market for groundnuts, but farmers are hesitant to expand their production area, partly due to the low yields. Another reason for their caution is that groundnut cultivation requires a considerable amount of labour, especially during and immediately after harvest. These tasks tend to be done mostly by women, and the work is tedious and time-consuming.

Groundnuts are commonly harvested manually, using a hoe in a lengthy and inefficient process. Some pods may crack during harvesting, which exposes them to increased risk of being attacked by Aspergillus, the fungus that produces aflatoxin. Other pods may be left in the soil after the plants are lifted. Removing pods from the haulm (stripping) and extracting the kernels from the pods (shelling) are also done by hand. Shelling the hard pods is an unpleasant task, as it is taxing on the fingers. To make the job easier, it is common to soak the pods in water to soften them before shelling. But moistening of the kernels creates a favourable environment for Aspergillus, increasing the risk of aflatoxin contamination when they are stored. Mechanizing these operations would make them easier and less time-consuming, in addition to lowering aflatoxin risk.

Women from the Lisasadzi Farmers Association in Kasungu District, central Malawi, stripping groundnuts by hand

Manual shelling of groundnuts by Lisasadzi farmers

Increasing groundnut productivity opens up opportunities for smallholder farmers to increase their income by selling surplus produce for cash. It also makes higher quality, aflatoxin-free groundnuts available for home consumption. This would be highly beneficial for adding protein to the diets of young children. At present, most complementary foods given to children aged six months to two years are based on starchy staples, especially maize. Adding groundnut would make an important contribution to reducing child malnutrition.

CCRP response

In 2009, the Collaboration Crop Research Program (CCRP) of The McKnight Foundation gave a grant to Compatible Technology International (CTI) of St. Paul, Minnesota, USA to explore the potential for inexpensive, labour-saving tools for pre- and post-harvest handling and processing of groundnuts. Other partners in the consortium were ICRISAT in Malawi and Sokoine University of Agriculture in Tanzania. An additional project aim was to research whether legume-rich complementary foods can improve the health of young children between the age of six months and two years.

Improving child nutrition

A survey conducted in Dodoma District in Tanzania identified an opportunity to improve the health of young children through a feeding intervention. To test the effect of complementary feeding on child growth, a study was conducted in this district. A total of 320 women were trained on the preparation of complementary food based on groundnuts. The research team monitored the feeding of

A woman stripping groundnut in Kasungu

children aged 6-24 months. Researchers assessed the effect of feeding by taking monthly records of the weight and height of the children. A control group of 80 women did not receive training, and their feeding was not monitored. Monthly measurements were taken of the weight and height of children in the control group in the same way as in the treatment group.

The results of the complementary feeding study are shown in Figures 1 and 2 and summarized in Box 1. The World Health Organization (WHO) Z-scores for height and weight at different ages is a standard measure of what should be expected for a healthy child. This is used as a reference point for the children in the treatment and control groups. Figure 1 shows that, on average, children in the study area were already stunted at six months of age. Although the feeding intervention halted stunting, it did not support a full recovery. Figure 2 shows that, on average, children had started to become underweight at weaning, and the intervention prevented this from developing. Overall, the benefits of adding groundnut flour to the complementary food is clearly evident. It is likely that several other factors affect child growth, including health status and hygiene practices in households. However, the clear effect of the feeding intervention remains significant.

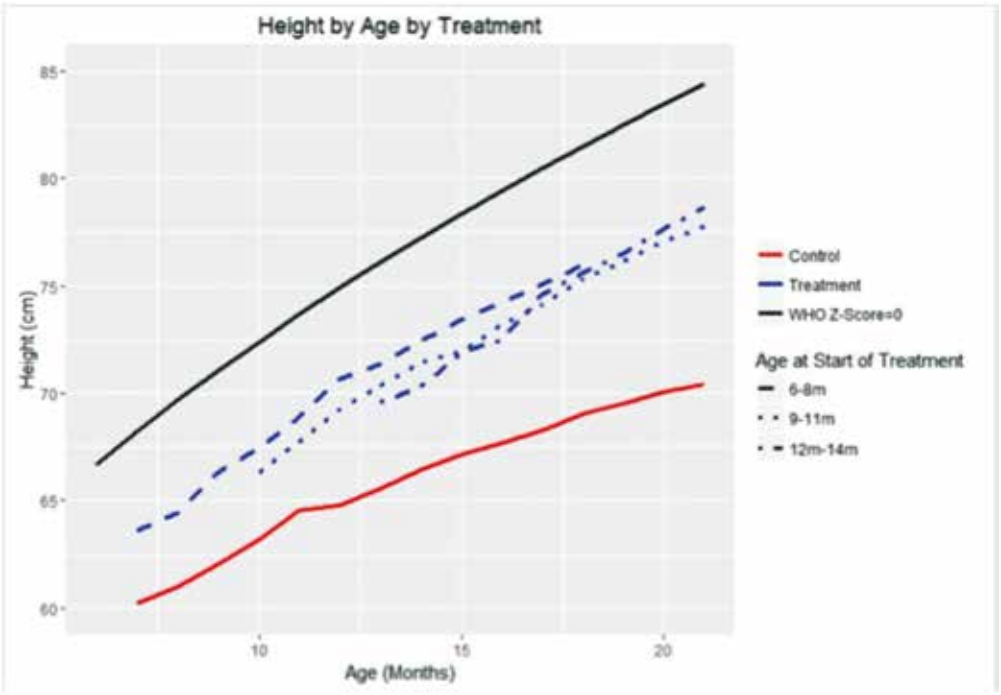


Figure 1. Height gain of children over time by treatment group and age when joining the study. The median growth rate for the WHO weight-for–age standard is shown as a reference.

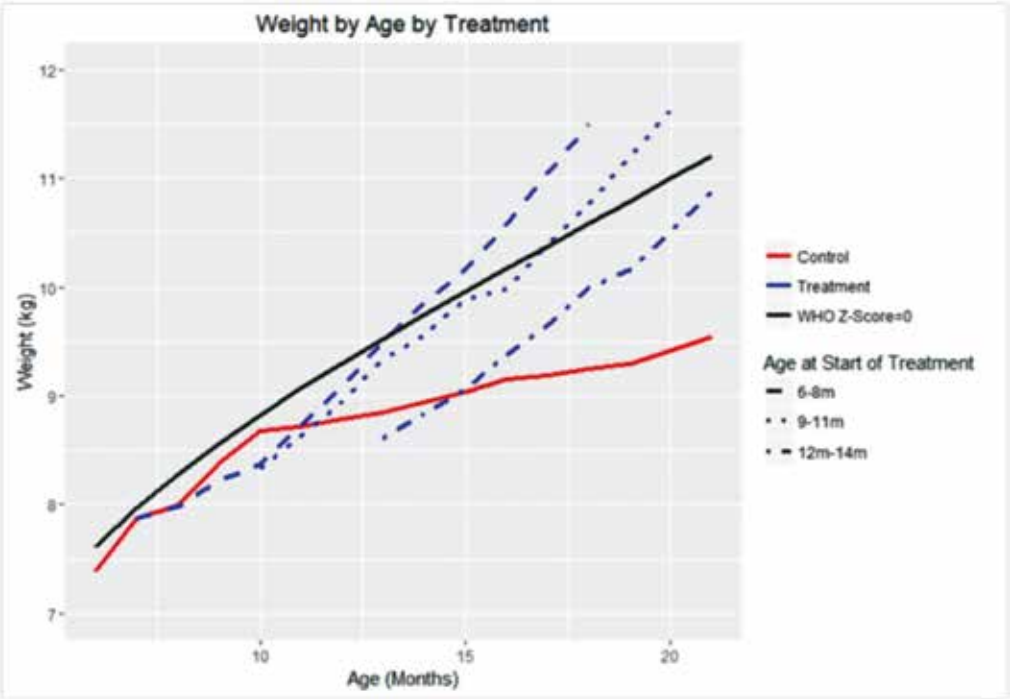


Figure 2 Weight gain of children over time by treatment group and age when joining the study. The WHO standard median growth rate is shown as a reference.

Box 1

Complementary feeding study in Dodoma District, Tanzania, for young children (aged 6-24 months)

Research showed the benefits of complementary feeding with a groundnut-rich diet using locally available ingredients. Compared to children in the control group (no intervention), children given the improved diet had:

- An increased monthly weight gain of 0.2 kg/month
- An increased monthly height gain of 0.4 cm/month

The % of children classified as stunted decreased from 61% before the study to 47% after 12 months in the treatment group whilst increasing in the control group (from 68% to 92%).

The findings suggest that if complementary feeding starts at 6 months of age, children can grow at a rate above stunted or underweight, and this effect will be permanent.

Labour-saving equipment for groundnut

A survey of 248 groundnut farmers from 16 villages in Kasungu and Lilongwe districts was conducted in the 2009-10 cropping season. Results showed 74% of the respondents described lifting as a labor intensive and time consuming process. A similar number (73%) expressed the same views about stripping, a job mainly done by women and children. Shelling was considered by 85% of respondents to be the most tedious post-harvest process.

Based on this information, the CTI-led team developed prototypes of a lifter, stripper, and sheller. These were evaluated with farmers in on-farm trials with the assistance of the Department of Agriculture Research Services (DARS). Based on their feedback, design modifications were made to optimize efficiency:

- **Lifter:** An ox-drawn lifter was designed that harvests an average of 0.4 ha/day, compared with 0.1 ha/day using a hand-held hoe. The lifter causes less damage to the pods. Though efficiency of the two harvesting methods were not significantly different, this was largely attributed to lack of farmer and livestock training to accompany the lifter tool being introduced.

- **Stripper:** Farmers preferred a "stationary screen" stripper, so an A-frame model was developed based on this design. This is easy to make and has no moving parts, which would need to be replaced after time. The stripper removes 38 kg groundnut pods per hour compared with 12 kg/hr with hand stripping.

- **Sheller:** A hand-cranked disc sheller was developed which is 18 times more efficient than hand shelling and produces a higher proportion of undamaged kernels than other designs. The sheller was further modified to be able to shell groundnut varieties with different kernel sizes. This was achieved by using different sieve sizes. The manual design of the shellers makes them suitable for rural areas, where there is no electricity and fuel is costly.

Performance data for each item of machinery was submitted to the Malawi government in 2015. The Agricultural Technology Clearing Committee of the Ministry of Agriculture, Irrigation and Water Development, approved and released the four technologies during February 2016. The machinery is now being developed by a local fabricator.

Box 2

The project has developed four items of equipment for groundnut that were approved for release in Malawi in February 2016.

- **Lifter:** can harvest four times faster than manual harvesting.
- **Stripper:** three times faster than hand stripping.
- **Sheller (2 models):** shells 18 times more nuts than hand shelling in the same period.

The project is now in a new phase, testing viable approaches to the dissemination and adoption of the technologies. Dr Takuji Tsusaka of ICRISAT is leading the research. "We are now trying to estimate farmers' willingness to pay to use the technologies and communities' preferences for how the technologies are made available," Dr Takuji says. A network of approximately 20 farmer groups consisting of more than 500 farmers has been established. NASFAM, ICRISAT, CTI, the Farmers Union of Malawi, and the Department of Agricultural Extension Services (DAES) are all playing a role in linking with these farmers. "The network has enabled us to exchange data and information between researchers and farmers", explains Dr Takuji. "We have also organized exchange visits between farmers from Kasungu district and those from Mzimba South so that they can learn from each other."

Bupe Mwakasungula, CTI's program manager in Malawi, says that farmer involvement from the outset has been a crucial factor in the project's progress. "The machinery was designed in response to priorities identified by farmers in the initial survey," Bupe says. "During the demonstrations, a checklist was also administered to get farmer feedback and inputs to optimize the tools. Their suggestions were incorporated in the final designs," she adds. However, improvements can always be made. For example, in recent tests, some farmers identified a need to further modify the lifter. Dorothy Banda from Elangeni Association in Chiwandauka village in Mzimba South is enthusiastic about the performance of the lifter (see Box 3). But she points out that "the hoe of the harvester is short and does not go deep into the ground. This means some nuts may be left unharvested or damage could be caused to the seed." Continued communication between the farmers, the project team and the fabricator will optimize the lifter as needed.

The farmer response to the stripper and sheller has also been very positive. In particular, they point to the time saved through these tools and the less arduous nature of the tasks. With the sheller, there is no need to soften pods with water before extracting the kernels. Stanton Josia Biton, assistant field officer for the Chinkhoma Farmers Association, recalls, "Spilling water affected the quality of seeds and exposed them to infection with aflatoxin, which meant they could not be sold in the market." One year, this practice had resulted in a large loss of groundnut seed in Chinkhoma. "I believe that this practice will stop when more farmers have access to this machine," Stanton adds.

Dorothy Banda and Olin Ngoma with the prototype groundnut lifter

Box 3

Dorothy Banda is a groundnut farmer is Chiwandauka village in Mzimba South, Malawi. She says that life was hard with hand harvesting but the introduction of the lifter would free her time for other tasks. "It took us about three weeks to harvest an acre, but with this machine I was able to do it in a day and I had enough time to take care of my children at home and attend to my tomato business". Olin Ngoma of nearby Nyifwayatose village agrees. "During the harvest I was able to save energy and time. I was able to attend to my maize field and cook for my family as five of my children need to eat when going and coming back from school", she says.

Benefits will not be realised unless the new equipment is available to farmers at a price they can afford. Dorothy Banda is concerned about the tools' cost. "The harvester pulled by oxen is a burden to farmers who do not have cattle or money to buy cattle, so it will favour those who are well-to-do." However, she sees a solution if farmers join together. "We were told that the harvester alone will cost over MK 200,000, an amount that is a burden to individual farmers. That is why we opt to purchase in groups," she says. Mrs. Kantangwale agrees with the idea of working through groups. "We have already discussed with other farmers that we formulate groups in order to buy the machines, so that we will be able to lend them to each other," she explains.

Patricia Kanyoza, NASFAM's assistant field officer for Ntunthama Association in Kasungu, confirms that farmers in her area are also prepared to buy the equipment through groups. "Farmers are willing to buy the machines in groups, and we are only waiting for NASFAM officials to tell us when the machines will be available on the market," she says. The project is exploring this issues in the current phase of the research, extending to Mozambique where there is strong interest and demand for the new technologies.

Next steps

The project is now working with farmers and other stakeholders, including government, to develop a system that will enable farmers to access and benefit the new equipment as a means to create demand. "These hand-operated post-harvest technologies have potential to greatly improve the lives of smallholder groundnut farmers in Malawi and other countries throughout Southern Africa. Now we must focus on strong business models that put them at the center, including shared

asset approaches, local product development, creative promotion, and marketing. It couldn't be more exciting," says Alexandra Spieldoch, Executive Director of CTI. Other CCRP Southern Africa CoP members are also keen to learn from this experience, and there is interest in transferring the approach to post-harvest mechanization for other crops, such as common bean.

The new equipment's success in farmer trials has shown major benefits for women in easing their workload and freeing up their time for other activities. However, there is a risk that they will not be able to take full advantage of the new technologies if men begin to take over post-harvest tasks in order to capture the financial rewards from sale of the groundnuts. The project will continue to track gender issues raised by the technologies and will seek to identify ways to mitigate any developments that place women at a disadvantage.

Shelling groundnuts with the mechanical sheller

Another task that farmers identified as time-consuming is sorting the kernels after shelling. They do this to grade them by size and discard shrivelled or diseased nuts. Mechanization would speed up this work, so the project team is now looking at low-cost practical options for winnowing and sorting. However, not all farmers are convinced of the importance of winnowing and sorting groundnuts, this increases consumer risk to aflatoxin exposure. CCRP has supported the development of communication products, including a flier and video, and training activities to raise awareness of aflatoxin. The response has been positive, but other measures are needed to address the problem. These include identifying a use for the nuts graded out so that there is an incentive for farmers to sort them effectively.

Lessons

The success of these efforts has demonstrated the value of strategic partnerships among local people, national organizations and international organizations. CTI has provided skills in equipment design and business development, and ICRISAT has provided comprehensive knowledge in legume research and sustainable ecological farming. It can take time to establish agreed ways of working among partners with different organizational cultures, but this investment is worth making.

The project has shown the critical importance of engaging smallholder farmers from start to finish—and women in particular—in order to establish their needs and ensure that their ideas are the basis for developing new technologies. Working with farmer groups has strengthened participatory research and improved the technology development process. It has provided a basis for subsequent dissemination of the equipment. All in all, this approach has had a positive impact and hopefully will lead to a more rapid farmer adoption.

Stripping groundnuts with the A-frame fixed screen stripper

The complementary feeding study clearly shows the value of including groundnut powder in the diet. However, improved feeding will not be sufficient in itself to ensure successful child growth and development. Other measures are needed to help combat child malnutrition, including improving hygiene, ensuring food safety, and enhancing maternal nutrition during pregnancy and throughout the period of breastfeeding.

Project team members

ICRISAT:

Takuji Tsusaka (Principal Investigator), Oswin Madzonga, Lorent Gondwe, Harry Msere, Gift Twanje

CTI: Alexandra Spieldoch (co-Principal Investigator), Bupe Mwakasungula, Wesley Meier, Dave Dupras; Andrews Chiwawula, Vern Cardwell

DARS:

Kelvin Dambuleni, Hendrex Kazembe-Phiri

NASFAM:

Frazer Mataya, Madalitso Chidumu, Betty Chinyamunyamu

IIAM-Mozambique:

Amade Muitia

FUM:

Christopher M. Phiri, Prince Kapondamgaga

For further information contact Dr Takuji Tsusaka at Takuji.tsusaka@gmail.com

The McKnight Foundation
Collaborative Crop Research Program
710 South Second Street
Suite 400
Minneapolis, MN 55401
T. 612-333-4220
F. 612-332-3833