Development of Sustainable Groundnut Seed Systems in West Africa

International Crops Research Institute for the Semi-Arid Tropics

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Development of Sustainable Groundnut Seed Systems in West Africa

Proceedings of the final workshop

2-3 July 2007
Bamako, Mali

Edited by

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International Crops Research Institute for the Semi-Arid Tropics
Patancheru 502 324, Andhra Pradesh, India

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Contents

Abbreviations and acronyms

ADA	Agricultural Development Authority
AOPP	Association des Organisation Professionnel Paysans
ARI	Advanced Research Institute
ASN	African Seed Network
ASPRODEB	Association de Producteurs de Bases
CBO	Community Based Organisations
CFC	Common Fund for Commodities
ECOWAS	Economic Community of West African States
ELISA	Enzyme Linked Inmmuno-Sorbet Assay
EU	European Union
FAO	Food and Agriculture Organization
FPVS	Farmer Participatory Variety Selection
GDP	Gross Domestic Product
GGP	Groundnut Germplasm Project
GSP	Groundnut Seed Project
IAR	Institute for Agricultural Research (Nigeria)
IARC	International Agricultural Research Centers
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	Institut d'Economie Rurale (Mali)
IFDC	International Fertiliser Development Center
IGG/OOF	Inter-Governmental Group on Oilseeds, Oils and Fats
INRAN	Institut National de Recherches Agronomiques du Niger
INSAH	Institut du Sahel
ISRA	Institut Sénégalais de Recherches Agricoles (Sénégal)
LDC	Least Developed Country
MDG	Millenium Développent Goals
NARS	National Agricultural Research Systems
NARES	National Agricultural Research Systems
NGOs	Non-governmental Organizations
M & E	Monitoring and Evaluation
OHVN	Office de la Haute Valle du Niger
PEA	Project Executive Agency
PRSP	Poverty Reduction Strategy Paper
SB	Supervisory Body
SONACOS	Societe National de Commercialization
USAID	United States Agency for International Development
USD	United States Dollar
WCA	West and Central Africa

Foreword

The Groundnut Seed Project (GSP) was initiated in April 2003 with the principal objective to promote utilization of improved groundnut varieties with farmer and market preferred traits through the development of sustainable seed systems. The activities ended on 31 March 2007.

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), as Project Executing Agency, organized an end-of-project workshop on 2–3 July 2007 at Bamako, Mali. The objective of this workshop was to present the remarkable achievements of the project to a wide range of stakeholders.

Participants at the workshop were from various spheres, including Research and Development, development partners, farmers, representatives of farmers associations and community-based organizations, non-governmental organizations, private seed companies, processors and traders. Project results were presented during the different sessions, one of which focused on mechanisms to sustain successful interventions.

These proceedings are a synthesis of the project's accomplishments including farmer participatory evaluation and dissemination of improved groundnut varieties, early adoption of improved varieties and on-farm management of aflatoxin contamination. It also presents experiences from non-project countries and how to sustain seed systems at the national levels.

I would like to express my appreciation of the Common Fund for Commodities (CFC) without whose funding this important workshop would not have been possible. The success of any workshop is the result of the effort and dedication of many people working behind the scenes. This refers particularly to the project staff and local links that were instrumental in organizing the workshop.

William D Dar
Director General, ICRISAT

Session I:
Opening session

Opening Speech by the ICRISAT Country Representative

BR Ntare[1]

Let me extend a warm welcome to all of you to this meeting which marks the successful completion of the Groundnut Seed Project (GSP).

The GSP began in April 2003 under ICRISAT management in partnership with Institut d'Economie Rurale (IER), Mali; Institut National de Recherche Agronomique du Niger (INRAN), Niger; Institute for Agricultural Research (IAR), Nigeria; and Institut Sénégalais de Recherche Agronomique (ISRA), Senegal. Together with groundnut farmers and other stakeholders, these institutions have played a crucial role in the implementation of project activities. It has been a long and fruitful journey of four years with significant achievements, lessons learnt and experiences gained. These will be presented and discussed in this workshop.

Allow me to thank the Government of Mali for its constant support to ICRISAT and its partners in Mali and for allowing their workshop to take place here. I would also like to thank the Director General, IER, who is here today, for their support and exemplary collaboration with ICRISAT in Mali.

The implementation of GSP would not have been possible without the financial support of the Common Fund for Commodities (CFC) and support of FAO as a supervisory body.

This project is of great importance to ICRISAT as it has ignited a strong desire among farmers to experiment with new technologies, which they believe can improve their well being. I would like to congratulate the farmers, representatives of farmers' associations and non-governmental organizations (NGOs) for being major players in the promotion of new technologies.

At this juncture, I would like to thank Mr Ramouch (who is not here with us today) former adviser and Managing Director of CFC, who played a crucial role in the development and approval of this project, and Mr Peter Thoenes of the Intergovermental Group on Oilseeds, Oils and Fats for his consistent support, guidance and encouragement.

I will not end this speech without thanking the national coordinators for their hard work toward achieving the set objectives of this project.

Despite the tight schedule, I am confident that you will profit from the discussions over the next two days. Once again, welcome, and I wish you great success.

Thank you for your attention.

[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Country Representative, BP 320 Bamako, Mali.

Opening Speech by the Project Executing Agency Representative

F Waliyar[1]

At the very outset, let me extend a warm welcome to all of you on the occasion of this meeting to mark the successful completion of the CFC IGOOF/21 project under the leadership of Dr Bonny Ntare. It has been a long and fruitful four years with significant achievements, lessons learnt and experiences gained. The project has largely achieved its objectives and has sensitized partners towards the usefulness of farmer participation in research and extension.

Farmer–scientist interactions during the course of this project ignited a strong desire among farmers to experiment with new technologies, which they believed could improve their well-being. This is the kind of involvement that helps us keep our research focus closer to reality. This is in cognizance of ICRISAT's own credo of 'Science with a Human Face'.

The first two years saw farmers testing new groundnut varieties, assessing their performance and choosing a portfolio of varieties that met their consumption, production and market needs. Over 100,000 farmers were exposed to groundnut varieties. The final year was devoted to up-scaling and out-scaling the technologies so that more stakeholders could partake of its benefits. In the long run, this will encourage lead farmers to serve as ambassadors in the promotion of improved technologies.

The project adopted a number of steps based on lessons learned from past failures of similar seed projects. This approach was almost solely based on community-based seed supply systems, where communities are trained in seed production and small-scale seed producers are trained in both seed production and business skills, resulting in successful delivery of seed at affordable price to users. This approach needs further strengthening and a long-term commitment.

The experiences gained in Mali, Niger, Nigeria and Senegal will ensure wider sharing of technologies within West Africa. This blend of partners has brought in significant synergy in our efforts to alleviate poverty by increasing the productivity of groundnut in West Africa.

The project has led to a number of lessons that have a strong bearing on the sustainable gains of the project, for despite being aware of improved varieties, farmers in many areas are still unable to save their own seed due to financial and social obligations when they are forced to dispose off their produce cheaply.

[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh 502 324, India.

Linkages with markets, credit and other agricultural inputs (especially fertilizers) were other issues tackled. While consolidating the gains made in the current project, it is important to address newer issues.

While we have achieved quite a lot, challenges still remain that can be tackled with a follow-up program. Let me take this opportunity to exhort the NARS partners to be proactively involved in investing opportunities that arise to improve the well-being of groundnut farmers.

At this juncture I would like to thank CFC for being a strong supporter of West African agriculture and a major donor to ICRISAT.

I wish you success in your deliberations. I am sure they will provide valuable guidance for future projects, all aimed towards the objective of alleviating poverty.

Thank you for your attention and good day.

Opening Speech by the CFC Representative

V Adler[1]

Let me first transmit to you the best wishes of Ambassador Ali Mchumo, the Managing Director of the Common Fund for Commodities, on whose behalf I am participating today in the end-of-project and dissemination workshop of the project on *Development of Sustainable Groundnut Seed Systems in West Africa*.

Our congratulations go to the organizing committee of the workshop for making such excellent arrangements. Special thanks go also to ICRISAT and Bonny Ntare, the project manager of this project, who has undertaken considerable efforts to prepare for this meeting and I am confident that we will all have a very interesting time learning about the findings of this project and lessons learned on farmers' needs and market requirements for improved groundnut varieties and its respective seed production and delivery schemes.

I limit myself to a brief account of the mandate and activities of the Common Fund for Commodities. Subsequently I will touch upon salient aspects of the project which is the subject of our meeting.

As you may know, the Common Fund for Commodities (CFC) is an autonomous intergovernmental financial institution established within the framework of the United Nations. The Fund forms a partnership of 106 Member States and three intergovernmental organizations.

The Common Fund's mandate may best be described as to enhance the socioeconomic development of commodity producers and to contribute to the development of society as a whole. Through cooperation with other development institutions, the private sector and civil society, the Fund's endeavor is to achieve overall efficiency and impact in commodity development.

The focus of the Common Fund is on commodities and this has good reasons. As you are aware, many developing and least developed countries are heavily dependent on commodities which form the backbone of their economies and account for the bulk of their export earnings. It is estimated that around 1 billion people derive a significant part of their income from the production of export commodities. This number would of course be substantially higher if production for domestic or national use were taken into account. It should also be noted that it is frequently the poorer strata of the population that is involved in commodity production. The Common Fund, therefore, deals with a core question of development in many regions of the world.

[1] Common Fund for Commodities (CFC), PO Box 74656, 1070 BT Amsterdam, The Netherlands.

The Common Fund operates under the novel approach of commodity focus instead of the traditional country focus. The activities of the Fund mainly comprise commodity development measures aimed at improving the structural conditions in markets and at enhancing the long-term competitiveness and prospects of particular commodities. They include research and development; productivity and quality improvements; transfer of technology; diversification and processing; and improvement of marketing and market access. Secondly, the Fund supports commodity market development activities which assist developing countries and, in particular, least developed countries (LDCs) to function effectively in a liberalized global economy. Projects in this field include physical market development, enhancement of market infrastructure, facilitation of private sector initiatives, and commodity price risk management.

The Fund concentrates on low cost, high impact projects which have the potential of becoming self sustainable, involving, whenever possible, the private sector.

By 31 May 2007, the Fund had approved 263 projects (152 regular projects plus a further 111 Fast Track projects) with an overall cost of $458.8 million, of which the Fund financed $229.5 millions. This comprises $198.6 million in grants and $30.9 million in loans. The high co-financing ratio of about 50% is evidence of the catalytic role the Common Fund plays in attracting resources from other institutions for the Fund's commodity development projects. The project covers 38 commodities, of which 35 are agricultural and 3 are mineral. The average size of a CFC-financed project is $3.0 million. To date, 68 projects have been completed.

Let me now come to the project which is the focus of our discussions in this workshop.

The project agreement for the implementation of the project was signed in March 2003 between the Common Fund for Commodities; the FAO-hosted Intergovernmental Group on Oilseeds, Oils and Fats and ICRISAT.

During project implementation, regular meetings have been held for coordination purposes and for exchange of technical experiences, and one can say that the project management unit, under the leadership of Dr Bonny Ntare and Dr Farid Waliyar gave effective guidance to the many different institutes involved in the project. With a fairly great level of independency, with the technical supervision of the Intergovernmental Group on Oilseeds, Oils and Fats (the Supervisory Body for this project), the project progressed through time, setting priorities for further research based on the results obtained and based upon the technical exchanges between the key partners in the project. An external evaluation was undertaken during February 2005, and its findings and recommendations have assisted in further focusing activities in the final phase of the project. The project is now due to be completed, and I should express

the Fund's appreciation for the determination of the whole project team to succeed in having the operational activities complete within the extended completion date.

This being said, let us look at the project and what it was aiming at to achieve. The project aimed to:

- Promote use of seed of improved varieties through sustainable community-based seed delivery systems; and
- Improve the skills of farmers and other entrepreneurs in seed production, delivery, processing, marketing and small seed enterprise management, including measures to minimize aflatoxin contamination.

Previous support by CFC and ICRISAT have been largely successful in germplasm conservation, variety maintenance and the development of appropriate groundnut varieties that meet farmers' preferences and market requirements.

The availability and uptake of high quality seed by farmers, which was promoted under the current project, is fundamental to the transformation of predominant traditional agricultural production practices to achieve increased stability and sustainable food production in West Africa. New seed with higher yield potential or ability to relieve constraints faced by farmers in using traditional varieties form part of the improved inputs required to increase crop production. In the light of increased liberalization of economies and structural adjustment policies there is a need to rethink alternative and sustainable arrangement for seed production and delivery schemes. Linkages between the private sector processing companies and producers are very important in this regard.

Based on the presentations to be made in the coming two days, it should be concluded whether the project has indeed achieved its objectives.

In concluding, Mr Chairman, I would wish to emphasize that in the presentations that will be made and in the discussions that will take place during the coming days, the following issues should be at the core. Crucial considerations will be whether the proposed methods and techniques will provide results that will convince groundnut producers that they will benefit from their introduction, and what type of parallel government support measures, if any, and which private sector activities would be required in order to channel the necessary inputs to the small producers.

With the request to keep the smallholder perspective at the centre of the exchanges during these days, Mr Chairman, on behalf of the Managing Director of the Common Fund for Commodities, I do wish you all fruitful deliberations and discussions.

Thank you, Mr Chairman.

Opening Speech by the Supervisory Body Representative

P Thoenes[1]

I am honored to participate in this meeting on behalf of FAO which acts as Supervisory Body (SB) for this project.

After four years of close collaboration with ICRISAT and the four national implementation agencies, I assume there is no need for a lengthy introduction. This meeting is meant to critically review the results obtained during the project's last four years of implementation, as well as to draw lessons and to plan future action to be taken once external project funding comes to an end.

During the last four years a very comprehensive and challenging program has been implemented to support the development of sustainable groundnut seed systems in the region. In order to revive the region's groundnut industry, we need a seed production system that supplies farmers with high quality seed material. In this regard numerous obstacles have been identified, such as:

- Limited farmer participation in the selection of new varieties;
- Insufficient supply of breeder and foundation seed;
- Inefficient seed production and uncertain seed demand;
- Inadequate national variety release mechanisms;
- Weak integration between the seed and the product market;
- Lack of an enabling institutional and policy environment.

Under this project tools have been developed to overcome these problems. In the four project countries, possible solutions have been identified and tested in close collaboration with the responsible NARS and through partnerships with farmer associations, small entrepreneurs, NGOs, the processing industry and other stakeholders. Extensive training has been provided and socioeconomic surveys and market studies have been undertaken.

Now we are here to review and draw lessons from the experience gained in the last four years, and also to share findings and exchange views with stakeholders from other countries. Preliminary reports seem to suggest that the following areas will require particular attention.

[1] Intergovernmental Group on Oilseeds, Oils and Fats, FAO, Commodities and Trade Division, Via Teme Caracalla-00 100, Rome, Italy.

- The role of revolving funds and access to credit for both, producers of foundation and breeder seed and community based seed multiplication.
- Remunerative and efficient seed marketing systems.
- Appropriate national variety release mechanisms and facilitation of regional seed trade.
- Scaling up of measures to control aflatoxin contamination along the commodity chain.
- The use of contractual arrangements between groundnut producers, traders and processors.
- The establishment of sustainable national consortium to promote and coordinate further action in the sector.

Before I conclude, I would like to thank you all for participating in this meeting and wish you two days of successful discussions and deliberations.

Furthermore, my sincere thanks to our hosts, the Institute de Economy Rural and the Ministry of Agriculture of Mali as well as to ICRISAT for organizing this event. Finally I am very glad that CFC is represented through Ms Adler and me.

Thank you for your attention.

Opening Speech by the Ministry of Agriculture Representative

F Diarra[1]

It is a great pleasure for me to be here in Bamako at this opening ceremony of the end-of-project workshop, marking the end of the Groundnut Seed Project (GSP). To our honorable invited quests, who have traveled great distances to attend this meeting, I would like to extend a warm welcome and a pleasant stay in Mali.

As you all know, groundnut used to be the major export crop in Mali from independence through 1970. But since the 1980s, production and export shares have declined. This is attributed to the low productivity of groundnut-based production systems, stringent regulations regarding aflatoxin contamination and other quality standards. These factors have limited the competitiveness of groundnut from West Africa in regional and international markets.

To regain its competitiveness, there must be increased productivity by adopting new technologies, particularly the development of sustainable groundnut seed systems. Despite the achievements the project has made to address this, a lot of work remains to be done in order to sustain these achievements. In particular, there is a need to strengthen linkages between the various actors, including farmers' associations, private sector and processors. Institutional mechanisms that allow producers to produce and sale seeds at affordable prices, focusing on integrating farm inputs and markets but also linking the actors of the value chain are extremely important.

Ladies and gentlemen, dear participants, I take this opportunity to thank ICRISAT and its national partners of Mali, Niger, Nigeria and Senegal, the NGOs, farmers and farmers' organizations for their collaboration that permitted the success of the project. I would not like to end this speech without thanking CFC for the financial support and FAO for supervision of the activities.

I would also like to appeal to producers to take advantage of these benefits to ensure that the interventions are sustained so that groundnut can regain its place in the profitable agricultural sector in Mali.

Wishing you success in your deliberations, I declare open of this dissemination workshop of the project *Development of Sustainable Groundnut Seed Systems in West Africa*.

Thank you.

[1] Technical Advisor, Ministry of Agriculture, Bamako, Mali.

Session II:
Project implementation and results

Background and objectives

F Waliyar[1]

Background

To date, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Common Fund for Commodities (CFC) have had a fruitful and decade-long partnership, resulting in a substantial and direct impact on the livelihoods of groundnut producers in West Africa (WA).

Groundnut production is a critical income generator for rural livelihoods. But since the 1970s, West Africa has lost both production and export shares. In order to reverse this trend, CFC financed a six-year (1996-2002) West African Groundnut Germplasm Project (FIGOOF/05), commonly known as GGP. ICRISAT, the Centre de Coopération Internationale en Recherches Agronomiques pour le Développement (CIRAD), and the Institut Sénégalais de Recherches Agricoles (ISRA) jointly implemented the project. The national agricultural research systems (NARS) in the sub-region, the West and Central African Council for Agricultural Research and Development (CORAF/WECARD), and the African Groundnut Council (AGC) were the main partners.

In the past, germplasm exchange in WA was rare, fortuitous and not usually monitored, and the development and distribution of improved groundnut varieties faced serious constraints. Under the project, a regional network for sustainable conservation of germplasm, and for the development and free distribution and exchange of improved seed material, has been put in place. In particular, a broad range of germplasm has been assembled and conserved to support future development, the capacity of NARS to handle and improve germplasm has been enhanced, and several improved groundnut varieties have been tested and are now available in the region. This represented the first essential step towards increased productivity and sustainable production of groundnut in West Africa.

Despite these achievements, the development and dissemination of improved groundnut varieties and related production technologies that will lead to increased productivity and improved household incomes remained a major challenge. Groundnut farmers rarely benefit from improved germplasm.

[1] Project Executing Agency (PEA) Representative, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andhra Pradesh 502 324, India.

CFC further financed a 4-year follow-up project (FIGOOF/21) in 2003 in partnership with NARS of Mali, Niger, Nigeria and Senegal, to disseminate improved groundnut varieties in these countries. A major thrust of this CFC-NARS-ICRISAT groundnut seed project was to establish sustainable community-based seed systems that assure good quality seed at the right time and at affordable prices. Training farmers and other stakeholders along the commodity chain was an integral part of this strategy.

Description of the project

Goal

Improve the livelihoods of farmers through uptake of seeds from high yielding groundnut varieties and promotion of sustainable seed systems in West Africa.

Objectives

- Promote utilization and uptake of improved groundnut varieties responding to market requirements through the development of sustainable community based seed production and distribution systems;
- Promote measures to minimize aflatoxin contamination;
- Improve skills of farmers and other entrepreneurs in seed production, delivery, processing, marketing and small enterprise management;
- Improve the flow of information between producers and market intermediaries.

Project components

1. Promote utilization and uptake of improved varieties
2. Minimize risks from aflatoxin contamination
3. Improve skills among farmers and other entrepreneurs
4. Disseminate information
5. Manage, coordinate and monitor project.

Outputs

Component 1

- Having groundnut varieties meet market standards
- Ensuring that sustainable breeder and foundation seed supply covers 20% of the area

- Creating alternative seed supply strategies
- Establishing linkages between producers and processors
- Measuring impact of improved varieties

Component 2

- Demonstrating integrated crop management practices to reduce aflatoxin contamination
- Extending better harvesting and storage technologies

Component 3

Training stakeholders in:

- Crop management, seed production and variety maintenance
- Postharvest crop management
- Impact assessment
- Marketing and small-scale seed business management

Component 4

Enhancing information flow through the following means:

- Project website
- Workshops, and training manuals
- Brochures in local languages, radio messages
- Village/community level workshops
- Publications

Project management

Coordination

- Project coordination committee meetings organized
- Annual work plan and budget prepared

Reporting

- Periodic progress reports (6-monthly and yearly)
- Yearly audited financial reports

Monitoring

- Periodic monitoring missions by supervisory body (SB)

Evaluation

- A monitoring and evaluation system
- Mid- and end-of-project evaluation

Verifiable indicators

- Number of improved groundnut varieties selected and adopted in target areas
- Area planted to new varieties
- Level of aflatoxin contamination reduced in target areas
- Sustainable community based seed schemes available
- Non-participating countries experimenting with seed production and distribution schemes developed by the project
- Appropriate market grades and standards applied
- Number of farmers who have acquired skills in seed production techniques
- Number of small seed enterprises established

Key features

- A purely demand or market driven-approach as opposed to research driven agenda
- New strategic partnerships (private sector, NGOs, farmer organizations and policymakers)
- Full integration or complementarily of formal and informal seed production activities

Methodology

- A phased approach, experimental in character
- Pilot activities in a limited number of representative locations
- Evaluate experiences gained through successful upscale/outscale interventions
- Build maximum collaboration with all stakeholders involved or potentially interested in groundnut seed production

Major activities

- Identification of market niches and match available varieties to these niches

- Characterization of current seeds production and supply systems
- Design and implemention of variety testing and demonstration of new varieties together with farmers
- Establishment of strategic partnerships with traders and processors, farmer associations and individual entrepreneurs
- Identification and training of entrepreneurs for foundation seed production
- Improvement of linkages of producers to markets
    - Group marketing
    - Contracting
    - Collection points
    - Development and distribution of relevant production and market information

  The results and lessons learned will be presented during the two-day workshop.

Project achievements and perspectives

BR Ntare[1], J Ndjeunga[2], F Waliyar[3], C Echekwu[4], O Kodio[5], A Da Sylva[6], I Kapran[7], AT Diallo[8] and HY Bissala[9]

Abstract

Important results have been achieved in particular in the following areas: (i) promotion of improved varieties, (ii) promotion of community based seed production systems, (iii) development of seed marketing strategies, (iv) promotion of techniques to reduce aflatoxin contamination, (v) direct interaction with farmer groups through training and related activities, and (vi) information dissemination.

Through Farmer Participatory Variety Selection (FPVS), 2-3 varieties have been selected in each of the countries for multiplication and wide scale production. Results from the FPVS activities showed the potential of farmer groups and associations that can play an important role in stimulating adoption of new technologies. The study on current seed systems concluded that options likely to be sustainable should focus on local village seed schemes whereas small-scale private seed entrepreneurs or community based seed systems should be encouraged to become seed entrepreneurs or engaged in the seed industry. The project successfully tested and demonstrated measures to prevent aflatoxin contamination at the farmer level. Large scale dissemination of these technical packages, along with intensive sensitization campaigns across the commodity chain remain a major challenge.

Good progress was made in establishing linkages with processors, and there is now a greater awareness amongst all stakeholders of the importance of quality, and particularly, the importance of suitability of varieties for the needs of growers, users and processors.

[1] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 320, Bamako, Mali.
[2] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 12024, Niamey, Niger.
[3] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India.
[4] Institute for Agricultural Research (IAR), Samaru, PMB 1044 Zaria, Nigeria.
[5] Institut d'Economie Rurale (IER), CRRA, Kayes, Mali.
[6] Institut Senegalais de Recherche Agricole (ISRA), CRRA Bambey, Senegal.
[7] Institut National de Recherche Agricole du Niger (INRAN), BP 429, Niamey, Niger.
[8] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 320, Bamako, Mali.
[9] International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), BP 12404, Niamey, Niger.

Background

Over the last four decades, groundnut production in West Africa has declined in importance as both food and cash crop for households and national economies. Since 1984, West Africa has lost its world production and export shares. Higher world prices for groundnut products compared to its substitutes, and difficulties in meeting the quality standards required by international markets (with regard to aflatoxin levels) have limited the competitiveness of groundnut. Prospects for regaining production and market shares lie in the adoption of improved varieties and crop management technologies that will significantly increase productivity and production and the improvement of quality standards (Ntare et al. 2005).

The availability and uptake of modern inputs by farmers is fundamental to the transformation of predominant traditional agricultural production practices to achieve increased stability, productivity and sustainable food production in West and Central Africa (WCA). New seeds with higher yield potential or ability to relieve constraints faced by farmers in using traditional varieties form part of the improved inputs required to increase crop production. This has motivated past and current investment in breeding by national agricultural research systems (NARS), international agricultural research centers (IARCs) and advanced research institutions (ARIs) in WCA. Studies on diffusion, adoption and impact conducted in WCA have pointed to the key role of seed production and distribution sector as a major driver to the achievement of significant impacts (Sanders et al. 1994; Yapi et al. 1999, 2000, Ndjeunga et al. 2003). This provided a rationale for investments by donors such as the United States Agency for International Development (USAID), French Cooperation, European Development Fund, the Food and Agricultural Organization of the United Nations (FAO) and the Common Fund for Commodities (CFC), in the establishment or re-enforcement of state-run, semi-private or local village seed production and distribution schemes in many West African countries.

In many countries, large public seed production and delivery infrastructure has been established, but has failed at delivering seed of high quality and varieties preferred by farmers or required by the market. Most of these infrastructures ceased to operate when projects ended because they were not sustainable. During and after the implementation of seed projects, the private sector has shown limited interest in entering the groundnut seed industry. The combination of poor public performance and lack of private sector interest may create a void in the seed market that needs to be filled. Governments are disengaged from product market organization and development that have long supported uptake of modern groundnut varieties. Groundnut state marketing boards have been dismantled. In the process, seed laws and regulations have not adjusted to the changing regulatory or institutional environment. Recent

efforts by governments, donors, international (FAO, ICRISAT) and regional (INSAH and ASN) organizations at facilitating the processes of identifying the constraints, redesigning and harmonizing seed laws, policies or regulations are underway. There is therefore a need to rethink alternative and sustainable arrangements for seed production and delivery schemes.

Since 1998, ICRISAT and partners have tested about 90 groundnut varieties and more than 45 were found adapted (Mayeux et al. 2003). However, their uptake remained low due to poor information flow on varieties and weak seed production and delivery systems. To improve access and availability of seed of modern varieties to end-users, CFC supported a four-year project entitled *Development of Sustainable Groundnut Seed Systems in West Africa* (GSP hereafter) with the aim to promote utilization and uptake of improved groundnut varieties responding to market requirements, through the development of sustainable community-based seed systems. The project was implemented in Mali, Niger, Nigeria and Senegal. The goal was to 'improve the livelihoods of farmers through uptake of seed of high yielding groundnut varieties and promotion of sustainable seed systems in West Africa'.

This paper summarizes the accomplishments of the four-year project and perspectives.

Activities

A range of activities were pursued including: Farmer Participatory Variety Selection (FPVS) trials to evaluate variety performance; production of high quality breeder and foundation seed; characterization of formal and informal groundnut seed systems in target countries; economic evaluation of seed production and delivery schemes; and a study on market prospects for groundnut in the domestic, regional and international markets. The other important activities were to promote measures to minimize aflatoxin contamination; improve skills of farmers and other entrepreneurs in seed production, delivery, processing and marketing, and seed enterprise management; improve the flow of information for decision making by farmers and market intermediaries along the commodity chain and finally, project management, coordination, monitoring and evaluation.

Achievements

Utilization and uptake of improved groundnut varieties responding to market requirements, through sustainable community-based seed systems

Market prospects for groundnut in the domestic, regional and international markets

Groundnut production, marketing and trade are major sources of employment, income and foreign exchange in West African countries. The Project Executing Agency (PEA), ICRISAT, commissioned a study to document the principal groundnut producing countries in the international markets, global market trends and quality requirements, recent trends in production and consumption in West Africa, and identify strategies for improving the efficiency of groundnut markets in West Africa. The findings were summarized in Technical Paper No. 39 of CFC (Ntare et al. 2005) and the first project newsletter (GSP news 2004). The primary conclusion of this study was that resources should be devoted to the improvement of the supply chain in each producer country targeting the production to satisfy national, sub-regional and regional demand. It further recommended that it was important to help build national and regional trade opportunities for producers by monitoring groundnut supply and price information on local and national markets; and by facilitating the diffusion of information to stakeholders via rural radio and other locally appropriate means.

Current seed supply systems in West Africa: constraints and opportunities

One aspect of the baseline information of GSP was to document current seed supply systems, their constraints and opportunities. This information is vital for the development of sustainable seed systems for groundnut in West Africa. A survey of groundnut supply and distribution systems was conducted in the major groundnut growing regions of Mali (Kita, Kayes and Kolokani), Niger (Dosso, Maradi and Zinder), Nigeria (Kaduna, Kastina, Kano and Gigawa states) and Senegal (Fatick and Kaolack). Following a review of literature, data were gathered at the institutional, household and plot levels. At the institutional level, data were collected on all institutions intervening in seed multiplication and distribution including NARS, NGOs, seed companies and oil seed processors with respect to their roles, quantities of seed production by class, cost of seed production and seed producing schemes.

The results from this study were published in Technical Paper No. 40 of CFC (Ndjeunga et al. 2006). The study revealed that the major constraints

limiting the uptake of improved groundnut varieties or performance of the groundnut seed system include:

- Limited access to seed of newly-bred varieties
- Limited supply of breeder/foundation/certified and commercial seed of varieties preferred by farmers or required by the markets
- Seed production not profitable for some seed classes
- Weak and uncertain seed demand
- Missing or non-functional national variety releases committees
- Poor integration between seed and product markets
- Lack of enabling policy and institutional environments.

However, there are opportunities around which sustainable seed supply systems can be developed. These include potential for regional seed trade, availability of seed infrastructure within countries, a large number of farmers trained in seed production techniques through various rural development projects, NGOs or research institutions etc, and large oil processing companies.

The study concluded that options likely to be sustainable should focus on local village seed schemes whereas small-scale private seed entrepreneurs or community based seed systems should be encouraged to become seed entrepreneurs or engaged in the seed industry. There is evidence of vertical integration between inputs and product markets. Appropriate linkages between seed and grain producers, and grain producers and processors are necessary to drive the private sector entry in the seed industry.

Farmer participatory variety selection (FPVS)

A broad range of groundnut varieties was available at the inception of this project. However, farmers often have limited access to these varieties. One way to ensure adequate supply of high quality seeds is to let farmers produce and market the seed.

Over 200 FPVS trials were conducted in 45 locations in Mali, Niger, Nigeria and Senegal. The mother and baby trial design was used as the participatory methodology. A total of 39 varieties were included in the trials. In each country farmers have selected at least one or two new groundnut varieties according to their preferences and seed production schemes were initiated to ensure availability of seed of these varieties. The FPVS process, pathways to adoption of improved varieties, lessons learned and perspectives are presented in a separate paper (Ntare et al. this volume).

Sustainable breeder and foundation seed production

Choosing a variety is only half the story. Equally important, after ensuring that the new variety meets the needs of the farmers or required by the markets, is to ensure that enough breeder/foundation/certified or commercial seed is available for all who want to grow it. In all countries in West Africa, breeder seed production and supply are inconsistent and very limited. Thus the project followed the following steps towards a more sustainable system:

Ensuring the supply of breeder seed. Two revolving fund schemes were experimented in Nigeria and Niger. This scheme is largely successful in Nigeria. Since project inception in 2003, the initial capital provided to IAR is still running and is supplying breeder as well as some foundation costs to users in a cost recovery basis with a small profit.

Defining market and diffusion strategies for reaching the end-user. Studies to assess market demand show that major drivers for seed demand are: (1) farmers' willingness to experiment with new varieties; (2) renewal of seed stocks; (3) eradication of some diseases/pests; and (4) combating insufficient seed stocks. In order to assess farmers' willingness to effectively demand groundnut seed, four seed producers in Kolokani, Mali, were linked to three small village retailers. Two groundnut varieties were available for a total supply of 400 kg. Each farmer was responsible for seed cleaning, conditioning and packaging into three convenient sack sizes: 1, 2 and 5 kg. Seed was sold in the markets of Kolokani, Toriobougou, Nosombougou and Djidjeni. Thus direct links between farmers and small-scale retailers were established. A price margin of 15% was deducted from the sale price. All groundnut seed was sold out only two weeks after the sale commenced, indicating very high demand. In Niger the PEA facilitated the sale of small packs of ground seed in the village of Gaya in the Dosso department. Of 935 seed packets of 0.5 and 1 Kg available, 844 packets were sold out only two weeks after the seed sale was commenced, indicating a very high demand.

Although this scheme is efficient at disseminating seed, one could hypothesize that after farmers have acquired seed of new varieties, they will keep it for a long time before re-entering the market making the seed market inconsistent and not attractive even for small scale seed producers. One important lesson learned is that there is a need for supplying new varieties in a more regular way to sustain the seed market.

Seed health and risks – to meet small farmer needs. Studies have been done to compare seed, the physical health of farmers' saved seed and those of public seed agencies. It was found that farmers' saved seed was of very acceptable quality.

Encouraging small-scale seed enterprises. Efforts have been to help establish small-scale seed enterprises in pilot sites. These efforts have been limited to

providing training at seed production, marketing and small-scale business skills. These schemes were found to be more sustainable in the project as many farmers were keen to become seed entrepreneurs.

Increasing the outlets in reducing seed costs through fostering linkages with other projects (FAO input shops projects). In Niger, there are now about 300 input shops. Some of these input shops are beginning to be used as seed outlets for farmers. In the two pilot sites of the Gaya region, we have encouraged farmers' associations to build their input shops with the support of FAO Projet Intrants. These outlets are serving as seed outlets and also for other inputs such as fertilizers and pesticides. At the same time, the project is fostering the linkage between producers and small-scale retailers.

Building coalitions between actors in the seed supply chain. One major constraint facing producers is that there is no market readily available for their products. As such there are no motivations and incentives to produce more by using modern technologies such as fertilizers and seed. Even when markets are available, farmers have often received low price for their products. Efforts have been initiated to build coalitions between seed producers, grain producers, traders and oil processors in the different countries.

Reducing seed costs. Earlier interventions by publicly funded institutions were operating with high transaction costs that were due to many reasons including management inefficiency and most importantly very few market outlets. Since a large share of the distribution costs was borne by transport coupled with handling and storage costs for legumes that are relatively fragile, efforts to empower community based organizations including farmers' associations and small-scale seed productions in rural communities were emphasized.

Building sustainable seed delivery systems

The private sector has shown little interest in producing seed of crops such as groundnut due to a number of reasons: the low seed variability which deters private investors from keeping seed stocks beyond one year; low genetic deterioration; and weak vertical integration between seed and product market. The local village systems are filling the void created by poor performance of the public sector and low interest from the private sector. Farmers consistently obtain seed from their own harvests, family, friends and relatives, or purchases from local village markets. Village seed systems offer a range of local and diverse varieties that are accessible and are of acceptable physical purity with flexible transactions. In addition, village systems offer cheaper and more efficient way of delivering seed to farmers especially at low transaction costs.

In order to ensure sustainable seed production and delivery schemes, the following measures are necessary: (1) there is a need to ensure a consistent supply of breeder seed through revolving fund schemes in public institutions,

(2) seed production and distribution has to be done close to end-users to significantly reduce transaction costs by empowering community based organizations to engage in seed production; (3) we need to encourage small retailers to engage in seed sales or communities to set up input shops – outlets for their seed and other inputs; (4) we need to train managers of farmers' association or small-scale farmers at marketing and small-business skills, and (5) to link seed producers to savings and loan institutions or commercial banks to improve their access to credit.

Monitoring and evaluation of uptake of modern varieties

A number of varieties have been identified in each country and these have been selected for further testing, demonstration and seed production. Many of these satisfy the requirements of traders and processors. Surveys on early adoption of the varieties in the different locations have been made. Results are presented in Ndjeunga et al. (this volume).

Measures to minimize aflatoxin contamination

Aflatoxin contamination is major problem facing West Africa's groundnut sector; apart from its serious health hazards, it significantly restricts the volume of groundnut exports. This restriction in groundnut exports is particularly serious, because of the European Union's imposition of a new aflatoxin regulation, which is stricter than that suggested by the Codex Alimentarius Commission (Ntare et al. 2005). The potential seriousness of the export-restricting effect of aflatoxin contamination in the groundnut sectors in many African countries has been documented in a number of studies (Otsuki, Wilson and Sewadeh 2001 a & b). The authors quantify the impact of the European Union's new harmonized aflatoxin standard on exports from Africa. For example, a 1 percent lower maximum allowable level of aflatoxin contamination will decrease groundnut trade by 1.3 percent. The study's results suggest that the implementation of the new and more stringent EU aflatoxin standards will impact adversely on African exports of even cereals, dried fruits and nuts to Europe. More specifically, the study suggests that even though the new EU standard would decrease health risk by roughly 1.4 deaths per billion a year, it will result in a $670 million (or 64 percent) reduction in African exports, in contrast to a regulation based on an international standard suggested by Codex guidelines.

Implementing programs to reduce the levels of aflatoxin contamination are likely to generate social benefits. Boakye-Yiadom (2003) used an economic surplus model that incorporates trade as well as domestic production and consumption to assess the potential benefits from research into the aflatoxin-reducing program on high quality edible groundnut exports in Senegal. Various scenarios (from a 30% increased to a 60% increase in high quality groundnut)

of program-effectiveness were examined. The results support that besides enhancing farmers' welfare, the adoption of the aflatoxin-reducing program is expected to yield an overall net-gain ranging between $0.56 million and $4.25 million. This study does not account for benefits accruing from improved health, nutrition and livestock.

Thanks to the availability of a new aflatoxin testing kit, more detailed research on best practices for postharvest handling of groundnut could be undertaken under GSP. Technologies such as tolerant varieties, pre-harvest and postharvest techniques were evaluated/demonstrated in farmer participatory trials. The effects are strikingly clear: groundnuts that are allowed to dry well immediately after harvesting tend to develop negligible levels of contamination, whereas groundnuts left out but covered with haulms and leaves tend to develop alarming levels of aflatoxin contamination. The most effective control was achieved through immediate removal of pods from the harvested plants, but this has labor constraints at the time of the year when other farm activities are at their peak. Farmers who are using the improved methods are producing groundnut with tolerable levels of aflatoxin contamination. In areas where these activities have been implemented, aflatoxin levels have been reduced by 50-90% compared to control plots. Details of this are presented in the paper on farm management of aflatoxin contamination in groundnut in West Africa (Waliyar et al. in this volume).

Efforts made to minimize aflatoxin contamination, though successful are very limited in coverage. The great majority of farmers, processors, traders, policymakers and consumers are still not well sensitized to the aflatoxin problem. The successful technologies need to be scaled-up and the information gap narrowed through intensive sensitization campaigns across the value chain.

Improving skills among farmers and other entrepreneurs

There is a general lack of trained and motivated staff to lead and manage national seed programs. Farmers often lack the necessary skills to maintain varietal purity and produce good quality seed. Small-scale retailers dealing with agricultural inputs including seed often lack business management skills. Thus training all stakeholders in priority skills was an integral part of GSP.

In-country short-term training programs on seed production techniques were organized for extension workers, NGOs, agronomists and breeders. Several training modules were developed for different participants. Training material, manuals and visuals were prepared. On-farm demonstrations and field days were organized for farmers, providing extension advice and creating awareness about new varieties, quality seed and other inputs.

The following was accomplished:

- Over 1000 farmers, extension agents, NGO staff received training on production technologies for increasing crop quality and productivity (eg, seed selection, time of planting, fertilizer use, water management and harvest procedures, methods of drying, sorting, bagging and assembly necessary to meet desired grades and standards); seed production and variety maintenance.
- 100 rural entrepreneurs (25 each from Mali, Niger, Nigeria and Senegal) were offered skills in how to manage small scale business and use market signals such as prices in different markets and quantities. Participants also learned how to prepare simple profit/loss flow statements, and mechanisms to reduce transaction cost.
- 10 socioeconomists from five countries (Burkina Faso, Mali, Niger, Nigeria and Senegal) were exposed to different methods of assessing impact of agricultural technologies.

Methodological and technical guides developed

The PEA developed a number of methodological and technical guides adapted to local situations. These include:

- A monitoring and evaluation system as a project management tool
- A methodological note on assessment of local village seed systems
- A methodological guide on Farmer Participatory Variety Selection (FPVS)
- A business plan for linking producers and processors
- A technical guide on seed production and variety maintenance
- A methodological guide on hand drying procedures
- A technical note on impact assessment
- A note on evaluation of seed production costs
- A training manual on business skills for small scale seed producers

These guides can be accessed on the groundnut seed project website, www.groundnutseedproject.info

Information dissemination

The project activities and accomplishments have been largely disseminated in the region through various pathways including flyers, newsletters, website, technical bulletins/manuals, rural radios and formal publications. Some of the information can be accessed on the project website, http://www.groundnutseedproject.info.

In addition to periodic progress reports, project related information was also disseminated through the following publications.

Refereed journal articles

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Book Chapters

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Edited Books

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Project management, coordination and monitoring

Organization and management

The project agreement was between the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) as the Project Executing Agency (PEA), the Intergovernmental Group on Oilseeds, Oils and Fats (IGG/OOF) of FAO as Supervisory Body (SB) and the Common Fund for Commodities (CFC) as the donor. ICRISAT implemented the project in partnership with the NARS of four countries: in Niger, L'Institut National de Recherche Agronomique du Niger (INRAN); in Mali, L'Institut d'Economie Rurale (IER); in Nigeria, Institute for Agricultural Research (IAR); and in Senegal, L'Institut Sénégalais de Recherches Agricoles (ISRA).

The governance structure consisted of a Regional Coordination Committee (RCC) comprising the PEA, national project coordinators, representatives of FAO and CFC. The committee met annually to review work plans and budgets for all the partners and provided guidance. The overall management of the project was the responsibility of ICRISAT through a project manager. The latter was responsible for overall execution of project activities according to the agreed work plan and budget, maintaining close communication with national coordinators and local partners in each participating country, and sharing information on the execution of project activities, organizing and planning and leading coordination meetings, workshops and preparation of periodic technical and financial reports.

At the national level the project was governed by a National Steering Committee (NSC) comprising stakeholders in each partner country. In each country a national project coordinator (NPC) was in charge of all activities at the pilot sites in the country.

Monitoring and Evaluation

The regional coordination developed a Monitoring and Evaluation (M&E) system as a management tool. An effective M&E system provides the project manager and other stakeholders with management information tools to learn from past experience, improve delivery of project outputs, plan and allocate resources, and demonstrate accountability in the use of project resources. When used creatively during the project cycle, M&E provides an integrated system of reflection and communication that can help to strengthen project design and implementation and stimulate partnership with project stakeholders. A critical initial task in the design of an M&E system was to identify the information needs of stakeholders.

Impacts

Opportunities for building or enhancing sustainable groundnut production and marketing schemes exist. These include the availability of varieties preferred by farmers and/or that meet market requirements, production enhancing technologies, existence of market information systems, existence of farmers trained at seed production techniques, and existence of farmers' groups or associations and models on market development.

Increased adoption of groundnut varieties and management packages will lead to better resource management including soils. Cultivations of improved disease resistant varieties is the most direct and safe method of preventing disease epidemics and avoiding excessive use of pesticides and therefore environmentally friendly.

The major beneficiaries of adopted varieties and management packages are the smallholder farmers. The secondary beneficiaries are the extension workers, NGOs and other stakeholders who have in the course of involvement in the project learned skills and knowledge in the area of groundnut production and utilization. At the national level increased groundnut production will subsequently translate into cash incomes leading to improved standards of the rural poor households.

Groundnut is commonly grown by smallholder farmers including women and often youth who are disadvantaged with regard to access to income generation activities. Successful interventions will contribute to raising incomes of women and the youth. In addition farmer associations were encouraged during the project and could be strengthened to access credit from microfinance institutions.

Adoption of improved groundnut varieties and the appropriate crop management options will increase production thus ensuring food security and rise in household incomes. Groundnut plays an important role in food security through providing energy, protein and vitamins in the predominantly cereal-based diets.

Commodity traders will benefit from the increase in market opportunities to more effectively draw upon facilities and resources, including capital.

Perspectives

The institutions and institutional arrangements that are sustainable and that could deliver seed at an affordable price to end-users should focus on: (1) integrating the input (seed) and the product market by linking all actors in the seed chain, (2) strengthening community based seed systems in producing seed, (3) initiate small-scale private sector initiatives in seed production and (4) developing the product market.

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Country reports

Mali

O Kodio[1]

Introduction

The principal constraints to groundnut production in Mali are the poor rainfall schedules and a number of biotic factors such as diseases and insect pests. In order to overcome these constraints, new varieties in combination with appropriate yield increasing technologies are essential. The development of sustainable groundnut seed systems in West Africa builds on the achievement of the predecessor project – the Groundnut Germplasm Project. In the latter, a number of improved and adapted varieties were identified and needed to be made available to farmers.

The groundnut seed project was implemented with a number of partners including farmers, farmers' associations, local NGOs, national seed services and the ministry of agriculture. Activities were conducted in the region of Kayes (Kita and Kayes districts) and Koulikoro (Kolokani, Sanankoroba and Mande districts).

Approach

The following steps were followed:

- Introduction of new improved varieties
- Farmer participatory variety selection
- Capacity building through training priority skills
- Monitoring and evaluation

Results

Promotion and adoption of improved varieties

At least 40 farmers in each of the districts of the two regions participated in variety selection trials. Two sets of varieties including five drought tolerant and five foliar diseases resistant were evaluated in 2003. Among the drought

[1] Institut d'Economie Rurale (IER), CRRA, Kayes, Mali.

tolerant varieties, Fleur 11, ICGV 86124 and JL 24 were selected based on productivity, early maturity and taste.

For the varieties resistant to foliar diseases, ICG 78, ICG (FDRS) 4, ICG (FDRS) 10 and ICGV 92093 were selected.

Seed production strategies

The principal objective of producing breeder seed is to maintain varietal purity and maintenance in order to satisfy the needs of other organizations in producing adequate quantities of foundation and other classes of seed. Breeder seed was produced by the research institutions (IER and ICRISAT), while other classes of seed were produced by individual farmers as well as farmer organizations. The National Seed Service of Mali is putting in place a financing mechanism to ensure adequate production of foundation seed.

In the second year of the project, farmers started forming village associations to multiply seed of varieties selected. In Kolokani, Kita and Kayes, there emerged four, three and two associations respectively. In the district of Sanankoroba, farmers obtained seed though Winrock International working with local NGOs. Area and amount of on-farm produced seed from 2003-2006 is presented in Table 1.

Table 1. On-farm seed production in pilot sites in Mali 2003-2006.

District	Area (ha)	Production (kg)
Kolokani	51	56
Kita	33	28
Kayes	41	38
Sanankoroba	7	5
Total	**132**	**127**

In all the years the yield were severely affected by either late planting, mid-season drought or early cessation of rains.

Options to minimize aflatoxin contamination

IER and ICRISAT have developed integrated management technologies to minimize aflatoxin contamination. These include both pre- and post-harvest techniques. Pre-harvest techniques include application of lime, crop residues and farm yard manure. These were used singly and in combination. The postharvest techniques involved improved harvesting and drying techniques. These were evaluated on-farm with the participation of farmers in Kolokani (under ICRISAT supervision) and Kayes (IER supervision). Overall 35 farmers participated in these trials. ICRISAT analyzed samples for aflatoxin content

using ELISA techniques. The reduction in aflatoxin content ranged from 50-90% compared to the controls.

Capacity building through training

This was characterized by 1-2 day intensive training workshop, field days, farmer-to-farmer visits and end of season community meetings. Through these mechanisms the various stakeholders exchanged ideas and learnt new techniques. The number of courses and beneficiaries are presented in Table 2.

Table 2. Capacity building through training.

Type of training	Number of participants	Beneficiaries
Crop management and seed production	52	Extension staff
Crop management and seed production	415	Farmers
Small-scale seed enterprise management	25	Rural entrepreneurs
Impact assessment methodologies	2	Agro-economists

Information dissemination

At the local level, project results were disseminated through a number of pathways including printed material, local radios and television. Flyers, technical manuals brochures produced by the regional project coordination unit were widely distributed.

Monitoring and evaluation

This was achieved through regular visits during the crop season, organization of national steering committee meetings.

Conclusions and recommendations

Several varieties that meet farmer requirements have been selected and some of the varieties have been registered in the national variety catalog for wide scale production. Farmers' associations and individual producers have started producing seed for sale within and outside the community. There is a need to complete the impact of improved varieties and seed dissemination pathways. There is also a need to extend these activities to other regions of Mali such as Sikasso, Segou and Mopti.

Simple techniques to minimize aflatoxin contamination have showed a significant reduction in aflatoxin contamination at the production level. Unfortunately most actors are still not aware of the effects of aflatoxin contamination on groundnut trade and more importantly on human health.

Interventions need to be extended widely and stakeholders sensitized about the aflatoxin problem in groundnut.

For a sustainable seed production and supply system, there is a need to establish and strengthen linkages between the various actors along the value chain. The role of the public sector remains essential in the development, conservation and supply of breeder and foundation seed of improved varieties. What is needed is an enabling environment favorable for the success of community based seed systems for groundnut.

Niger

I Kapran[2]

Introduction

Groundnut is an important cash and food crop in Niger. It is produced mainly in the departments of Dosso, Maradi and Zinda. About 90% of groundnut requirement in Niger is imported. Groundnut production peaked in 1966/67 period but has since declined drastically partly due to frequent droughts and other biotic stresses. The area covered by groundnut has remained static but yields have declined from an average 663 kg/ha in 1970 to 337 kg/ha in 1990. The crop is generally grown intercropped with cereals (sorghum and millet) but monocrop fields are also common.

Production constraints and solutions

The principal constraints include:

- Low and poorly distributed rainfall
- Low yields
- Lack of organized markets
- Stiff competition from imported vegetable oil
- Poor seed quality
- Lack of human resources
- Use of obsolete varieties

Solutions to the above constraints include:

- Promotion of modern varieties
- Capacity building through training

[2] Institut National de Recherche Agronomique du Niger (INRAN), Niamey, Niger.

- Producing seed in secure environments (reliable rainfall and/or under irrigation during the dry season
- Quality control along the value chain

Accomplishments

1. Promotion of varieties
2. Development of sustainable community based seed production systems

This activity was achieved through farmer participatory variety selection, assessment of varieties for oil content and quality, evaluation of the cost of production of groundnut seed and socioeconomic characterization of groundnut seed production. These activities were conducted in partnership with decentralized public sector institutions such as regional agriculture departments and extension services. The number of tests and varieties in each region are presented in Table 1.

Table 1. Number of FPVS trails and varieties tested between 2003 and 2005.

Department	No. of tests	No of new varieties
Dosso	85	12
Maradi	21	5
Zinder	18	4
Total	124	21

The mean yield of the varieties tested were 854 kg/ha in Dosso, 571 kg/ha in Maradi and 481 kg/ha compared to the current national average of 337 kg/ha.

The varieties selected by region are presented in Table 2. These have been recommended for wide scale seed multiplication in the respective regions.

Table 2. Varieties selected in the variations regions.

Region	Variety selected
Dosso	RRB and 55-437
Maradi	JL 24 and RRB
Zinder	T181-83, T169-83 and 55-437

Foundation seed production

This was achieved through a number of contractual arrangements between INRAN's seed unit and farmer organizations. The seed unit produced a total of 15.3 t between 2003 and 2006, which was sold to groundnut growers.

Evaluation of the cost of seed production

This exercise revealed that it was profitable to produce seed at a more secure location under rainfed conditions such as Bangou compared to less secure locations such as Maradi, where the crop is prone to drought stress.

Evaluation for oil content and quality

Results from samples taken from the different participatory trials indicated that the oil content and quality was acceptable. Oil content was the most important criterion for accepting a variety.

Capacity building through training

A total of 210 participants including health workers, farmers, development agencies, journalists and seed service personnel received training in aflatoxin management techniques, seed production and small-scale seed business management.

Lessons learned

1. There has been increased interest in groundnut production motivated by:
    - Producers becoming more interested in contractual arrangements and micro-credit facilities such as warrantage,
    - A strong demand for high quality seed by private entrepreneurs,
    - Participatory evaluation selection of modern varieties, and
    - Increased awareness about aflatoxin contamination.
2. Sustainability is likely to be assured through:
    - Specialized farmer organizations such as Kalgo, Gidan Gab and Gabi,
    - A network of seed multiplication centers supported by other projects such as IFDC, FAO and PPILDA.
3. The foundation seed unit of INRAN is playing a catalytic role by:
    - Guaranteeing a continuous supply of foundation seed,
    - Initiating public-private partnership,
    - Linking producers to seed markets involving contractual arrangements, rebuying seed and re-orienting it to seed buyers such as APPILDA and FAO.
4. The private sector is crucial but faces a number of constraints:
    - Oil processing still largely artisan,
    - The two modern oil processing companies currently existing are faced with stiff competition from all kinds of imported vegetable oils,

- The few small-scale seed companies such as MANOMA have shown limited interest in getting involved with buying and selling groundnut seed.

5. There is a need for a national forum comprising the various actors to develop an efficient national groundnut seed sector in partnership with development projects, agro dealers and processors.

Nigeria

A Echekwu[3]

Farmer Participatory Variety Selection trials

- Farmer-managed, farmer-implemented trials were undertaken in farming communities in pilot areas to evaluate variety performance under typical crop management conditions.
- A total of 69 farmer managed trials and 15 demonstrations were conducted at the three pilot areas of Kaduna, Kano and Katsina states between 2003 and 2004 cropping seasons.
- After two years, these activities were scaled-up to two other states of Jigawa and Zamfara involving 60 more farmer-managed trials and eight demonstrations.
- Field visits and field days were organized and used not only to provide extension to the participants, but also to provide training in pre-harvest crop management.
- The three newly released varieties – SAMNUT 21, SAMNUT 22 and SUMNUT 23 were selected by farmers in all the pilot sites.

Breeder and Foundation seed production

- During the project period, breeder and foundation seed production was vigorously pursued on-station at Samaru.
- A total of 5 tons of breeder and 25 tons of foundation seed was produced.
- A major part of the foundation seed was used for the FPVS and demonstrations at the pilot sites.
- Part of the seed was sold and the proceeds were used to open a revolving account for breeder seed production in IAR. This account is still operational.

[3] Institute for Agricultural Research (IAR), Samaru, PNB 1044, Zaria, Nigeria.

Community-based seed supply: Accomplishments

- In 2005, two large demonstration plots of 1.0 hectare each were established in Kano, Katsina and Kaduna pilot sites.
- The purpose was to help communities produce their own seed, with proper quality control.
- Informal training of farmers in pre-harvest crop management took place during field monitoring.
- The produce from these demonstration trials was to serve as seed capital for the benefiting communities.
- In 2006, ten seed farms involving ten farmer groups with a combined membership of 174 participants and covering an area of 17 hectares were established across the five pilot areas of Kaduna, Kano, Katsina, Jigawa and Zamfara states.
- A total of 9 tons of seed of the three varieties were produced and are being retained by the farmer groups, most of whom have indicated their desire to take up groundnut seed production as a venture.

Testing of market for seed

- Seed sale at community level was pilot-tested using small seed packets and the retail outlets of the state Agricultural Development Authorities (ADAs) in the three pilot areas.
- Packaging was done using plastic and baft materials in units of 1, 2, 5 and 10 kgs.
- There was a high demand for seed of the three varieties earlier selected by the farmers.
- All seed stocks were cleared within two weeks of introduction to farmers in all pilot areas.
- There was a preference for small packs of 1 and 2 kg.
- In the matter of packaging, farmers preferred baft to plastic.

Minimizing risks from aflatoxin contamination

Improved harvesting techniques

Aflatoxin contamination of groundnut is a major hazard to human and animal health and is one of the most important constraints to groundnut trade. In 2004 and 2005, trials were established at six locations to demonstrate management practices that minimize aflatoxin contamination in groundnut.

The improved practices which involved lifting the groundnut at the right stage of maturity, placing them in an inverted position to expose the pods to sunlight and then picking after 5-7 days was compared with the farmers practice of lifting the plants and leaving them on the windrow to dry, then picking the pods 5-7 days later.

Aflatoxin levels were reduced by the improved practice to < 20 parts per billion (ppb).

Raising public awareness on aflatoxin contamination

Interactions with farmers and extension staff during field visits to demonstration trials were used to raise public awareness on aflatoxin contamination. GSP also participated in discussions on the aflatoxin challenge during a one-day pre-summit workshop of the Groundnut Rediscovery Summit in September, 2005, which was attended by over 200 participants from both state and local governments of the main groundnut growing states in Nigeria.

Improving skills among farmers and other entrepreneurs

The objective of this component was to impart to farmers the necessary skills needed to maintain varietal purity and produce good quality seed.

Seed production techniques

- A two-day training workshop on groundnut seed production and variety maintenance was organized at IAR in December 2003. Twenty participants drawn from farmer organizations, NGOs, agro-input dealers and oil millers attended the workshop.
- On-farm demonstrations (2003-2006) and field days (2003 and 2004) were organized for farmers, providing extension advice and creating awareness about new varieties, quality seed and other inputs. More than 500 farmers benefited from this exposure.

Marketing and business management

- Small-scale retailers dealing with seed and other inputs often lack business management skills. A three-day training workshop in marketing and small seed business management was conducted at Samaru in 2005 for small seed business entrepreneurs.
- The 28 participants who attended the workshop were offered skills in how to manage a small-scale business and use market signals such as prices in different markets and quantities. Participants were also taught on how to prepare simple profit/loss and cash flow statements, and mechanisms to reduce transaction costs.

Information dissemination

- This was done mostly through technical reports/flyers, print media and farmer-to-farmer visits.
- Some specific project activities resulted in the production of technical documents.
- Two proceedings of training workshops were published as manuals.
- Six 'Groundnut Booster' and two 'Field Day' series were produced as fliers and widely circulated.
- A training module on postharvest crop management was produced as a flyer and widely distributed.

Lessons learned

Development lessons

- The participatory mode of operation that was used in this project has improved the participation of all collaborators.
- Farmers are highly motivated by new varieties and by being directly involved in variety selection and seed production which has led to the increased acceptance of the new varieties in Nigeria.

Operational lessons

- There is increased awareness among farmers and other entrepreneurs in matters relating to seed.
- Individual farmers and community-based associations, especially women's groups, can produce good quality seed if offered training and assured of markets for their seed.

- Sharing knowledge and information is very important to dissemination of project results and new technology. Empowering the rural farmer and reinforcing farmer groups/associations through training and increased access to information needs to be emphasized for scaling up the success from this project for greater impact.
- Simple techniques to manage and reduce aflatoxin contamination are effective and acceptable to farmers. This should contribute to improved quality of groundnut and its products.

Senegal

A Da Sylva[4] and O Ndoye[5]

The project was executed in the major groundnut growing regions of Senegal, commonly known as the groundnut basin, which includes the regions of Thies, Dioubel and Kaolack.

Promotion of improved groundnut varieties

Farmer participatory variety selection

During the first two years of the project (2003 and 2004), two types of trials were conducted. The first involved PVS and the second involved on-farm demonstrations. Because of the desire to find a solution to pre-harvest sprouting of the short duration varieties (Fleur 11 and 55-437), emphasis was put on the search for new varieties that have limited fresh seed dormancy. Ten such breeding lines were evaluated at seven site in 2004. This resulted in the identification of seven that met the criteria. These lines had a fresh seed dominancy ranging from 15-30 days and were also appreciated by farmers. Their yield was also more or equal to existing varieties that lack seed dormancy. The selected varieties are being evaluated in different zones to determine their zone of adaptation, followed by release and inclusion in the national variety catalog.

Farmer participatory demonstrations

A total of 27 demonstrations were established in 8 sites across the groundnut basin of Senegal. In the north and central regions, early maturing varieties were evaluated while the medium-to-late-maturity were evaluated in the central and southern zones. From these demonstrations, 55-437, Fleur 11 and ICGV

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[5] Institute Senegalais de Recherche Agricole (ISRA), CNRA-Bambey, Senegal.

86124 were selected for earliness in the northern zone; 73-73, PC 79-79 and ICGV 89063 were selected for the central zone while GH 119-20 and H75-O were selected for edible groundnut characteristics.

Breeder and foundation seed production

This activity focused on released and pre-release varieties. The released varieties were 55-437, Fleur 11, Early Sefa, 73-73 and GC8-35. Amounts ranging from 75 to 290 kg of seed was produced. The pre-release varieties were ICGV 86124, ICGV 89063, PC 79-79, 78-936, 55-33, SRV1-19, 73-9-11 and H 75-O. Small quantities ranging from 15-70 kg were produced. Overall quantities produced during the project period are presented in Table 1.

Table 1. Breeder and foundation seed produced in Senegal 2003-2006.

Seed type/year	2003	2004	2005	2006
Breeder (kgs)	708	**	638	1253
Foundation (kgs)	*	**	2627	6250

* No foundation seed was produced.
** Locust invasion destroyed the entire crop in Senegal.

Characterization of seed systems in Senegal

Results from this study showed that there were seven varieties being grown in Senegal before the groundnut seed project began, but all except Fleur 11 released in 1988 were developed more than 40 years ago. The study also revealed that the common method of seed conservation was in sacks and phostoxin was often used to control insect pests. The study also revealed that the main sources of seed were: village selection (30%), personal reserves (29%), weekly markets (16%) and the state-owned groundnut enterprise, the Société nationale de commercialisation des oléagineux du Sénégal (SONACOS) (25%).
The major constraints identified were:

- Lack of good quality seed
- Lack of storage infrastructure
- High cost of seed
- High interest on credit for inputs
- Scattered supply centers

Proposed solutions are:

- Improve seed quality
- Provide technical assistance in seed production
- Reduce intermediaries in seed trade
- Increase seed stocks of acceptable quality

- Create village seed banks
- Centralize sale of certified seed

Monitoring of market prices revealed that seed process ranged from 220-450 FCFA depending on the variety. The costs of seed production was found to be high when all fixed and variable costs are considered. This necessitates subsidy from the government.

Technologies to minimize aflatoxin contamination

On-farm demonstrations of improved methods of drying and threshing and the use of lime were conducted at two locations. These treatments resulted in improved pod and seed quality that fetched a premium price. Producers were sensitized to the effects of aflatoxin contamination on groundnut trade and human health.

Capacity building through training

Group discussions at the village level were the main method of imparting knowledge to groundnut farmers on various aspects of groundnut production and trade. On the whole, 240 persons benefited from such discussions. One or two-day workshops were also organized for a limited number of actors and in all 80 participants benefited.

Conclusion

The project has produced positive results which are being applied by the Association de production de base (ASPRODEB) du Senegal. This association has the objective of linking processors, grain and seed producers and research in order to have a sustainable groundnut seed sector in Senegal through contractual arrangements among the various actors. In addition to production, emphasis will be on wide campaign on the effects aflatoxin contamination.

Discussion

Session II: Project implementation and results

Rapporteur: Ousmane Ndoye

The presentations revealed that the project had attained its objectives of promoting improved groundnut varieties through farmer participatory variety selection with impressive early adoption rates, demonstrating integrated management technologies to minimize aflatoxin contamination. Also, small-scale farmers were empowered to produce quality seed at the community

level, there was skill enhancement in seed production techniques and small-scale seed business management, and greater awareness was created about the dangers of aflatoxin contamination. The project has provided critical information on constraints and ways to improve market efficiency as well as monitoring changes resulting from policies or institutions build up by policymakers and development partners.

The results of the project have been disseminated through various pathways including print and electronic media, books and scientific papers and a website.

The key issues arising from the discussion are:

- How to sustain the achievements in the respective countries,
- How to strengthen linkages between the various actors along the value chain (farmers, seed producers, industrialists, and processors), and
- How to sensitize farmers and policymakers on the aflatoxin problem.

Session III:
Technical papers

Farmer Participatory Evaluation and dissemination of improved groundnut varieties in West Africa

BR Ntare[1], J Ndjeunga[2], F Waliyar[3], O Kodio[4], CA Echekwu[5], I Kapran[6], A Da Sylva[7], AT Diallo[8], HY Bissala[9] and K Sako[10]

Abstract

Farmer participatory variety selection (FPVS) trials were conducted in pilot sites of the Groundnut Seed Project (GSP) using a mother and baby trial design. Thirty-nine improved varieties (released and pre-released) from ICRISAT and National Agricultural Research and Extension Systems (NARES) partners were evaluated in over 200 FPVS on-farm trials in 45 locations in Mali, Niger, Nigeria and Senegal. The objectives were to identify farmers' preferred traits and varieties and test a range of seed multiplication and delivery schemes. The farmers evaluated the different varieties under their own management practices and resources.

Preferred traits included: early maturity, high pod and fodder yield, resistance to diseases, seed color, taste, oil content, tolerance to drought and marketability. Preference often differed among the sites, which reflected differences in agro-ecological zones. In each location farmers selected at least two improved groundnut varieties based on some of these traits. Overall five varieties (Waliyartiga [ICG 7878], Fleur 11, JL 24, ICG [FDRS] 4 and Mossitiga) were selected in Mali; four (ICG 9346, RRB, J11 and T 81-73) in Niger; three (SAMNUT 21, SAMNUT 22 and SAMNUT 23) in Nigeria and five (ICGV 86124, ICGV 89063, PC 79-79, H 75-O and 55-33) in Senegal. Industrial testing showed that the varieties had oil content above the local check 47-10 in Mali and 55-437 in Niger.

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After two years of evaluations, more than 30 farmers' associations and small-scale seed producers were involved in seed production and distribution. More than 150 tons of seed of different classes that could cover 100,000 hectares were produced. About 74% of the farmers in pilot areas are using modern varieties, and about 67% of the groundnut area is planted with them. In locations where FPVS was limited to providing only seed for experimentation without ensuring seed supply such as in Mande and Dioila in Mali, the proportion of the area covered with improved groundnuts was low (28%), whereas in locations where FPVS was implemented in conjunction with setting up institutions and institutional arrangements to supply seed to farmers (such as in Kolokani, Mali), the uptake in areas around the pilot sites was estimated at 83%.

Introduction

Over the last 25 years, a range of varieties has been developed, tested and adapted in West and Central Africa. Thirty-nine were found adapted according to Mayeux et al. (2003). However, resource-poor farmers seldom have access to such new varieties that may improve their livelihoods. Many farmers still grow old varieties and hence fail to benefit from the most modern products of crop improvement. One of the reasons for low adoption of new varieties is that farmers have little exposure to new varieties, or the varieties do not satisfy their preferences and needs. Thus, farmers need to test a range of varieties under their own conditions, resource levels and environment in order to select the ones they prefer. Farmers' participation in technology generation and selection as drivers to adoption are well documented (Ashby 1991; Sperling et al. 1993). FPVS has shown successes in identifying varieties preferred by farmers, and accelerated their dissemination (Joshi and Witcombe 1996; Witcombe et al. 1996; Mulatu and Belete 2001; Mulatu and Zelleke 2002).

The demand for varieties by farmers and oil processing industries is a result of plant, seed and other desirable traits that are embodied in the varieties. Knowledge of the range of plant, seed and processing traits are valuable for crop improvement programs and good market signals for processors (Ndjeunga et al. 2003). The demand for improved groundnut varieties will increase if varieties are designed to include producer and consumer preferred traits. Therefore, improving the performance of varieties accounting for all significant traits will contribute to the productivity and profitability of groundnut.

Choosing a variety is only half the story. Equally important is to ensure that seed of preferred varieties is accessible, and affordable to end-users. However, in West Africa, the constraints limiting the performance of seed supply systems remain the lack of awareness among farmers about new varieties, poor functional seed and product markets, limited access to seed of new varieties, limited

supply of breeder/foundation/certified and commercial seed (Ndjeunga et al. 2006).

The objectives of the present study were: 1) to identify farmers' preferred traits and varieties through FPVS and 2) to test a range of seed multiplication and delivery schemes. This paper is organized as follows: Section 2 describes the context and production environment, Section 3 deals with methodology, Section 4 outlines the results and discussion and Section 5 supplies conclusions and lessons learned.

The context

In 1998, under a predecessor project, the Groundnut Germplasm Project (GGP) supported by the Common Fund for Commodities (CFC), ICRISAT and partners coordinated a network of regional variety trials in 13 countries of West Africa to enable NARS have access to a diverse range of improved varieties and to select those adapted to a range of agroecologies. A total of 92 varieties with various economic traits such as resistance to foliar diseases and groundnut rosette, tolerance to aflatoxin contamination, tolerance to drought, having confectionery traits, and yield potential, were included in these trials. After four years of testing, 39 new adapted varieties were identified. A regional variety map was developed, based on agro-climatic criteria and results from the performance analysis of these new varieties, to facilitate easier choice of varieties and regional exchange. A bilingual variety catalogue describing the new varieties and zones of adaptation was published (Mayeux et al. 2003).

In addition to the variety trials, FPVS on-farm trials were initiated in Mali and Niger. In Mali these were conducted in the districts of Kolokani, Dioila, Mande and Janankoroba. Those in Kolokani started in 1998 and by 2002, nine varieties were evaluated by 166 farmers in 46 villages using a combination of the mother and baby trial designs. The number of farmers and varieties varied from year to year and/or according to the set of varieties tested. The major characteristics of the varieties were resistance to cercospora leaf spots, short to medium-maturity, medium-size pods and grains. Their yield potential ranged from 1-2 t/ha of pod and 2.5-4.0 t/ha of haulms (above ground dry matter). Haulms are important for livestock feed during the dry season.

Among the varieties evaluated in Kolokani, ICG 7878 (renamed Waliyar tiga) was the most resistant to foliar diseases and produced the highest haulm yields (Table 1). ICGV 92093 and ICGV 92088 were also resistant to early leaf spot but had lower pod yield than the local check. The low haulm yield of Mossitiga and 47-10 are largely due to their susceptibility to early leaf spot which results in defoliation, thus reducing the above-ground biomass.

Table 1. Late leaf spot (LLS) severity and yield of selected varieties in on-farm trials in Kolokani (averaged over 53 trials).

Cultivars	% LLS	% Defoliation	Yield t/ha	
			Pod	Fodder
ICGV 92088	17	13	1.06	1.61
ICGV 92093	22	18	1.23	1.80
ICG 7878	8	3	1.71	2.61
ICG (FDRS) 4	26	22	1.43	1.81
Mossitiga	56	52	1.97	0.69
47-10 (Local)	49	44	1.52	0.67
SE	2.6	2.66	0.081	0.076
CV (%)	38	46	24	23

In 1999, ICRISAT made available seed of a set of nine varieties to Winrock International, an international NGO working through a network of local NGOs in Mali. The main characteristics of these varieties were similar to those tested in Kolokani. Trials/demonstrations were established in 15 villages in the districts of Janankoroba and Segou in Mali. After the first year, selected varieties were put in larger multiplication plots of 500 sq m involving 23 farmers, the majority of whom were women.

From these trials and demonstrations, two varieties, ICG (FDRS) 4 and ICG (FDRS) 10 were selected by most farmers. The yield of these two varieties compared to the local variety is presented in Table 2. These varieties have comparable pod yield as the local variety with the added advantage of earliness (about three weeks earlier than the local) and resistance to foliar diseases.

Table 2. Yield performance (kg/ha) of selected varieties in the NGO supervised trials.

Variety	Number of farmers	Range	Mean
ICG (FDRS) 4	22	350-1450	782
ICG (FDRS) 10	20	200-1350	729
Local (28-206)	22	360-1400	760

Source: Winrock International Annual Reports.

In the 2000 crop season, five female farmers each from the districts of Mande and Dioila visited ICRISAT research station and selected three varieties (ICGV 86124, Fleur 11 and JL 24) from a demonstration plot. After harvest each farmer was given 1 kg each of the three varieties. They were told to grow the new varieties along with their own variety using their management practices

and resource base. Other than occasional visits during the cropping season, no technical support was given to the farmers. After the first year of testing, farmers started exchanging small quantities of seed of the preferred variety. By 2003, 75 farmers had access to seed of the new varieties.

In Niger, 70 farmers from the villages of Bengou, Koita Tegui and Kouara Zeno near the research station of the Institut National de Recherche Agronomique du Niger (INRAN) at Bengou in Gaya, visited a large nursery of groundnut germplasm established by ICRISAT for characterization in 2000 crop season. Fascinated by the diversity of the varieties, farmers were eager to test some of them on their farms. Based on their observations and information given by ICRISAT technicians, the farmers selected 52 varieties. After harvest, each farmer was given one kilogram seed of the selected variety. In 2001, the farmers collectively grew the varieties on a 2-ha plot provided by the village chief of Bengou. ICRISAT technicians demonstrated to the farmers on how to sow in lines and taught farmers pre-and postharvest crop management. Each variety was grown in a 10 x 10 m plot. The farmers carried out all field operations (land preparation, planting, weeding and harvesting). The Programme d Appui au Développement Local (PADEL), a Swiss-funded development project in Gaya, supported three field days: 45 days after planting to assess plant vigor, at harvest to assess yield and the third one during oil extraction to assess oil and cake yields. More than 150 women and men attended each of the field days. Twenty varieties were selected based on productivity.

Women with 20 years of experience in groundnut oil processing conducted the assessment of the selected varieties for oil and cake yields using traditional methods. From this assessment five varieties (ICGV 86124, 55-437, ICG 9346, ICG 9199 and ICG 7299) were selected. The average pod yield of these varieties ranged from 1.5 to 2.9 t/ha. The oil yield ranged from 218 to 287 g/kg, while cake yields ranged from 648 to 713 g/kg.

Methodology

Pilot sites

The Groundnut Seed Project (GSP) launched in 2003 was designed to promote groundnut varieties found adapted during the Groundnut Germplasm Project (GGP) through sustainable seed systems. Thus, FPVS on-farm trials were extended to pilot sites in other major groundnut growing regions of Mali, Niger, Nigeria and Senegal (Fig. 1). The sites span a range of socioeconomic and demographic settings and are representative of agro-ecologies suitable for groundnut production, ie, the Sudan-Sahelian zone with 400-700 mm rainfall, the Sudan savanna zone (700-1000 mm) and the northern Guinean zone (1200-

1500 mm). In Mali, the trials were extended to Kita and Kayes districts. In Niger, the pilot sites were in the departments of Dosso, Maradi and Zinder. In Nigeria, trials were set up in Kaduna, Kano and Kastina states, while in Senegal the trials were established in the northern, middle and southern regions of the groundnut basin.

Participatory variety evaluation

The trial designs

The mother and baby trial design was used as the main participatory tool in the evaluation and selection of varieties**.** These are single-replicate designs used to assess the relative performance of varieties. In mother trials many entries are grown together in the same field. The trials are researcher-designed but farmer-managed, and they are replicated across villages. They not only serve as demonstration plots or focal points for discussion but are also specifically designed to provide quantitative analyzable data on yield (Snapp 2002) and farmers' preference for traits embodied in the varieties.

In the baby trials, only farmers' perceptions on yield is collected. A farmer grows 1 to 3 new varieties along with the local variety under traditional management practices. Replication is across farmers, either in the same village or across villages. The varieties tested in the four countries are presented in Table 3. In 2003 crop season, 144 FPVS trials were established in 45 locations across the four countries. In 2004, the trials were increased to over 200.

Table 3. Varieties and attributes of varieties in the FPVS on-farm trials in Mali, Niger, Nigeria and Senegal (2003-2004).

Mali	Niger	Nigeria	Senegal
Released			
ICG (FDRS) 4	TS 32-1	SAMNUT 21	GH 119-20
ICG (FDRS) 10	RRB	SAMNUT 22	55-21
ICG 7878	796	SAMNUT 23	73-33
JL 24	55-437		
Mossitiga			
47-10			
Pre-release			
Fleur 11	ICG 9346		ICGV 89063
ICGV 86024	ICGV 96894		ICGV 86124
ICGV 86015	ICGV 86124		ICGV 89112
ICGV 86124	Fleur 11		ICGV 97065
ICGV 92093	T 169-83		ICGV 94222
ICGV 92088	T 177-83		H75-O
ICGV 97188	T 181-83		PC 79-79
	J 11		55-33
Attributes			
Resistance to foliar diseases and tolerance to drought	Early maturity and high oil content	Resistance to groundnut rosette disease	Drought tolerance, early maturity and limited fresh seed dormancy, confectionary types
Total: 13	**12**	**3**	**11**

Variety preference assessment

Plant and grain characteristics: In most locations, a simple and median ranking by the farmers based on their criteria were used. At harvest, farmers' perceptions were monitored for few traits such as crop cycle, pod yield and other traits of interest.

In the Dosso region of Niger, the mother trials were located on central or visible locations in the villages of Kara Kara, Sia and Sambera. Trials were set

up in a randomized complete block design of five varieties and five replications. Plot size for each variety was 10 x 10 m per replication. The trials were implemented collectively by farmers selected by the village chief or farmers' associations. During the vegetative cycle, two assessments were carried out with farmers at flowering and another at the harvesting period. At harvest a preference survey was conducted involving 25 farmers.

The development of a survey instrument for data collection involved a number of steps. The available literature was reviewed to develop a list of important groundnut plant and seed characteristics for potential inclusion in the questionnaire. Germination, plant type, disease resistance, flowering, shape of leaves, maturity, pod and haulm yields, pod filling sizes of pod, seed, color were often cited as important plant and seed characteristics. Based on potential characteristics likely to explain choice for varieties, a participatory rural appraisal (PRA) was held with groundnut producers in the three villages in order to evaluate alternative question formats, contents and elicit general advice from consumers for different traits. The last stage in the process involved the development of the survey instrument. Only characteristics that were ranked high via the focus-group meetings were included in the questionnaire. Accordingly, 16 plant and seed characteristics were included (Table 4). Respondents evaluated the five groundnut varieties using a five-point preference scale (0 being the least preferred and 4 being the most preferred) using the 16 criteria.

Oil content: In all the project countries, groundnut is used for oil extraction and varieties with high yield and oil content are sought by both village level and industrial vegetable oil processors. In Mali, 12 varieties introduced to farmers were assessed for oil content by the Huicoma Group Tomta–Mali, which processes cotton oil. In Niger, the analyses were conducted in the laboratory on samples of the varieties tested by the farmers in the different villages in the three regions.

Building seed supply and delivery systems

After varieties that are preferred by farmers or required by the market have been selected, access to seed becomes a major constraint to uptake. Thus, a range of institutions and institutional arrangements were tested to identify the best strategies involved in seed production and delivery to ensure a sustainable supply of high quality seed at affordable prices.

Breeder and foundation seed: The production of breeder and foundation seed is the responsibility of NARS. Technical support was provided to NARS to produce breeder and foundation seed stocks of the preferred varieties that can be used by farmers' associations, and small-scale seed producers to bulk into commercially seed stocks. A revolving fund scheme for these classes of seed was tested.

C*ommunity-based seed production and supply:* The aim was to help communities produce their own seed of acceptable quality and at affordable prices. This scheme essentially involved farmers' association and/or organizations and emerging small-scale private seed growers. Farmers were trained in crop management and seed production techniques, in marketing and small-scale business management.

Promotion of improved seed through the sale of small seed packs: The project pilot-tested the sale of small seed packets (1-5 kg) to respond to the need for farmers to experiment small quantities of seed, to uncover the size of the demand and identify the types of packaging, standard and norms that best suit end-users.

Enhancing linkages between producers, processors and other stakeholders along the value chain: This involved facilitating dialogue between the various actors along the value chain through groups meetings in the various location and/or national forums and workshops. This was stimulated by the need to establish trust and reputation among actors and favor contractual arrangements that could arise in order to ensure ready markets for products demanded and stimulate uptake of improved technologies and innovations.

Assessing the performance of FPVS pathways

Baseline surveys were carried out in pilot sites in 2003 to assess households' resource endowments (natural, physical, human, economic and financial capital and social capital) at project inception. In addition, the seed supply schemes were assessed. At the end of the project in 2007, a survey was carried out to assess the level of uptake of varieties through the different alternative arrangements.

Pilot sites were randomly selected. Within pilot sites, farmer participants in the FPVS trials were randomly selected and non-participants were selected using a list of households provided by the chief of villages or developed by enumerators. Control sites were considered in neighboring villages where the project did not intervene.

Information was collected on farmers' socioeconomic profile (age, gender, education and family size); the institutional and infrastructural environment (access and availability of seed of preferred varieties and markets), technological constraints, plant type, cycle, seed size and color, utilization (oil, edible, confectionary, fodder for livestock) and resistance to foliar diseases were hypothesized to be the main constraints to uptake of modern groundnut varieties and factors explaining farmers' variety preferences. A simple system of mean and median ranking was used to assess farmers' preference for varieties.

Table 4. Comparison of the five groundnut varieties for plant and seed attributes in Dosso, Niger.

			VARIETY					
					FLEUR			Pearson Chi-square (df) P
Attribute	55437		9346	96894	11	RRB	**Total**	value
Germination	0	1		17	7		25	80.12 (8) ***
	1	12	9	14	30	15	80	
	2	37	41	19	13	35	145	
Plant type	0	2		8	9	1	20	27.53 (8) ***
	1	7	2	5	8	11	33	
	2	41	48	37	33	38	197	
Resistance to	0	6	3	15	7	3	34	31.11 (8)
diseases	1	6	1	11	6	11	35	****
	2	38	46	24	37	36	181	
Flowering	0	1	2	1	2	1	7	10.13 (8)
	1	5	2	8	9	2	26	
	2	44	46	41	39	47	217	
Leaves	0			2	2	1	5	14.06 (8) *
	1	3	1	7	9	4	24	
	2	47	49	41	39	45	221	
Maturity	0			10	3		13	66.86 (8) ***
cycle)	1	7	1	19	9	3	39	
	2	43	49	21	38	47	198	
Number of	1	2		5	2	2	11	18.07 (8)***
pods	2	14	9	15	24	16	78	
	3	34	41	30	24	32	161	
Pod yield	1	2		23	3	1	29	88.68 (8) ***
	2	11	9	15	18	5	58	
	3	37	41	12	29	44	163	
Haulm yield	1	4		5	2	2	13	19. 22 (8) **
	2	8	5	17	9	7	46	
	3	38	45	28	39	41	191	
Large pods	0			1			1	20.75 (8) ***
	1	9		2	1	5	17	
	2	41	50	47	49	45	232	
Pod filling	0			19	1		20	90.21 (8) ***
	2	14	5	15	12	10	56	
	3	36	45	16	37	40	174	
Beak	0			10			10	47.16 (8) ***
	2	11	4	10	10	8	43	
	3	39	46	30	40	42	197	
Pod	0			3			3	16.74 (8) **
constriction	2	7	5	11	8	5	36	
	3	43	45	36	42	45	211	

Table 4. cont'd. Comparison of the five groundnut varieties for plant and seed attributes in Dosso, Niger.

Attribute		VARIETY 55437	9346	96894	FLEUR 11	RRB	Total	Pearson Chi-square (df) P value
Reticulation	0	1		17			18	78.84 (8) **
	2	4	5	11	12	7	39	
	3	45	45	22	38	43	193	
Large seed	0			4	1		5	21.99 (8) ***
	1	7		2	2	4	15	
	2	43	50	44	47	46	230	
Seed color	0	3	1	3	2	1	10	2.08 (4)
	1	47	49	47	48	49	240	
Rank	1	3	15	24	6	4	52	92.55 (16)
		6.0%	30.0%	48.0%	12.0%	8.0%	20.8%	***
	2	8	1	10	22	8	49	
		16.0%	2.0%	20.0%	44.0%	16.0%	19.6%	
	3	17	13	2	9	8	49	
		34.0%	26.0%	4.0%	18.0%	16.0%	19.6%	
	4	15	8	1	9	19	52	
		30.0%	16.0%	2.0%	18.0%	38.0%	20.8%	
	5	7	13	13	4	11	48	
		14.0%	26.0%	26.0%	8.0%	22.0%	19.2%	
Median ranking		3.30	3.06	2.38	2.66	3.50		
Average ranking		2	3	5	4	1		
Total		50	50	50	50	50	250	
		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	

Results and Discussions

Farmer Participatory Variety Selection

Mali

In Kolokani district, the most preferred traits cited by farmers were higher pod and haulm yield, large seed size, taste, and drought tolerance (Table 5). In particular, Mossitiga was well rated because of its high drought tolerance, early maturity and high yield compared to the local variety. Similarly, ICG (FDRS) 4 was preferred for the same reasons, but to a lesser degree. ICG 7878 was chosen for its high haulm yield, large pods and sweet taste. However, it was rated low for drought tolerance and pod yield. This variety is a medium-maturing (115-120 days) and yield can be severely affected if rains end early as is often the case in Kolokani.

Table 5. Ranking* of the four most preferred groundnut varieties by traits against the local check in Kolokani, 2003.

	Variety name				
Trait	ICG (FDRS) 4	ICG 7878	ICGV 92093	Mossitiga	Local
Higher haulm yield	2	1	3	4	4
High pod yield	3	4	5	1	2
Large seed size	2	1	3	4	4
Early maturing	3	5	4	1	2
Taste	2	1	5	3	3
Marketability	3	5	3	1	2
Drought tolerance	3	5	4	1	2
Overall ranking	**2**	**4**	**5**	**1**	**3**

* Ranking was on a 1 to 5 scale, where 1= the best and 5 = the poorest.

In Kayes, the majority of farmers selected Fleur 11, JL 24 and Mossitiga in the first growing season. The main criteria used were pod yield, bold pods, vegetative growth, haulm yield and taste. The yield performance of these varieties is presented in Table 6. Overall the new varieties did not significantly out-yield the local variety. However, farmers preferred them over their traditional variety because the new varieties have larger seeds, and taste better than the local variety.

Table 6. Yield performance of drought tolerant varieties conducted in Kayes 2003 averaged over 20 farmers.

Variety	Pod yield (t/ha)	% over local	Haulm yield (t/ha)	% over local
Mossitiga	1.67	93	1.95	91
ICGV 86124	1.78	99	2.05	96
ICGV 86024	1.68	93	1.87	88
Fleur 11	2.02	112	2.30	108
JL 24	1.95	102	2.23	105
47-10 (local)	1.80	100	2.13	100
SE	0.052		0.058	
CV (%)	13		13	

In Kita, the new varieties were generally lower yielding that the local variety (Table 7). Nonetheless, farmers selected ICG 7878 for its big pods, while ICGV 92093 was selected based on its productivity comparable to the

local variety. Both varieties are resistant to foliar diseases while the local variety is susceptible. The results from pilot sites in Mali indicate that farmers' choice of varieties is not based on yield alone.

Table 7. Yield (t/ha) of foliar disease resistant varieties evaluated by 10 farmers in Kita, 2003.

Variety	Pod yield	% of local	Haulm yield
RMP 12	0.99	63	1.12
ICG 7878	1.11	71	1.28
ICG (FDRS) 4	1.10	71	1.24
ICG (FDRS) 10	1.11	71	1.22
ICGV 92093	1.57	101	1.66
28-206 (local)	1.56	100	1.77
SE	0.124		0.131
CV (%)	32		30

The oil content of 12 varieties as assessed by the Huicoma Group Tomata–Mali are presented in Table 8.

Table 8. Oil content of varieties exposed to farmers in Mali, 2005.

Variety	% Oil content
ICG (FDRS) 4	49.2
JL 24	51.4
ICGV 86024	52.5
ICG 7878	49.0
ICGV 86124	47.2
Fleur 11	49.8
47-10	47.8
55-437	45.0
Mossitiga	52.2
ICGV 86015	52.2
J 11	49.2
ICGV 97188	51.0

Five varieties had oil content $\geq$ 50%, three of which (ie, ICGV 86024, ICGV 86015 and ICGV 97188) were not among those selected by the farmers. This indicates that the linkage between groundnut producers and processors is critical in forging input and product market integration.

Niger

In the Dosso region, 47 of the 75 farmers participated in the evaluation of varieties in three villages (15 in Sia, 16 in Kara Kara and 16 in Sambera). Results from analyses of variance of pod and haulm yields are presented in Table 9. The average pod yield obtained in the three villages was 665 kg/ha (higher than the national average of 375 kg/ha) with significant differences in yields between varieties and villages. RRB and 55-437 had the highest yields and ICGV-IS-96894 the lowest. ICG 9346 produced significantly higher fodder yield than the other varieties.

Table 9. Average pod yield by variety in the pilot sites in the Dosso region, Niger.

Pod yield (kg/ha)	*N*	*Mean*	*Std*	*Min*	*Max*
55-437	14	747	296	383	1213
Fleur 11	10	551	165	310	827
ICG 9346	11	735	283	393	1157
ICGV-IS 96894	14	504	294	123	1140
RRB	14	766	416	77	1477
Total	63	665	320	77	1476
Haulm yield (kg/ha)					
55-437	14	636	201	356	953
Fleur 11	10	616	184	320	930
ICG 9346	10	853	292	516	1456
ICGV-IS 96894	14	480	244	136	890
RRB	14	653	302	80	1193
Total	62	636	268	80	1456

There were significant differences in pod and haulm yields between villages with Sambera recording the highest yields for pod and fodder (data not shown).

The average ratings for the attributes and overall average rating for varieties indicate that the panelists were able to discriminate between varieties for each of the attributes and overall acceptability of the varieties (Table 4). While all traits were associated with varieties, only color and flowering were poorly associated. The mean ranking of overall acceptance of the varieties was estimated to range between 2.66 and 3.50 for RRB and 55-437 had the best overall ratings, while ICGV-IS 96894 had the lowest score.

In the other regions of Niger (Maradi and Zinder), the extension agent and farmers participated in the choice of varieties to include in the FPVS on-farm trials. Nine varieties (55-437, T 183-83, T 177-83, T 169-83, 796, TS 32-1, RRB, J 11 and ICGV 86124 were evaluated. In Maradi trials/demonstrations were set up in five locations. Plot sizes ranged between 750-1500 sq m. In Zinder, similar trials were conducted under the supervision of the regional agricultural extension agents. Overall 15 trials and 6 demonstrations were set up in the two regions in 2003. In Maradi, farmers selected RRB and JL 24, while in Zinder, T 169-83 was selected.

The oil content of some of the varieties evaluated in Niger is presented in Table 10. Other than TS-32-1, all had average oil content of 48%, which is within the acceptable range.

Table 10. Oil content of some of the varieties tested by farmers (results from 126 samples across the three regions of Niger).

Variety	Oil content (%)
RRB	47.8
55-437	46.7
T169-83	48.3
T181-83	48.0
JL 24	48.3
T177-83	48.5
TS 32-1	50.8
Local	48.0

Nigeria

FPVS on-farm trials focused on three groundnut rosette resistant varieties – SAMNUT 21, SAMNUT 22 and SAMNUT 23 released in 2001 from the predecessor project GGP. A total of 69 on-farm trials and 15 demonstrations across the pilot sites were conducted in 2003-2005. These were extended to Jigawa and Zamfara states. Farmer-to-farmer visits and field days were organized to provide training in pre-harvest crop management. The dual-purpose (pod and haulm), and medium-maturing (110-120 days) varieties (SAMNUT 21 and SAMNUT 22) were selected in the higher rainfall zones (northern Guinea savanna zone) of Kaduna state. SAMNUT 23, which is early-maturing (90-100 days) was selected by the farmers in the drier Sudanian savanna zones of Kano, Katsina, Jigawa and Zamfara states. The criteria for choosing these varieties were earliness, good pod and fodder yields and resistance to groundnut rosette disease.

Senegal

Two types of FPVS trials were conducted. The first set involved 10 new early-maturing breeding lines developed for limited fresh seed dormancy. In the first year (2004 crop season) the trials were set up in seven sites in the groundnut basin: two in the north, three in the central north and two in the central south. In the second and third years the sites were reduced to two in the central-north and two in the central south. Seven lines with fresh seed dormancy ranging from 21 to 30 days after physiological maturity were selected for further evaluation.

The second set involved released and pre-released varieties. The characteristics of these varieties were short-to-medium maturity, drought tolerant and edible groundnut traits. In 2003 crop season, nine FPVS trials were conducted in the central north and central south in six villages. After the first year of evaluation, six varieties were selected based on tolerance to drought (ICGV 86124), uniform maturity (PC 79-79 and 73-33), productivity (ICGV 89063) and for edible groundnut traits (H75-O and ICGV 94222). Most of the varieties presented to farmers were acceptable, and four have been proposed for release.

In the second year (2004 crop season) the crop was ravaged by desert locust in the northern central region of Senegal and in the third year (2005) floods in the central south affected the crop.

Building seed supply and delivery systems

Breeder and foundation seed production

After ensuring that the new variety meets the needs of the farmers and product market requirements, the next step is to produce and supply enough seed to all who want to grow it.

Breeder and foundation seed are critical for a successful seed sector. Lack of these classes of seed has been identified as one of the major constraints hindering the growth of the groundnut seed sector (Ndjeunga et al. 2006). The Agricultural Research Institutions are responsible for variety development and maintenance, production of breeder and foundation seed of both released and pre-release varieties. The quantities of breeder and foundation seed produced over the project period are presented in Table 11.

Table 11. Breeder and foundation seed production (tonnes) by institutions (2003-2006).

Institution	2003		2004		2005		2006	
	B	F	B	F	B	F	B	F
Mali	17	12.0	1.7	8.8	1	20	1.1	10.0
Niger	1.0	4.9	-	5.5	-	4.8	-	-
Nigeria	2.0	5.7	1.9	10.0	0.4	3.8	0.4	5.6
Senegal	0.7	-	-	1.0	0.6	3.2	1.2	7.4
ICRISAT	4.0	-	4.0	-	5.0	5.0	2.5	-
Total	**9.4**	**22.6**	**7.6**	**25.3**	**7**	**36.8**	**5.2**	**23**

B= breeder, F=foundation

In all countries, production of breeder and foundation seed as well as supply is inconsistent and very limited. This was attributed to a number of factors including climatic (drought), low yields, poor soil fertility and natural calamities such as desert locusts and flooding as happened in Senegal in 2004 and 2005. In Nigeria, the government provides very limited funding for breeder seed production and this activity is being carried out mostly though special projects. In Niger and Mali, there is no breeder seed production per se. This is often done in partnership with ICRISAT. In Senegal, on the other hand, the government provides funding for breeder seed production by the seed unit of ISRA. This is largely motivated by the high demand by the parastatal groundnut oil processing company, SONACOS. Efforts by IAR in Nigeria and INRAN seed unit in Niger at establishing revolving funds are underway. The success of these schemes will rely on the possibility to fully recover at least the cost of production (using economies of scale) and government commitment to encourage such schemes.

In Senegal, the government and projects subsidize groundnut breeder seed production. In 2004, breeder seed was sold at $1.62/kg whereas the average cost of production was estimated to $1.81/kg. In Nigeria, breeder seed production is profitable. In 2004/05, breeder seed was sold at $7.60/kg, whereas the average cost of breeder seed production was estimated to be $6.44/kg*. In all countries except for Niger, groundnut foundation seed production is profitable. In Nigeria, foundation seed is sold at $3.81/kg whereas the average cost of production is estimated to $2.48/kg. In Senegal, the seed unit generates profits estimated to about $0.71/kg. Foundation seed is cheaper to produce in Senegal than in other countries providing opportunities for regional groundnut seed trade+. Similarly the price of certified seed is cheaper in Senegal than in Nigeria. In effect, while a kg of groundnut seed costs $0.82/kg in Senegal, it is about double in Nigeria estimated to about $1.62/kg.

* On average 1 USD equaled 136 Naira and 550 FCFA in 2004/05.

+ This assumes that the intermediation costs (transport costs, import taxes and other intermediation costs are less).

Profits generated by seed companies are very narrow. Seed companies in Nigeria derive little profits from selling groundnut seed compared to other crops such as sorghum, pearl millet and maize or hybrid seeds. While certified groundnut seed is sold at $1.62/kg and the average cost of production is estimated to $0.88/kg, the carry-over stocks are often too high on average 50% of seed produced limiting the returns to seed production.

Community-based seed production

In an attempt to resolve the access and availability of seed, ICRISAT initiated a small-scale seed production scheme with four farmers in Kolokani. To further enhance farmer access to modern varieties, three associations were also formed. Membership to these associations averaged 40 groundnut producers who were trained in seed production techniques. Most of the seed produced was distributed among members with little being sold in the market. The quantities of seed produced by the associations and individual farmers are presented in Tables 12 and 13.

Table 12. Quantity (in kg) of quality declared seed produced by farmers' associations in Kolokani (2003-2006).

Association	V1	V2	V3	V4	V5	V6
2003						
Tioriobougou	177	71	107			
Somon	142	71	80			
Kolokani	194	106	93			
Mambougou	113	39	70			
Total	**626**	**297**	**517**			
2004						
Tioriobougou	91	238	180	14	-	
Somon	76	72	-	-	-	
Kolokani	35	200	144		-	
Mambougou	6	-	-	-	-	
Other	233	59	307	163	1241	
Total	**441**	**569**	**631**	**177**	**1241**	
2005						
Kolokani	1068	682	356			
Mambabougou	95	277	-			
Somon	80	679	67			
Toiriobougou	241	541	403			
Total	1484	**2179**	**826**			
2006						
Kolokani	1140	2025		651		549

V= Variety; V1 = ICG (FERS) 4; V2 = Fleur 11; V3 = JL 24; V4 = ICG 7878; V5 = Mossitiga; V6 = ICGV 86124.

Table 13. Area planted (in ha) and seed produced (in kg) by individual seed producers in Kolokani (2003-2006).

	2003		2004		2005		2006	
Variety	Area	Quantity	Area	Quantity	Area	Quantity	Area	Quantity
Fleur11	0.8	693	7.4	4992	5.1	3644	10	9,859
ICG 7878	0.9	570	2.7	1356	1.3	694	6.3	5,780
ICG (FDRS) 4	1.4	1374	6.5	3313	6.0	3516	7.8	7,407
JL 24	0.6	517	4.6	2750	2.8	1879	3.5	3,043
ICGV 86124	0.05	30	1.0	920	2.7	1901	4.0	4,463
ICGV 86015	0.5	277	-	-	0.9	624	1.5	1,502
ICGV 97188	0.5	301	-	-	1.2	611	3.0	1,383
Total	**5.0**	**3,762**	**22**	**13,330**	**20**	**12,869**	**36**	**33,437**
Number of farmers	4		4		4		7	

Few case studies of small-scale seed entrepreneurs in Nigeria show that local village seed is cheaper. Price of seed is often set at about 12.50% above the price of grains in the market estimated to about $0.59 at planting times. Small-scale entrepreneurs are often farmers who have established their reputation in seed production. In effect, these farmers often favor social status over profits. They have accumulated more than 20 years of experience in producing seed for their neighbors. They often supply seed on credit recoverable at harvest. Despite potential profits that may be generated from seed production, it is still largely unsustainable.

Seed marketing and distribution

In 2003, ICRISAT and IER launched a pilot test of small packs of groundnut seed in the Kolokani district based on seed stocks from individual farmer associations. The major objectives were to assess the size of seed demand or the willingness of farmers to pay for new varieties and allow more farmers to experiment new varieties. The farmers were linked to the national seed certification agency. Two groundnut varieties were available, including Mossitiga and ICG (FDRS) 4 for a total supply of about 400 kg. Every farmer or farmer association was responsible for seed cleaning and packaging into three convenient pack sizes: 1, 2 and 5 kg. Seed was sold in the markets of Kolokani, Tioribougou, Nossombougou and Djidjeni, and direct links between farmers and small-scale retailers established. Seed prices were set at 420, 415 and 410 FCFA per kg of seed packs weighing 1, 2 and 5 kg respectively. A price margin of 15% was deducted from the sale price. All groundnut seed was sold out

only two weeks after the seed sale commenced, indicating potentially large demands (Ndjeunga and Ntare 2003).

A similar scheme was launched in the villages of Faska and Hankoura in the Dosso region of Niger in 2006. In Faska, three varieties were selected while five varieties were preferred by farmers in Hankoura (Table 14). Overall, about 640 kg of seed were sold through pack sizes of 0.5 kg and 1.0 kg by small retailers identified in the Bengou market. Sales started on 7 July 2006 and ended on 31 July 2007. Prior to sales, for one month and on a weekly basis, seed sales were advertised through rural radios to inform farmers on the characteristics of seed and location of sales as well as seed prices. Seed labeling was done *in situ* with simple labels in local languages and French indicating the name of the variety, the village, weight and the prices.

Seed prices were set in relation to the cost of production. Retailers were required to place a mark-up price to 15%. Prices for smaller size were a little higher than prices for larger sizes. For example, the price of 0.5 kg of seed was set to 425 FCFA/kg and that of 1.0 kg at 825 FCFA/kg. Information on seed purchasers were recorded by seed retailers to allow better monitoring and evaluation of variety use and perception by farmers.

This scheme was very successful. Within three weeks, more than 90% of seed packs were sold and by the end of the fourth week, all seed was sold. A large number of farmers were reached. In effect, more than 500 farmers purchased and used the seed. Although this scheme is efficient at disseminating seed, one could hypothesize that after farmers have acquired seed of new varieties, they will keep it for a long time before re-entering the market, rendering the seed market inconsistent and not attractive even for small-scale seed producers. One important lesson learned is that there is a need for supplying new varieties on a more regular basis to sustain the seed market. Additionally, there is a need for testing larger quantities of seed to assess the potential size of the seed market in order to uncover the demand for seed.

Encouraging small-scale seed enterprises

Efforts have been made to help establish small-scale seed enterprises in few pilot sites. These efforts were limited to providing training in seed production, marketing and small-scale business skills. This has stimulated the emergence of community-based associations at the village level wanting to engage in seed production and supply. Four individual farmers and four associations in Kolokani district and a women's group association in Wakoro in Mali have begun to produce seed of selected varieties for sale in the community. A similar situation is occurring in the other countries. In all cases farmers reported the lack of credit as the main constraint to expanding groundnut production. In effect, credit will increase farmers' access to other inputs such as seed, fertilizer and pesticides. This is consistent with earlier findings from Niger (Baidu-Forson et al. 1997).

Table 14. Distribution of seed by seed stocks, quantity of packs sold by monitoring period in two villages, Faska and Hankoura, in Niger.

		Pack of 0.5 kg			Packs of 1.0 kg		
Village/Variety	Quantity (kg)	Number	Sold as on 7 July 2007	Sold as on 31 July 2007	Number	Sold as on 7 July 2007	Sold as on 31 July 2007
Faska							
RRB	179	180	104	180	89	75	89
ICG 9346	34	34	15	28	16	11	12
FLEUR 11	56	56	19	50	28	25	26
Sub-total (1)	**269**	**270**	**138**	**258**	**133**	**111**	**127**
Hankoura							
RRB	124.5	105	40	105	72	55	72
ICG 9346	110	70	17	60	75	45	60
FLEUR 11	11.5	15	5	10	4	4	4
55-437	25	30	8	20	10	7	8
J11	88	108	21	89	34	12	22
ICG 87003	9	0	0	0	9	9	9
Sub-total (2)	**368**	**328**	**91**	**284**	**204**	**132**	**175**
Total	**637**	**598**	**229**	**542**	**337**	**243**	**302**

Fostering linkages with other projects (FAO input shops projects)

In Niger, there are about 300 input shops throughout the country. Some of these input shops are beginning to be used as seed outlets as well. In the two pilot sites of the Gaya region, the farmer groups have been encouraged to build their input shops with the support of FAO Projet Intrants. At the same time, the project fostered linkages between producers and small-scale retailers through dialogue meetings at the village level. This needs to be vigorously pursued.

Adoption by diffusion pathways

Seed was delivered to farmers using two different pathways. The first pathway was implemented in the Kolokani region and consisted of the mother and baby trial approach followed by the development of seed supply and delivery schemes to ensure access and availability of seed of preferred varieties. The second consisted of baby trials in the villages of Gonsolo in Mande district and Diola without follow-up and building up seed production schemes.

R&D interventions started in 1998 in the Kolokani region, and in the year 2000 in Gonsolo and 2001 in Diola. Baseline surveys in 2003 showed that 32% of area in Kolokani was planted with improved varieties and about 10% in the Diola and Gonsolo villages. Results from a survey undertaken in 2006/07 in the same villages showed that uptake had increased. In Kolokani about 83% of the area covered by surveyed farmers was planted with improved varieties and 28% in Gonsolo and Diola. The proportion of farmers that have adopted new varieties is higher among those who participated in FPVS on-farm trials in pilot sites (94%) than among non-trial participants (69%) and a little lower in neighboring villages estimated at 51%. The area covered by trial participants is estimated at 68% compared to 42% for non-trial participants and 34% in neighboring villages. In Kolokani, factors driving the intensity of adoption of improved varieties include the total work force, the involvement of farmers in on-farm trials and their location with regard to pilot sites, the value of animal traction, low diseases and pests pressure, the market value and social capital (Table 15). However, household with larger families are less likely to intensify.

Conclusions and lessons learned

FPVS provides farmers with firsthand information on the characteristics of improved varieties and agronomic practices. They also empower farmers to select new varieties under their own management and criteria. The trials are also a source of good quality seed and farmers' hands-on training in seed production and variety maintenance. Individual farmers and farmers' associations willing to produce and supply seed have emerged in the pilot areas and are promising options for a sustainable community-based seed system. These programs need to be replicated in other target areas in collaboration with partners who have established links with farming communities there.

Table 15. Tobit results on the intensity of groundnut adoption in the Kolokani district of Mali.

	Tobit model			
Variable	*Coef.*	*Std. Err.*	*T*	*P>t*
Age of Household Head (years)	0.002055	0.003887	0.53	0.598
Family size	-0.0306	0.01479**	-2.07	0.041
Illiteracy (0=illiterate, 1=literate)	0.015804	0.127525	0.12	0.902
Cultivated area (ha)	0.01083	0.013898	0.78	0.438
Sex of farmer (0=female,1=male)	0.021822	0.075373	0.29	0.773
Marital status (0=not married, 1=married)	0.01574	0.067755	0.23	0.817
Total work force (adult equivalents)	0.053121	0.028045*	1.89	0.061
Dependency ratio	0.098414	0.061581	1.6	0.113
Location (0=control village, 1=non-participant, 2=participant)	0.252427	0.066277***	3.81	0
On-farm trial participant(0=No, 1=Yes)	0.069413	0.12408	0.56	0.577
Total value of crop production (FCFA)	-0.00056	0.000257**	-2.18	0.031
Total value of equipment (FCFA)	0.000258	0.000169	1.53	0.13
Off-farm revenue (FCFA)	0.000346	0.000325	1.07	0.289
Value of animal traction (FCFA)	4.03E-05	0.000022*	1.84	0.069
Seed constraint (0=No, 1=yes)	-0.31462	0.152758**	-2.06	0.042
Low yield (0=No, 1=Yes)	0.311011	0.348402	0.89	0.374
Low diseases and/or pest (0=No, 1=Yes)	0.319776	0.11671***	2.74	0.007
Market value (0=No, 1=Yes)	0.703643	0.382106*	1.84	0.068
Kolokani (cf. Gonsolo and Diola)	-0.16596	0.285151	-0.58	0.562
Social capital	0.12087	0.045041***	2.68	0.008
Constant	-0.39844	0.409781	-0.97	0.333
σ	0.33564	0.024195		
Number of censored observations	22			
Number of observations	128			
Pseudo R2	0.41			
LR chi2	77.46			

The participatory approach has led to rapid spread of groundnut varieties among farmers in the villages surveyed. This suggests that resource-poor farmers are constantly in search of new opportunities to diversify their income source to improve their well-being. Technologies that have a comparative advantage in farmers' agro-ecological and socioeconomic conditions that provide new opportunities for income generation and diversification is critical. When a technology is appropriate, it stimulates an endogenous process of auto diffusion through a dynamic farmer-to-farmer horizontal spread of planting material. Thus, adoption coupled with building seed supply systems is crucial.

Agricultural research institutions can achieve substantial impact through a dynamic farmer participatory approach to technology development, dissemination and evaluation. However, to speed up dissemination and widespread adoption in other areas, there is a need to involve national agricultural extension services and non-governmental organizations as well as the private sector in making seeds available to larger numbers of farmers. This will undoubtedly make an important contribution to diversifying farmers' income opportunities and improving household food security.

Farmers have little access to other essential agricultural inputs to increase productivity as well as information on varieties and crop management practices. Technical, institutional and market solutions to improve access and availability of households to basic inputs should be vigorously pursued.

The sale of small seed packets of groundnut seed of preferred varieties involving farmers and village retailers gives an idea of the actual demand for seed as well as farmers' willingness to buy seed. It will also show to the private sector whether there was a small niche for marketing groundnut seed.

Seed production relying entirely on rainfall is highly risky. Efforts are needed to ensure that critical classes of seed such as breeder and foundation seeds are produced in secure environments with appropriate facilities including supplementary irrigation.

Training stakeholders along the value chain is critical for the sustainability of the interventions.

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Early adoption of modern groundnut varieties in West Africa

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Abstract

This study investigates the early adoption of modern groundnut varieties in the pilot sites of the Groundnut Seed Project (GSP) in Mali, Niger and Nigeria following government and donors' investment. Seventeen varieties were disseminated in the pilot sites of the three countries. Uptake has increased significantly during the last three years partially as a result of project intervention.

The proportion of area planted with modern varieties has increased by 22% in Nigeria, 12% in Mali and 10% in Niger in the pilot sites since 2003. Farmers using modern varieties have derived significant yield gains of 24%, 43% and 31% over the local varieties in Mali, Niger and Nigeria respectively. The modern varieties had significantly lower per unit cost of production estimated to 9.8%, 11% and 11% in Mali, Niger and Nigeria respectively. The net income derived by adopters is 66% higher than non-adopters in Mali, 73% in Niger and 111% in Nigeria. Relative to household types, income gains are estimated to be less than 20% compared to poor households in Mali, while it is more than 50% in Nigeria.

Results from the Logit models indicate that the major determinants of adoption in the three countries include the participation of farmers to on-farm trials, the build up of social capital through the empowerment of farmers' associations and small-scale farmers at producing and marketing seed. Constraints to adoption remain the poor access and availability of seed of modern varieties, pest and disease pressure in at least two out of three countries. Tobit results indicate that intensification of modern varieties is dependent essentially on seed availability, social capital, exposure to the varieties through farmers' participatory variety trials.

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Policies and institutional innovations that enhance the opportunities of farmers to experiment (on-farm trials and demonstrations) varieties and select those with preferred traits, followed by the development of village seed supply and delivery schemes are essential drivers of adoption of modern groundnut varieties in West Africa.

Introduction

Groundnut production, marketing and trade are still major sources of employment, income and foreign exchange in many West African countries. Until the mid-1970s, groundnut contributed between 15% (Senegal) and 40% (The Gambia) of gross domestic production in West African countries. With the exception of Nigeria and Sudan, groundnut exports provided between 40% to 90% of export revenues of West African countries during the 1960s and the early 1970s (Kinteh and Badiane 1990).

Groundnut production in West Africa averaged about 4.832 million t in shells in 1997-2001. This represents about 60% of Africa's production and about 15% of world production (Table 1). Since 1961, production has been stagnant with an annual growth rate of 0.38%. Groundnut yield in West Africa is low with yields estimated to 981 kg/ha below the world average of 1386 kg/ha. This represents about one-third of the yield in China estimated to 2922 kg/ha in 1997-2001. Nigeria and Senegal are the largest producers accounting together for about 45% of total African production. Mali, Niger and Burkina Faso are also groundnut producers.

West Africa lost its world production share, which dropped from 23.2% in 1961-65 to 15.6% in 1999-01. However, groundnut remains the most important source of vegetable oils and fats in the sub region. The development of other competing sources of oils is becoming important. Soybean *(Glycine max)* production grew by an annual rate of 11.61% during 1984-2001 to reach an average of 440600 t annually in 1997-2001. Similarly, sesame *(Sesamum indicum)* production grew by 5.2% since 1984. Sesame is also a potential oil seed crop that could serve as second crop in a sequential cropping system (as in some mono-modal rainfall regions). Its versatility in the local diet renders it a promising oilseed crop. Cotton *(Gossypium* spp) seed production is increasing faster than groundnut. Groundnut and cotton must also compete for land and farm labor. Given the prospects in the fiber market, the relatively well developed product markets for cotton, and drought-tolerant character of the crop, cotton production is likely to be a competitive force to reckon with for the groundnut sector (Ndjeunga et al. 2003).

Table 1. Evolution of African groundnut production in selected countries from 1961-2001: Area harvested, production and yield.

	Production					Area		Yield	
Aggregation	Average 1997-2001 ('000 t)	Average share of Africa 1997-2001 (%)	Average share of World 1997-2001 (%)	Annual growth rate 1984-2001 (%)	Annual growth rate 1961-2001 (%)	Average 1997-2001 ('000 ha)	Annual growth rate 1961-2001 (%)	Average 1997-2001 ('000 kg/ha)	Annual growth rate 1961-2001 (%)
World	32,945	NA	100	3.30	2.01	23,772	0.56	1386	1.45
China	12,698	NA	38.54	6.2	5.86	4,927	2.72	2922	3.14
India	6.855	NA	0.02	0.46	1.18	7,287	0.20	943	0.98
Africa	8,018	100	24.34	4.87	0.53	9,154	0.33	875	0.20
Western Africa	4832	60.2	14.67	5.69	0.38	4,920	0.16	981	0.55
Gambia	113	1.4	0.34	0.23	-1.08	98	-0.40	1146	-0.68
Mali	141	1.8	0.43	2.91	0.22	146	-0.57	962	0.79
Niger	105	1.3	0.32	9.50	-3.66	254	-2.03	416	-1.63
Nigeria	2730	34.1	8.29	9.93	0.55	2571	-0.35	1063	0.90
Senegal	852	10.5	2.59	1.45	-0.65	871	-0.86	981	0.21
Benin	94	1.2	0.29	3.10	2.85	109	0.99	862	1.86
Ghana	193	2.4	0.59	1.17	3.72	188	3.53	1023	0.18
Liberia	4.2	0.0	0.01	1.87	1.94	7.0	2.10	600	-0.15
Mauritania	2.0	0.0	0.01	1.05	2.52	2.5	0.96	808	1.56
Guinea	180	2.3	0.55	7.65	2.26	180	1.04	1002	1.22
Guinea-Bissau	19	0.2	0.06	-1.73	-5.34	16	-5.95	1170	2.71
Burkina Faso	198	2.5	0.60	4.00	3.30	239	1.84	824	1.46
Cote d'Ivoire	145	1.8	0.44	1.99	5.19	151	3.59	962	1.60
Sierra Leone	26	0.3	0.08	2.42	0.70	30	1.68	868	-0.99
Togo	30	0.4	0.09	1.01	2.18	57	2.20	523	0.01

NA= not applicable

Source: FAOSTAT Database 2002.

Groundnut oil prices have fluctuated widely over time with peak in 1981 and 1987. This variability is partially due to the thinnest of markets; and also to climatic conditions, policy shocks, or structural changes in these countries. Another factor is substitutability. Relative to substitutes such as soybean or palm oil, the price of groundnut oil is more than double. Similarly groundnut meal prices have fluctuated significantly for almost the same reasons. However, the relative price of meal is lower than that of substitutes, making it more competitive than soybean meal for example.

Groundnut production has suffered major setbacks from the groundnut rosette epidemics and foliar diseases, aflatoxin contamination and lack of sufficient and consistent supply of seed of improved varieties. This has significantly affected productivity and thus production and subsequently led West Africa to lose its share in the domestic, regional and international markets. To regain its competitiveness, groundnut yield would have to increase substantially, using yield enhancing technologies including varieties tolerant or resistant biotic and abiotic stresses.

The major constraints facing the development of the groundnut sector in West Africa are known to be, among others, the poor access and availability of high yielding groundnut varieties resistant to the rosette virus and foliar diseases. Since the 1990s, the International Crops Research Center for the Semi-Arid Tropics (ICRISAT) and partners – Institute for Agricultural Research (IAR), Institut d'Economie Rurale (IER) and Institut National de Recherche Agronomique du Niger (INRAN) – have developed or introduced a range of groundnut varieties with various attributes including different maturity groups resistant to groundnut rosette disease, foliar diseases and other desirable agronomic traits. About 39 varieties have been selected from regional variety trials across a range of agro-ecological zones.

In 2003 and 2004, crop seasons were under Groundnut Seed Project (GSP), a larger program of more than 200 Farmer Participatory Variety Selection (FPVS) trials in Nigeria, Niger and Mali. Following the choice of varieties by farmers, ICRISAT and partners initiated and catalyzed the development of institutions and institutional arrangements that will deliver seed at low transaction costs to smallholder farmers. Research institutions were involved in the production of breeder and foundation seed using revolving fund schemes, a process that involved more than 30 farmers' associations and led to 20 small-scale farmers being trained in seed production and marketing. This resulted in the production of more than 33 tons of breeder seed and 107 tons of foundation seed. In addition, more than 130 tons of certified seed have been produced by community based organizations. This amount of seed could cover more than 100 000 ha of groundnut area. However, little is known on whether the modern varieties have spread beyond the FPVS participants and the pilot sites, whether

the area cultivated to modern varieties has increased in the pilot sites, whether the number of households using modern varieties have increased, what the major drivers are in the uptake of modern varieties and the options of scaling up and out such technical and institutional interventions.

This study has three main objectives. The first was to assess the level of adoption of modern varieties and compare it with baseline information in the pilot sites. The second was to identify the determinants of uptake and intensity adoption of modern varieties, and the third is to propose options for scaling up and scaling out successful interventions.

The report is organized as follows: Section II presents a description of the study region, Section III presents the research and development process under the Groundnut Seed Project. Section IV presents the conceptual framework while Section V outlines the methodology. The results are presented in Section VI and Section VII concludes with options for scaling up and out successful interventions in developing seed supply systems in West Africa.

Section II. Description of the study area – Infrastructure and production environment in Mali, Niger and Nigeria

This study was undertaken in the GSP pilot sites in Nigeria, Niger and Mali. These countries are among the least developed in the world with low human development index (HDI). More than 60% of the population lives with less than US$1/day (Table 2). Agriculture employs more than 90% of the active population in Niger and Mali and 43% in Nigeria. The development of the agricultural sector remains a prerequisite for economic growth.

Table 2. Socio-demographic and economic profile of Mali, Niger and Nigeria.

Indicator	Country/Region				
	Mali	Niger	Nigeria	LDCs[+]	SSA[++]
People					
Population (million)	11.7	11.8	135.6	703	702.6
Population growth (annual %)	2.4	2.9	2.1	2.2	2.1
Life expectancy rate (years) in 2002	40.9	46.2	45.3	50.7	45.8
Literacy (% more 15 years)	24.9[*]	17.1[*]	66.8[#]	53.8[*]	64.9[#]
Environment					
Surface area (million sq km)	1.2	1.3	0.924	20.8	24.3
Arable land ('000 sq km)	46.06	49.94	303.71	--	--
Economy					
Gross National Income per capita (current $US)	290	200	320	310	490
Gross Domestic Product (current $US billion)	4.3	2.7	50.2	232.1	417.3
Gross Domestic Product growth (annual %)	6.0	4.0	10.6	4.8	3.4
Value added in agriculture (% GDP)	36.3	40.0	37.4	32.3[2]	14.1
Agricultural labor in 1990 (% of labor force)	93	91	43	--	--
Technology and Infrastructure					
Percentage of paved roads of total area in 1999	12.1	7.9	30.9	13.3	12.9
Trade and finance					
Trade in goods as a share of GDP (%) in 2002	60.7	33.8	52	45.1	55.3
Aid per capita (current US$) in 2002	41.5	26.1	2.4	25.4	28.2
Poverty proxies					
Human Development Index (2003)	0.337	0.292	0.463	--	--
Population with less US$1 per day in 2004 (%)	72.8	61.4	70.2	--	--

[*] in 1999; [#]in 2002. LDC[+] = Least Developed Countries; SSA[++] = Sub-Saharan Africa.
Source: World Development Indicators Database August 2004.

The pilot sites by region by country are presented in Table 3. The sites span a range of socioeconomic and demographic settings and are representative of agro-ecologies suitable for groundnut production.

Table 3. GSP pilot sites by country, region/state and villages.

Country	Region/State	Number of villages	Name of villages
Mali	Kolokani	8	Tioroubougou, Bambabougou, Somon, Gouakoulo, Seriwala, Soninkoro, Kanekebougou, Kolokani
	Diola	3	Wolome, Wobougou, Wakoro
	Kita	2	Sanoko, Senko
	Kayes	7	Same, Babala, Diakandape, Same Oulof, Dar Salam, Soutoucoule, Kayes center
	Katibougou	2	Winzinbougou, Mamaribougou
	Bancoumana	1	Gonzolo
Niger	Dosso	7	Sia, Karakara, Sambera, Sormo, Kigoudou Koara, Faska, Hankoura
	Maradi	3	Atchi da Koloto, Kourougoussao Kagera-Bargaja
	Zinder	2	Langiwa, Angoal-Gandji
Nigeria	Kano	7	Gezawa, Minjibir, Albasu, Daurawa, Sharadan, Gaya, Danbata
	Katsina	5	Zango, Daura Mashi, Dutsin ma, Kankiya, Makurda
	Jigawa	9	Kantoga, Jalomi, Masaya, Kangire, Dalarin Kwetta, Dalarin-lungu, Rangera, Gareri

Nigeria

The study was carried out in Jigawa, Katsina and Kano states where groundnut production accounts for more than 50% of total groundnut production. These states are located in+ the Sudan savanna and Sahel ecological zones where pearl millets, sorghum, cotton, groundnut, cowpea, vegetables, maize, cassava, sugarcane and beniseed are the main crops grown under rainfed and irrigated conditions.

The three states occupy each between 20,400 sq km and 22,600 sq km with average rainfall ranging between 600 to 900 mm. Farm sizes are relatively small and are estimated between 1.6 ha in Kano to 2.7 ha in Jigawa. Kano is the most densely populated, estimated to 276 people/sq km more than double

that of Jigawa. Average household sizes range between 8 and 10 members with average income ranging between 3200 Naira ($25) in Jigawa to 4000 Naira ($30.7) in Kano. The major ethnic groups are Hausa and Fulani (Table 4).

Table 4. Bio-physical and socioeconomic characteristics of three states in the Sudan-savanna and Sahel zones of Nigeria.

	State		
Characteristic	Jigawa	Katsina	Kano
Climate			
Rainfall (mm)	635-890	600-700	816
Temperature (°C)	31-33	NA	26-33
Land area (sq km)	22 600	25938	20400
Arable land area (sq km)	1695	1726	1632
Cultivated area (sq km)	1627	1537	1626
Average farm size (ha)	1.9	2.7	1.6
Population			
Total ('000 inhabitants)	2830	3878	5632
Population density (per sq km)	125	162	276
Ethnic groups	Hausa, Fulani, Kanuri	Hausa, Fulani	Hausa, Fulani
Farm households			
Average household size (no of members)	8.0	9.7	8.2
Average household income (in Naira)	3500	3200	4000

Source: Adapted from Ogungbile et al. 1999. p. 11-12.

Niger

The pilot sites were located in south-west and eastern parts of the country, involving Dosso, Maradi and Zinder regions. These regions are representative of the different agro-ecological zones with different assets endowments and market orientation.

The region of Dosso, located in southwest Niger covers 33,844 sq km with a population density of 44 persons/sq km and population estimated to 1,504,684 inhabitants accounting for 14% of the total population of Niger (République du Niger 2005). The climate is the Sudano-Sahelian type, with annual rainfall ranging between 400 and 1200 mm. Soils are mainly sandy accounting for two-

third of the region, with clayey soils in less than 10% of the region. There are hydromorphic soils located in the dallol and river valley, which are very rich in organic matter (Danguiwa 2000). Zarma, Maouri and Peulh are the main ethnic groups representing 48%, 34% and 12% respectively. The main rainfed crops grown are millet, sorghum, 'fonio', rice, cowpea, groundnut and bambara nuts. Irrigated crops such as rice, vegetables or fruit trees are grown in the river valley, silty and sandy-clay soils in the low lying areas and dallol. Major crop associations include millet-cowpea, followed by millet-sorghum-cowpea, millet-sorghum and millet-cowpea-sesame. The size of production units ranges between 7.3 ha in the Gaya area to 19.7 ha in the Loga area.

Maradi in the center of Niger covers about 41,796 sq km, ie, about 3% of Niger. About 72% of this area is suitable for agriculture, 24% to grazing land for livestock and the remaining 4% is forestland. The climate is the Sahelian type in the north, Sudano-Sahelian in the center and Sudanian in the south with rainfall ranging from 200 to 700 mm. The region of Maradi is the most densely populated with population density estimated to about 54 persons/sq km. In 2001, the population was estimated to 2,235,748 inhabitants accounting for 20% of Niger population in 2001. Haoussa, Peulh and Touareg are the main ethnic groups, representing 83%, 10% and 6% respectively. Maradi is among the highest production zone in Niger accounting for 18% of millet, 20% of sorghum, 21% of cowpea and 38% of groundnut. Farmers are exposed and are using modern technologies due to numerous interventions by the rural development projects and non-governmental organizations (NGOs) during the last 30 years. More than 50% of households are equipped with animal traction. Millet-cowpea-fallow is the major production system. Millet and sorghum remain the major cereal crops. Groundnut, cowpea, sesame and cowpea are the major cash crops. The importance of vegetable crops is growing rapidly.

Zinder in eastern Niger covers 155,778 sq km with a population estimated to 2,080,250 inhabitants accounting for 19% of the total population. Population density is estimated to 19 persons/sq km, whereas in almost all the regions, population growth has been decreasing. It fell from 3.71% to 3.05% in 1977-88 and 1988-01 in Dosso and from 3.29% to 3.03% in Zinder during the same periods. In the region of Maradi it has slightly increased from 3.66% in 1977-88 to 3.73% in 1988-01 (Republique du Niger 2005). This is the least endowed area with respect to resources.

Mali

Groundnut production in Mali is concentrated in the west, south and parts of the center, covering the regions of Kayes, Koulikoro, Sikasso and Segou. These account for 97% of the area and 98% of groundnut production in Mali. Average rainfall ranges from 400 and 800 mm per year.

The survey was carried out in the regions of Koulikoro and Kayes, and specifically in the districts of Kolokani, Diola, Mande, Kita and Kayes. The region of Kayes is the most important groundnut producing region, accounting for 33% of area and 35% of groundnut production in the country. This is followed by the region of Koulikoro which accounts for 21% of groundnut area and 24% of groundnut production.

Kolokani is one of the largest groundnut-producing areas in the region of Koulikoro. It has a history of experiencing repeated droughts, at least during one year out of three. Groundnut is the main source of rural livelihoods representing 37% of the total cultivated area. It is mostly planted as a sole crop and in rotation with cereals. Only about 8% of groundnut area is cultivated in association with cereals. Groundnut is cultivated on collective plots by all household members or individual plots owned by either men or women in the household (DNSI 1996/97).

A survey of groundnut producers in Mali in 1997/98 showed that family size ranges from 16 to 28 persons of which half is considered as active population. Cereal crops account for 62% of the total cropped area in Kolokani, followed by Bougouni with 45% and Kita with 20% of total cropped area. Cotton and groundnut are the main cash crops grown with the proportion of groundnut cultivated area estimated to 17% in Bougouni, 38% in Kita and 37% in Kolokani (CPS-IER 1998). Average area cultivated per household is estimated to 5.8 ha in Kolokani, 2.9 ha in Kita and 2.1 ha in Bougouni.

Groundnut is cultivated as a sole crop or associated with cereals such as pearl millet or sorghum or other crops such as 'dah'. However, there are differences by region. While in Bougouni, groundnut is cultivated as mixed crop in 48% of the groundnut-cropped area, groundnut is cultivated almost as sole crop in 92% of the total groundnut-cropped area. Yields are higher in Kita (1249 kg/ha) against 661 kg/ha in Bougouni and 760 kg/ha in Kolokani (CPS-IER 1998). The low yields are partly due to the poor quality of seed used by farmers. About 32% reported poor quality seed to be a major constraint to groundnut production. Almost all farmers complain of low supply of seed of improved varieties. Farmers also use very little inorganic fertilizers.

Section III. The Groundnut Seed Project: Dissemination and institutional processes

The Groundnut Seed Project (GSP) started in April 2003 and evolved through two phases. During the first phase, from 2003/04 to 2004/05, farmer participatory variety selection (FPVS) trials were carried out in pilot sites to evaluate variety performance under farmers' own crop management and expose farmers to new varieties. On-farm trial participants were selected among volunteers in Nigeria and Niger and were purposely selected in Mali among

the best farmers whose management was already known. This is because, in Mali, the pilot sites were basically the social laboratory of ICRISAT and IER where all technologies had been tested with many farmers since 1997 under the Groundnut Germplasm Project (GGP).

Mali

Since 1996, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the Institut d'Economie Rurale (IER) have been working in Kolokani. Apart from other constraints, foliar diseases were targeted as the major biological constraint limiting groundnut productivity and were estimated to be responsible for more than 60% of yield losses. ICRISAT has developed a range of varieties tolerant or resistant to many foliar diseases. Since 1998, ICRISAT initiated a large on-farm testing program with partners in the research and development continuum in order to test the performance of these varieties in the real conditions and provide opportunities to farmers to select their preferred varieties. Nine groundnut varieties* resistant to foliar diseases and with early-to medium-maturity were identified. Selected farmers were given 1 kg seed of each of the varieties. This quantity was sufficient to plant a plot of 10 m ×10 m along with the traditional variety. Field monitoring and evaluation were conducted by ICRISAT and IER scientists, and a range of development partners including NGOs such as Winrock International and ADAF GALLE (a local organization), and rural development projects such as the Office de la Haute Vallee du Niger (OHVN) and la Compagnie Malienne du Developpement Textiles (CMDT).

Every year, data on yields and farmers' rapid assessment of their preferences were collected. In 2000, ICRISAT initiated a small-scale seed production scheme with four farmers in the villages of Bambabougou, Kanekebougou, Tioribougou and Komokorobougou in the region of Kolokani. These farmers produced about 3.6 tons of seed of the variety ICG 7878, Mossitiga and Demba Niouma. Seed was marketed using small-scale pack seed (Ndjeunga et al. 2003).

Since 2003, GSP continued to promote a range of seed multiplication and delivery schemes in other regions of Mali. Four farmer associations and 10 individual farmers were selected and tasked with seed multiplication and distribution. More than 40 tons of seed were produced by farmers and marketed through seed demand from NGOs, or individual farmers through village markets and seed exchange between farmers.

Nigeria

Since 1990, ICRISAT and IAR developed, tested or adapted 44 groundnut varieties. These varieties were tested in multi-location trials in partnership with

* ICG 7878, ICG (FDRS) 4, ICG (FDRS) 10, Mossitiga, Demba, Niouma (ICGS (E) 34), ICGV 92093, ICGV 92088, ICGV 92082 and ICGV 91225

Agricultural Development Projects (ADPs) and Sasakawa Global 2000 in many states including Kaduna, Kano, Jigawa and Katsina. The specific locations for on-farm testing included Samaru (1996-97, 1998-99) in the state of Kaduna, Bagauda (1997-98), Minjibir (1996-98), Shika (1998-99), Kano (1998-99) in the state of Kano, Katsina (1998-99) in the state of Katsina and Maiduguri (1998-99) in Borno State[*]. Following the on-farm testing program, three groundnut varieties (UGA 2 (SAMNUT 21), M 572.80I (SAMNUT 22) and ICGV-IS-96894 (SAMNUT 23) were formally released in 2001.

In 2003, GSP promoted a range of high yielding groundnut varieties resistant to groundnut rosette disease (GRD) with market and farmer preferred traits through participatory variety selection (PVS), seed multiplication and delivery systems. Four states were targeted including Kaduna, Kano, Katsina and Jigawa. On-farm trials with farmers' management were conducted under the supervision of Agricultural Development Programs, the state agricultural extension services. Once farmers had selected the preferred varieties, the next task was to increase access to seed of selected varieties and evaluate the size of the seed market. Thus, scientists initiated the sale of small-seed packs. Besides, seed was produced through the private sector with seed companies such as Alheri and Premier Seeds and farmers' associations. Seed was also sold through private companies outlets.

Niger

In the 2000 crop season, farmers from Bengou village in Gaya district visited the INRAN research station where ICRISAT had established a large nursery of groundnut germplasm for characterization. Fascinated by the diversity of varieties, farmers were eager to test some of them on their farms. They chose the varieties based on their observations, information given by ICRISAT technicians, and their know-how. Each of the seventy farmers was given 1kg of seed of the selected variety after harvest. Overall 52 varieties[#] were selected by these farmers who came from the villages of Bengou, Koita Tegui and Kouara

[*] Varieties tested were ICGV IS 96894 (SAMNUT 23), ICGV IS 96900, ICGV IS 96901, ICGV IS 96859, ICGV IS 96909, ICGV IS 96871, ICGV IS 96898, ICIAR 18 AR, ICIAR 7B, ICIAR 18 AT, ICIAR 19 BT, ICIAR 9 AT, ICIAR 12 AR, ICIAR 10 B, ICGV IS 96826, ICGV IS 96801, ICGV IS 96848, ICGV IS 96808, ICGV IS 96804, ICGV IS 96805, ICGV IS 96855, ICGV IS 96802, ICGV IS 96845, ICGV IS 96827, ICGV IS 96840, ICGV IS 96809, ICGV IS 96828, ICGV IS 96835, ICGV IS 96810, ICGV IS 96841, ICGV IS 96847, ICGV IS 96825, ICGV IS 96824, ICGV IS 96816, KH 241 D, RRB, 55-437, ICGV IS 96891, ICIAR 6AT, ICGV 96891, UGA 2 (SAMNUT 21), UGA 4, M572.80I (SAMNUT 22) and Fleur 11.

[#] 55-437, 796, FLEUR 11, ICG 10105, ICG 10187, ICG 10203,ICG 10399, ICG 10425, ICG 10485, ICG 10511, ICG 10514, ICG 10529, ICG 11028, ICG 12020, ICG 12115, ICG 12139, ICG 12965, ICG 1305, ICG 1476, ICG 2373, ICG 3151, ICG 3190, ICG 3783, ICG 5193, ICG 544, ICG 564, ICG 6080, ICG 6102, ICG 6118, ICG 6428, ICG 6575, ICG 6592, ICG 6743, ICG 6747, ICG 7257, ICG 7371, ICG 7758, ICG 7759, ICG 7920, ICG 7922, ICG 8055, ICG 8482, ICG 8534, ICG 8801, ICG 8811, ICG 8849, ICG 8852, ICG 8892, ICG 9199, ICG 9232, ICG 9346, ICG 9360, ICG 9380, ICG 9829, ICG 9829, ICGV 86047, ICGV 86124

Zeno. The varieties were grown in a 2-hectare field provided by the village chief. ICRISAT technicians trained the farmers in how to sow in lines and the basics of good crop husbandry. Farmers themselves carried out all field operations such as land preparation, planting, weeding and harvesting. The Programme d'Appui au Développement Local de Gaya (PADEL), a Swiss-funded development project, assisted in the organization of three field days: 45 days after planting to show plant vigor, at harvest, and the third one during oil extraction. More than 150 women and men attended each of the field days. A total of 20 varieties was selected based on productivity .

Women with at least 20 years of experience in groundnut oil extraction conducted the assessment of the selected varieties for their oil and cake yields using traditional methods. From this assessment, five varieties (ICGV 86124, 55-437, ICG 9346, ICG 9199 and ICG 7299) were selected.

In 2001, PADEL initiated on-farm variety testing and dissemination in the region of Gaya, using the varieties selected above. Thirteen farmer trials from the villages of Mallan Kadi, Sabon-Birni, Makani, Guéza gado, Mallamawa, Gawassa, Garin Hamani, Goumandey and Rountoua Tanda participated in the trials. Two additional varieties (Fleur 11 and J 11) were added.

In 2002, eight individual farmers and five farmers' associations in the villages of Mallam Kadi, Sabon Birni, Makani, Guéza Gado, Mallamawa, Gawassa, Goumandeye, Kawara Gohé, Garin Hamani, Tanagaye, Toungan Darfou and Toungan Donfou were targeted to produce seed of farmer-selected varieties (J 11, Fleur 11, RRB, ICGV 96894 and ICGV 96891). In other villages in the region of Gaya also, viz, Tounga Darfo, Tanagueye, Guéza gado, Makkani and Rountoua Dolé, farmers' associations were targeted to produce seed of the selected varieties, ICGV-IS 96891, ICGV-IS 96894, JL 24, J 11, Fleur 11, and ICG 9199. Little follow-up was done on the where-abouts or use of those varieties by the farmers.

With the inception of the GSP in 2003/04, a mother and baby trial approach was implemented in three villages of western Niger to assess household preferences for plant and seed traits of five groundnut varieties based on a random utility based choice experiment. Preferences were estimated for five groundnut varieties. Median ranking of varieties showed that farmers preferred by order: RRB, 55-437, ICG 9346, Fleur 11 and ICGV 96894. Similarly pod yields followed the same patterns as the overall ranking of varieties. However, ICG 9346 yields significantly more haulm than others. Ordered probit results show that color (red), maturity (short cycle), pod yield and disease pressure (low) are the most important attributes by order of importance.

In 2004/05, using the same varieties and trial design, the on-farm trials were extended to other villages including Faska, Hankoura, Gobery, Fabidji, Sadeizi Kouara and Simari. Similar results were obtained. This was followed

up by the production of seed of selected varieties by farmers' associations and individual farmers. More than 30 tons of improved seed was produced and marketed through small pack seed sales or by individual farmers in the village markets or farmer-to-farmer exchanges.

During the second phase of the GSP starting in 2005/06, the project focused on building institutions and institutional arrangements that would enhance access and increase seed availability of selected varieties in sufficient quantities and suitable quality to end-users. Breeder and foundation seed production and delivery schemes were experimented. While revolving fund schemes were established in Niger and Nigeria, production of breeder seed was ensured by the public sector in Senegal and the GSP project in Mali. Certified and quality declared seed (QDS) were produced by farmers' associations and small-scale farmers in pilot sites. Strategies to enhance delivery of seed include among others the sale of small-seed packs in pilot sites. The quantities of seed produced by seed class, year and country are summarized in Table 5.

Table 5. Seed produced ('000 kg) by country during four years (2003/04–2006/07).

		Seed class			
				Certified	
Country	Year	Breeder	Foundation	FA	SCSP
Mali	2003/04	1.7	12.0	1.440	3.762
	2004/04	1.7	8.8	3.059	13.330
	2005/06	1	20.0	4.489	12.869
	2006/07	1.1	10.0	4.365	33.437
Niger	2003/04	1.0	4.9		
	2004/05	-	5.5		
	2005/06	-	4.8		
	2006/07	-	-		
Nigeria	2003/04	2.0	5.7		
	2004/05	1.9	10.0		
	2005/06	0.4	3.8		
	2006/07	0.4	5.6		
Total		11.2	91.1		

FA: Farmer association, SCSP: Small-scale seed producers

Project activities were undertaken in partnership with NARES, NGOs and rural development projects. Certified and quality declared seed were produced using three major multiplication schemes: farmers' associations; small-scale seed producers, and rural development projects through contract growers.

Theory and conceptual framework

The conceptual framework for this study is based on diffusion theory using a sustainable livelihood framework. An important issue in discussing diffusion theory is that it is not one, well-defined, unified and comprehensive theory. Rather, a large number of theories, from a wide variety of disciplines, each focusing on a different element of the innovation process combine to create a meta-theory of diffusion. Four of the theories discussed by Rogers (1995) are among the most widely-used theories of diffusion. These are: Innovation Decision Process; Individual Innovativeness; Rate of Adoption; and Perceived Attributes. In this study, we will focus on the perceived attributes which fit best farmers' circumstances when selecting their preferred groundnut varieties.

The theory of perceived attributes states that potential adopters judge an innovation based on their perceptions in regard to five attributes of the

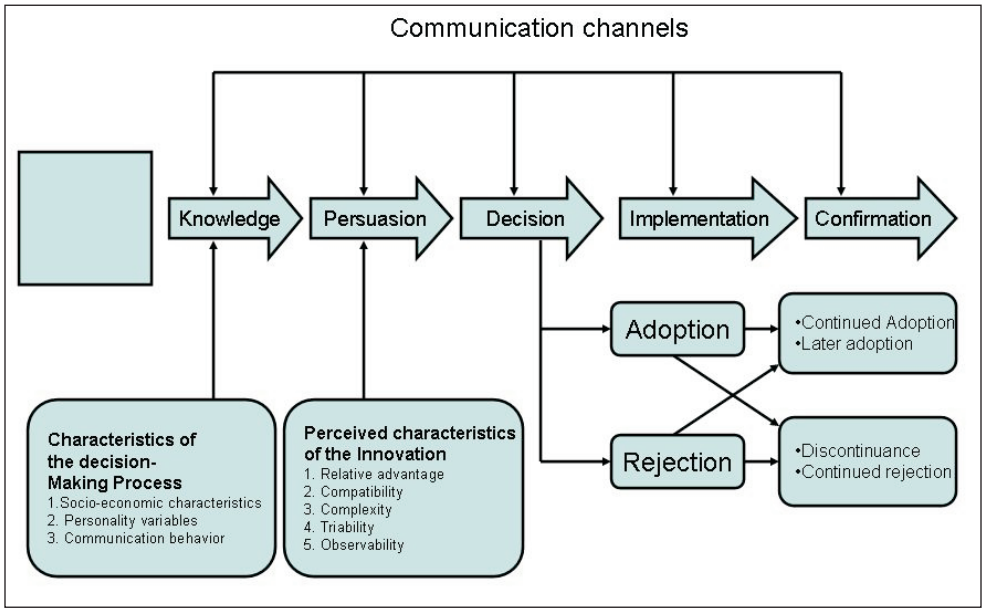

Figure 1. A model of stages in the innovation decision process.
Source: Rogers & Shoemaker (1973)

innovation. These attributes are: Trialability; Observability; Relative Advantage; Complexity and Compatibility. The theory holds that an innovation will experience an increased rate of diffusion if potential adopters perceive that the innovation: 1) can be tried on a limited basis before adoption; 2) offers observable results; 3) has an advantage relative to other innovations (or maintains status quo); 4) is not overly complex; and 5) is compatible with existing practices and values. The Theory of Perceived Attributes has been used as the theoretical basis for several studies relevant to the field of instructional technology. Perceptions of compatibility, complexity, and relative advantage have been found to play a significant role in several diffusion studies. Wyner (1974) and Holloway (1977) each found relative advantage and compatibility to be significant perceptions among potential adopters of technology. Surry (1993) studied the perceptions of weather forecasters in regard to innovative computer based training and found relative advantage, complexity and compatibility were important adoption considerations. This study draws from a mixture of the theories of the Innovation Decision Process and the perceived attributes of the technology and will then attempt to address the following research questions and hypotheses.

The conceptual framework will be that of the Sustainable Livelihood Framework (SRL) presented in Figure 2. The framework brings together relevant concepts to allow poverty to be understood more holistically (Farrington et al. 1999). It draws on the improved understanding of poverty, but also on other streams of analysis in economic theory, development theory, anthropology and sociology relating to households, gender, governance and farming systems.

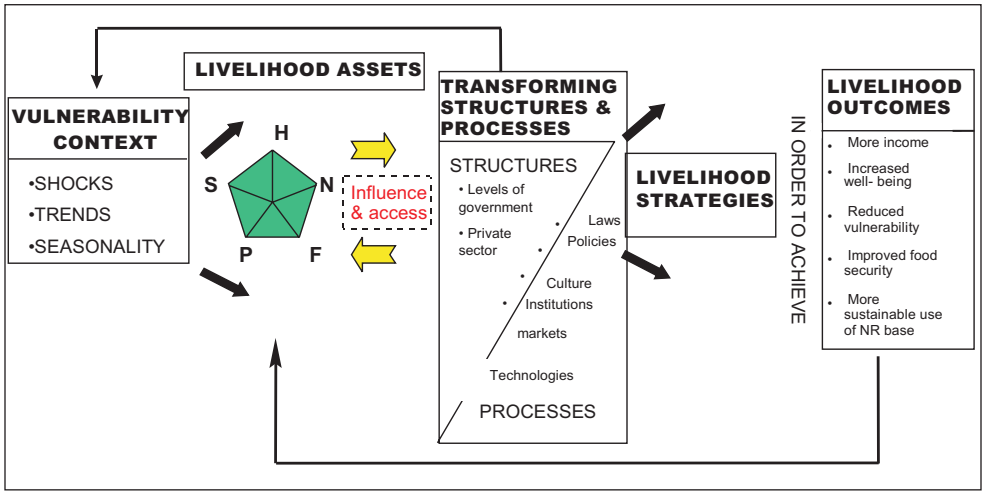

Figure 2. A modified version of DFID's Sustainable Livelihoods Framework.

Where:

H represents **human capital**: the skills, knowledge, ability to labor and good health, which is important to the ability to pursue different livelihood strategies

P represents **physical capital**: the basic infrastructure (transport, shelter, water, energy and communications) and the production equipment and means that enable people to pursue livelihoods

S represents **social capital**: the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods

F represents **financial capital**: the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) which provide them with different livelihood options

N represents **natural capital**: the natural resource stocks from which resource flows useful for livelihoods are derived (eg, land, water, wildlife, biodiversity, environmental resources)

The framework encourages users to think about existing livelihood patterns as a basis for planning research and development activities. This entails analysis of various tools to better understand:

- the context in which (different groups of) people live, including the effects upon them of external trends (economic, technological, population growth etc.), shocks (whether natural or manmade) and seasonality;
- people's access to different types of assets (physical, human, financial, natural and social) and their ability to put these to productive use;
- the institutions, policies and organizations which shape their livelihoods; and
- the different strategies that they adopt in pursuit of their goals.

The value of a framework such as this is that it encourages users to take a broad and systematic view of the factors that cause poverty – whether these are shocks and adverse trends, poorly functioning institutions and policies, or a basic lack of assets – and to investigate the relations between them. It does not take a "sectoral" view of poverty, but tries to recognize the contributions made by different interconnected assets, processes and structures that people draw on to devise livelihood *strategies* in order to achieve an anticipated livelihood *outcome*. This does not imply that development activity itself should always be multi-sectoral. The need is to conceive of problems and solutions in a holistic way, but then to select target and manageable approaches for implementation.

Methodology

The study was carried out in pilot sites in Mali, Niger and Nigeria where GSP started its activities in 2003/04. These regions encompassed the Sahelian and Sudanian-savanna zones.

Sampling procedure and data collection

The survey was carried out from November 2006 to February 2007. A purposive random sampling was used to select project sites. In each country, 75% of all project sites were selected. Next to every selected project site was a control site (a neighboring village) where GSP did not intervene. In each project site, 15 on-farm trial participants were selected from the population of participants and 10 non-trial participants were selected from the population of non-participants. Finally, 10 households were randomly chosen from the population of households in the comparator villages (ie, the control site). In case the number of on-farm participants was less than 15 farmers, enumerators were asked to survey all on-farm trial participants with the remaining unchanged.

The distribution of households selected to on-farm trials as well as the control sites according their participation or non-participation is presented in Table 6. Overall, 1190 households were selected and interviewed in the three countries including 868 households in the project sites and 322 in the neighboring villages. Of the households located in project sites, 450 participated in on-farm trials and 418 were non-trial participants.

Table 6. Distribution of villages and farmers in GSP pilot and control sites by country.

	Pilot villages			
Region	Participants	Non-participants	Control villages	Total
Mali	122	123	98	343
Niger	106	167	97	370
Nigeria	222	128	127	470
Total	450	418	322	1190

Source: ICRISAT/NARS survey, 2006/07.

Data was collected at the household and plot levels using structured survey questionnaires. Survey questions included modules on (1) socioeconomic and demographic profile of the households, (2) diffusion mechanisms pathways including knowledge of varieties and sources of first information and adoption and dis-adoption of groundnut varieties; (3) use of modern varieties at plot level, (4) diffusion pathways of modern varieties, (4) utilization, consumption and commercialization of groundnut, (5) household transactions, (6) household

perception of modern varieties relative to local varieties, (7) farmers' estimate of losses due to GRD in Nigeria and foliar diseases in Niger and Mali and finally (8) households' perception of changes in welfare resulting from the use of modern groundnut varieties.

Profile of varieties investigated in the study

The pre-released and released varieties in the three countries are presented in Table 7. Following FPVS trials conducted during the 2003/04 to 2004/05 crop seasons, the varieties selected by farmers are described below:

Nigeria

The modern varieties targeted are SAMNUT 21, SAMNUT 22 and SAMNUT 23.

(1) SAMNUT 21 (UGA 2)

This variety, also known as UGA 2, was developed jointly by the University of Georgia in the USA and the Institute of Agricultural Research (IAR) in Nigeria. It results from a cross between (RMP 12 × ICGS (E) 52). It is a medium-maturing variety with vegetative cycle between 115 and 120 days. It is a Virginia type and is resistant to GRD and foliar diseases. It has high oil content estimated to 51%. The potential pod yield is about 2.5 tons and 4 tons of haulm on-station and about 1.5 tons on-farm under the best agronomic practices. It was officially released in 2001 but was introduced in on-farm trials in many northern states since 1996. The adaptation zone is between 700 to 1000 mm annual rainfall.

(2) SAMNUT 22 (M572.80 I)

This variety is also known as M572.80 I under IAR nomenclature. It was selected in 1980 under irrigation at IAR's Mokwa research station in central Nigeria. It results from a cross between RMP 91 x (4753.70 x 3520.71). It is a medium maturing variety with a vegetative cycle of between 115 to 120 days. It is of Virginia type, resistant to GRD and tolerant to cercospora leafspots. It has moderate oil content estimated to 45%. The potential on-station pod yield is about 2.5 tons/ha and 1.5 tons on-farm. It was officially released in 2001 but was already introduced in on-farm trials in many northern states since 1996. The adaptation zone is the Sudan and Guinea savannah zones (which have average annual rainfall of 700-1500 mm).

(3) SAMNUT 23 (ICGV-IS 96894)

This variety is also known as ICGV-IS 96894 under ICRISAT nomenclature. It results from a cross between ICGV-SM 85048 and RG 1. It was developed by ICRISAT in partnership with IAR in Nigeria. It is an early maturing variety

with vegetative cycle between 90 and 100 days. It is of Spanish type, resistant to GRD and foliar diseases. It has high oil content estimated to 53%. The on-station potential pod yield is about 2.0 tons and 4 tons of haulm. On-farm yield potential is about 1.5 tons. It was officially released in 2001 but was already introduced in on-farm trials in many northern states since 1996. The adaptation zone is between 700-1000 mm annual rainfall.

Other varieties being grown by farmers include 55-437, RMP 12, RMP 91, RRB and other local varieties. Although 55-437 and RRB are popular varieties, they are highly susceptible to rosette which nearly wiped out the entire groundnut industry in Nigeria in the mid 1970s. On the other hand RMP 12 and RMP 91 though resistant to GRD, are very late maturing (more than 120 days) and are no longer adapted to the short-season environment of the dry savanna zone of Nigeria, where most of the crop is grown.

Mali

The varieties targeted are ICG (FRDS) 4, ICG (FDRS) 10, ICG 7878, JL 24, Fleur 11 and ICGV 86124.

(1) ICG (FDRS) 4

This variety was developed by ICRISAT in India and introduced to West Africa. It is an early-maturing variety with vegetative cycle averaging 90 days. It is of Spanish type, resistant to rust and tolerant to late leafspot. It has a moderate oil content estimated to 48%. The potential pod yield ranges between 1100 and 1500 kg/ha. It was officially released in 2002 but was already in use in on-farm trials in the Kolokani region since 1998. Its zone of adaptation is between 700 to 1000 mm annual rainfall.

(2) ICG (FDRS) 10

This variety results from a cross between (Ah 65 x NC Ac 17090) F2-B1-B1-B2-B1-B1-B1-B2. It was developed by ICRISAT in India and introduced to West Africa. It is a medium maturing variety with vegetative cycle averaging 115 days. It is of Spanish type, resistant to rust and tolerant to late leafspot and drought. It has a moderate oil content estimated to 48%. The potential on-farm pod yield averages 2000 kg/ha. It was officially released in 2002 but was already introduced in on-farm trials in the Kolokani region since 1998. The adaptation zone is between in the 700 to 1000 mm annual rainfall.

(3) ICG 7878

This is a germplasm line selected from screening of germplasm for foliar disease resistance. It originates from North Carolina, USA and was adapted to West Africa. It is a late maturing variety with vegetative cycle averaging 120 days. It is of the Virginia type, resistant to early and late leafspots. The potential pod yield ranges between 1500 and 1800 kg/ha. It was officially released in 2002

but was already used in on-farm trials in the Kolokani region since 1999. The adaptation zone is between 700 to 1500 mm annual rainfalls.

(4) Fleur 11

Originates in China but was introduced in Senegal through Peanut CRSP. It is early maturing (85-90 days) and significantly out-yields the widely adapted 55-437. It has larger seeds than 55-437 and was released in Senegal in 1988. ICRISAT introduced the variety in Mali through regional variety trials.

(5) ICGV 86124

This variety was developed by ICRISAT in India and introduced to West Africa. It is early maturing, high yielding and tolerant to drought.

(6) JL 24

This is a selection from an exotic collection 94943, released in 1978 in India as Plus Pragati. It has an average pod yield of 1.8 t/ha, shelling percentage of 75%, average oil content of 50.7%, average 100-seed weight of 53.7 g based on data from several trials conducted over three to four years. Other morphological features include dark green leaves, early maturity (90 days in West Africa), smooth pods and compact bearing. This variety is widely adapted but is susceptible to foliar diseases and insect damage. It lacks fresh seed dormancy, making it vulnerable to field sprouting if harvesting is delayed.

There are other varieties being grown in Mali such as 47-10, 55-437, 28-206, TS32-1, ICGS (E) 34 (ICGV 86065) and CN 94C. Apart from ICGS (E) 34, these varieties were introduced more than five decades ago and are highly susceptible to foliar diseases.

Niger

The varieties targeted in Niger are ICG 9346, J 11, Fleur 11, RRB, T 181-83, T 177-63, O-20 and T 169-83.

(1) ICG 9346

This is a germplasm line selected by farmers from a large characterization nursery of groundnut germplasm. It was selected based on high pod, oil and cake yields.

(2) J 11

A variety collected by ICRISAT in India in 1965 and introduced in 1988 in West Africa through the ICRISAT groundnut improvement program. It is early-maturing with vegetative cycle of between 90 and 100 days. It is of the Spanish type, tolerant to aflatoxin but susceptible to foliar diseases. It has moderate oil content between 42 and 45%. The potential pod yield ranged between 1.5 and 2.0 kg/ha. It was introduced in on-farm trials in the Gaya district in Niger since 2000. The adaptation zone is around 700 mm annual rainfall.

(3) Fleur 11

This variety was introduced in Niger in 1991 by the ICRISAT groundnut improvement program. Its dissemination was enhanced by the Groundnut Germplasm Project (GGP) since 1996.

(4) RRB (Resistant Red Bulk)

This was developed by the Institute for Agricultural Research (IAR) in Nigeria in 1988 and introduced in Niger through the GGP. It is crossbred between KH149 A (rosette resistant) x 2424.74 (rosette susceptible). Pods which are moderately constricted are clustered around the base of the main stem. The seed coat is red, and 100-seed weight is between 32 to 35 g. Leaves are large and pale green. Its oil content is estimated to 53.55%, it is drought tolerant but susceptible to GRD and leaf spot diseases. The adaptation zone is between 700 and 1000 mm annual rainfall.

(5) T 181-83

This variety was introduced by INRAN. It is an early maturity variety with crop cycle averaging 90 days but is susceptible to foliar diseases. Its oil content is estimated to 49%. The average yield on-station is estimated at about 2 t/ha.

(6) T 169-83

Introduced by INRAN, this is an early maturing variety with a 90-day crop cycle. It is susceptible to foliar diseases with yield averaging 2 t/ha under on-station conditions. The percentage oil content ranges from 49 to 50%.

(7) T 177-63

Introduced by INRAN, this is an early maturing variety with a 90-day crop cycle. It is susceptible to foliar diseases with yield averaging 2 t/ha under on-station conditions. The percentage oil content ranges from 49 to 50%.

(8) O-20

Introduced by INRAN, this is an extra-early maturing variety with crop cycle between 85 to 90 days but it is susceptible to foliar diseases. The average yield on-station is estimated to about 2 t/ha.

Other varieties grown in Niger include 55-437, 44-16, 47-16, TS 32-1 and 796 and are the so-called local varieties. They were introduced over five decades ago. It is important to note that some of the varieties included in FPVS were 'introduced' more than three decades ago but were never made available to smallholder farmers. However, through the ICRISAT groundnut improvement program, the regional trials under GGP (1996-2002), and a follow-up program of dissemination (2003-2007), these varieties have been made available and accessible to farmers in the pilot sites of GSP.

Table 7. Characteristics of released and pre-release groundnut varieties in Mali, Niger and Nigeria.

	Country/Varieties	Crop cycle (days)	Average yield (tons/ha)	Year developed/ introduced	Institution
MALI					
1	47-10	90	1.5	Introduced	IRHO/CRA Bambey
2	JL 24	90	1.5	Introduced	ICRISAT
3	TS 32-1	90	2.0	Introduced	INERA
4	55-437	90	2.0-3.0	Introduced	IRHO/CRA Bambey
5	Mossitiga	90	1.9	Introduced	INERA
6	ICGS (E)-34 (Demba Niouma)	90		Introduced	ICRISAT
7	Fleur 11	90	1.3	Introduced	China via ISRA
8	ICGV 7878	120	2.5	Introduced	ICRISAT
9	ICG (FDRS) 4	110	2.0	Introduced	ICRISAT
10	ICG (FDRS) 10	110	2.0	Introduced	ICRISAT
11	ICG 7878 (Waliyartiga)	120	2.0	Introduced	ICRISAT
NIGER					
1	55-437	90	2.0-3.0	Introduced	IRHO/CRA Bambey
2	T-169-83	90	2.5-3.5	1983	INRAN
3	T-181-83	90	2.0-3.0	1983	INRAN
4	TS 32-1	90	2.5-3.5	Introduced	INERA
5	796	90	2.0-3.0	Introduced	from Russia
6	KH 149-A	90	3.5	1973	IRHO
7	47-10	120	3.5	1977	IRHO
8	57-422	120	3.5	1957	IRHO
9	79-22	90	3.5	1979	IRHO
10	ICG 9199	90	3.5	Introduced	ICRISAT
11	ICG 9346	90	3.5	Introduced	ICRISAT
12	ICGV 96981	90	3.5	Introduced	ICRISAT
13	J 11	90	3	Introduced	ICRISAT
14	JL 24	90	1.5-2.5	Introduced	ICRISAT
15	RRB	90	2.5-3.0	Introduced	IAR
16	T-177-83	90	2.5	1983	INRAN
17	O-20	90	2.5	1983	INRAN

AT: Advanced testing, RE: Released

Sources: LABOSEM (2002) and INRAN (1994).

Table 7. cont'd. Characteristics of groundnut varieties released by country in West Africa.

	Country/Varieties	Crop cycle (days)	Average yield (tons/ha)	Year developed/ introduced	Institution
NIGERIA					
1	SAMNUT-1 (MK 374)	130-150	2.5-3.0	1960	IAR
2	SAMNUT-2 (SAMARU - 38)	130-150	2.5-3.5	1960	IAR
3	SAMNUT-3 (M-25.68)	130-150	2.8-3.0	1970	IAR
4	SAMNUT-4 (69-101)	130-150	2.5-3.0	1970	ISRA
5	SAMNUT-5 (M.599.74)	130-150	2.5-3.0	1970	IAR
6	SAMNUT-6 (M – 95.71)	130-150	2.0-2.8	1970	IAR
7	SAMNUT-7 (M104.74)	110-120	2.0-2.8	1980	IAR
8	SAMNUT-8 (M103.74)	110-120-	2.0-2.8	1980	IAR
9	SAMNUT-9 (59-127)	130-150	2.5-3.0	1980	IAR
10	SAMNUT-10 (RMP 12)	130-150	2.8-3.5	1988	INERA (Introduction)
11	SAMNUT-11 (RMP 91)	130-150	2.8-3.5	1988	IAR
12	SAMNUT-12 (M 318.74)	130-150	2.5-3.0	1980	IAR
13	SAMNUT-13 (Spanish 205)	90-100	2.0-2.8	1980	IAR
14	SAMNUT-14 (55-437)	90-100	2.0-2.8	1988	IRHO/CRA Bambey
15	SAMNUT-15 (F 452.2)	90-100	2.0-2.8	1970	IAR
16	SAMNUT-16 (M554-76)	130-150	2.5-3.0	1988	IAR
17	SAMNUT-17 (49-115B	130-150	2.5-3.0	1988	IAR
18	SAMNUT-18 (RRB)	100-110	2.0-2.8	1988	IAR
19	SAMNUT-19 (K720.20)	100-110	2.0-2.8	1994	IAR
20	SAMNUT-20 (M412.801)	120-130	2.8-3.5	1994	IAR
21	SAMNUT- 21 (UGA 2)	110-115	2.5	2001	IAR/ UGA
22	SAMNUT- 22 (M 572.80 I)	110-120	2.5	2000	IAR
23	SAMNUT- 23 (ICGV-IS 96894)	90	1.5-2.5	2001	ICRISAT-IAR

Sources: MDRH/DA/DS (1994) and IAR (1989).

Methods and baseline data

Descriptive statistics and ONEWAY analysis of variance were used to compare the relevant variables between adopters and non-adopters of groundnut varieties in 2006/07. Logit models were used to identify factors explaining adoption of the modern varieties. Tobit results were used to determine factors explaining the intensity of adoption. These results were compared with the baseline data collected in 2003/04 at project inception. In particular, project intervention should result in better access to seed of new varieties compared to the beginning of the project, area cropped to modern varieties should have significantly increased, more institutions producing and marketing seed should have emerged as a result of project intervention. However, it would be difficult to assess the project impacts on the livelihood of the smallholder farmers with regard to more income, increased well-being, reduced vulnerability, improved food security and more sustainable use of natural resource base. This is due to the short duration of the project that does not suffice to conduct any impact analysis.

Results and discussion

Results are presented by country on household characteristics differentiating between adopters and non-adopters of modern groundnut varieties in 2006/07. They also include the diffusion mechanism of modern groundnut varieties assessing farmers' knowledge and source of first information on modern varieties as well adoption and dis-adoption of groundnut varieties, household participation in technology transfer activities, social capital and varieties grown during the last three years; groundnut commercialization and the traits preferred by farmers; and the factors explaining the probability of their continuing to use modern varieties and the determinants of intensity of adoption.

Household socioeconomic and demographic characteristics

The household level characteristics by uptake of modern varieties in Nigeria, Mali and Niger are presented in Tables 8, 9, 10 and 11.

Human and social capital

Nigeria. Survey results showed that users and non-users of modern groundnut varieties[*] do not differ significantly based on their age, dependency ratio, the proportion of illiterates and ethnicity, but differ on household size, work force, and the proportion of members that have the primary or tertiary school education levels. The average age of the household head is estimated to be 49 years with household dependency ratio estimated to 1.69. The illiteracy rate

[*] Modern groundnut varieties in Nigeria are SAMNUT 21, SAMNUT 22 and SAMNUT 23.

is estimated to 2.5% members of the households. About 98% of respondents belong to the Hausa ethnic group. The household size for users of modern varieties is estimated to 14 members significantly greater than 13 for non-users. The proportion of family members with tertiary school education level is significantly higher for users than non-users. Paradoxically the proportion of households with primary school education is higher for the non-users groups than adopters of modern varieties.

It was expected that adopters would be younger than non-adopters because adopters are likely to experiment new technologies, take more risk ie, be less averse to risk as opposed to non-adopters. Likewise, educated household heads should be more receptive to new innovations than less educated household heads. Therefore, it was expected that adopters would be more educated that non-adopters. The relationship between household size and adoption may be uncertain. In effect, large families may be less likely to adopt new innovations because of the risk of failure to ensure household food security. However, if households are wealthier, they could take more risk than otherwise. Therefore, even large households could experiment with new varieties. In general, the interaction between age, household size, work force and others such as wealth status, farm size, and level of education could produce confounding effects (Feder et al. 1985).

About half the household heads invest their entire time in agriculture, against about 30% who are part-time farmers and the remaining do not work on-farm. The participation of the household head in labor in agriculture does not differ much among groups except for the sub-group of non-participants. However, one would expect adopters to invest more of their time in the farm business ie, to be full-time farmers because they will tend to manage their farming business more than had the case been otherwise. However, if farmers are engaged in other activities, they may be likely to generate more cash to re-invest in agriculture and thus invest in modern technologies including modern varieties.

Mali. Survey results showed that users and non-users of modern varieties* differ by age, family size, dependency ratio, education and ethnic group. Users are significantly younger (46 years old) than non-users (48 years old). There are significantly less members in households headed by users of modern varieties (18 members) against 20 members for non-users. There are significantly more dependents in households headed by non users (1.4) against 1.2 for users. The illiteracy rate is higher in households headed by users than non-users (74% of household members against 66% respectively). Similarly, the proportion of household members who have primary school level education is significantly

* Modern groundnut varieties in Mali are ICG (FDRS) 4, ICG 7878, Fleur 11, ICGV 86124, JL 24 and ICG (FDRS) 10.

higher for non-users of modern varieties than users. The same trend is observed for the proportion of household members who have attended Koranic schools. There are three main ethnic groups, Bambara, Malinke and Peulh. Users of modern varieties are mainly from the Bambara ethnic group (70%) against 50% for the non-users. There are more Malinke (22%) among non-users against 10% among users.

These results are consistent with the expected trends. In effect, adopters of modern technologies were expected to be younger than non-adopters because they could take greater risks; it was expected that household size would be smaller, that adopters would have fewer dependents and higher levels of education. Overall, agriculture is the major occupation for household heads interviewed: the figures were 98% of users against 99% of non-users with non significant differences.

Niger. Except for age and ethnic groups, there are no differences between the two groups based on family size, work force and education. Users of modern varieties* are older than non-users (49 years against 47 years). There are three major ethnic groups: Zarma, Hausa and Peulh. There are significantly less Zarma in the users' group (4%) than the non-users (15%). There are proportionally more Peulh in the users' group than non-users (9% against 4% respectively). However, the proportion of Hausa estimated to 82% is not significantly different in the two groups. The estimated family size is 10 members, with work force of 4.4 adult equivalents. The rate of illiteracy is high with 75% of household members with no significant differences between the two.

The trend on age was not expected: adopters were found to be older than non-adopters. This may happen if there are confounding effects between age and wealth, farm size or level of education. Agriculture is the major occupation for household heads; about 92% of users reported agriculture to be their major occupation against 93% for non-users.

Overall, these results are consistent with those selected in the baseline data. In Nigeria, the average age of household head was estimated to 47.5 years against 49.22 years; household sizes have increased from 12 to 13 members in 2006/07 and the total work force has remained the same, 6.35 against 6.23 adult equivalents. Similar trends have been found in Niger (Ndjeunga et al. 2006).

* Modern varieties in Niger are O-20, T 169-83, T 81-83, T 177-63, ICG 9346, RRB, J 11 and Fleur 11.

Table 8. Household level characteristics by uptake of modern groundnut varieties in Nigeria, Mali and Niger in 2006/07 – Human Capital.

Variable		Overall sample (n=477)	Use of modern varieties: Did not use (n=217) Mean	Did not use Std	Used (n=260) Mean	Used Std	F value
Nigeria							
Age of household head		49.22	49.14	11.26	49.29	11.16	0.02
Household size		13.10	12.05	8.81	13.98	11.56	4.09b
Work force		6.23	5.75	4.88	6.63	6.67	2.60c
Dependency ratio		1.69	1.64	1.64	1.73	1.87	0.33
Education	Illiterate	0.025	0.369	0.188	0.0154	0.123	2.23
	Primary	0.111	0.138	0.345	0.088	0.285	2.97c
	Secondary	0.149	0.138	0.346	0.158	0.365	0.35
	Tertiary	0.092	0.051	0.219	0.127	0.333	8.32a
	Adult education	0.098	0.097	0.296	0.100	0.300	0.01
	Koranic school	0.577	0.576	0.495	0.577	0.495	0.00
Gender (male) (%)		99.37	99.54		99.23		
Marital status – married (%)		96.86	97.24		96.54		
Full time labor		0.48	0.456	0.499	0.5	0.500	0.91
Part time labor		0.294	0.272	0.446	0.311	0.464	0.89
Not working on farm		0.184	0.230	0.422	0.146	0.353	5.62b
Mali							
Age of household head		46.81	47.96	10.74	46.17	9.30	2.60c
Family size		18.98	19.95	9.22	18.45	6.33	3.17c
Work force		8.93	9.26	5.32	8.74	3.56	1.14
Dependency ratio		1.27	1.37	0.94	1.21	0.58	3.65c
Education	Illiteracy	0.70	0.74	0.26	0.66	0.31	9.15a
	Primary school	0.16	0.21	0.41	0.14	0.34	3.46c
	Secondary school	0.02	0.02	0.16	0.018	0.13	0.16
	Koranic school	0.12	0.19	0.39	0.08	0.27	8.73a
Literacy/numeracy		0.30	0.11	0.31	0.42	0.49	39.37a
Ethnic group	Bambara	0.63	0.50	0.50	0.70	0.46	14.15a
	Malinke	0.15	0.22	0.42	0.10	0.31	8.85a
	Sarakole	0.02	0.016	0.13	0.03	0.16	0.40
	Peulh	0.07	0.11	0.31	0.05	0.22	3.92b
Gender (female %)		45.48	39.34	-	48.87	-	-
Major occupation (agriculture)		98.54	99.18	-	98.19	-	-

Table 8. cont'd. Household level characteristics by uptake of modern groundnut varieties in Nigeria, Mali and Niger in 2006/07 – Human Capital.

Variable		Overall sample (n=477)	Use of modern varieties: Did not use (n=217) Mean	Did not use (n=217) Std	Used (n=260) Mean	Used (n=260) Std	F value
Niger							
Age of household head		47.59	46.83	13.01	49.21	13.04	2.67c
Family size		10.12	10.40	6.30	9.54	5.16	1.63
Work force		4.40	4.41	3.15	4.36	3.20	0.02
Education	Illiterate	74.68	74.28	31.64	75.53	30.68	0.13
	Primary	14.05	14.62	35.41	12.82	33.58	0.21
	Secondary	6.22	5.93	23.66	6.83	25.35	0.11
Literacy/numeracy	Koranic	33.24	31.62	46.59	36.75	48.42	0.95
		9.18	9.49	29.36	8.55	28.08	0.08
Ethnic group	Zarma	11.35	14.62	35.41	4.27	20.76	8.67a
	Haoussa	82.16	80.04	39.89	86.32	34.51	2.02
	Peulh	5.95	4.35	20.43	9.40	29.31	3.67c
	Dandy	0.3	0.3	6.29	0	0	0.46
Gender (male %)		92.43	90.51	-	96.58	-	-
Major occupation (agriculture %)		92.97	93.28	-	92.31	-	-

a. significant at 1%; b. significant at 10%; c. significant at 10% probability level; - indicates 'not applicable'.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Physical assets

Table 9 presents the physical capital stock of households in the three countries.

Nigeria. On average, households cultivate about 7.5 ha over a cultivable area estimated to 8.41 ha with no differences between adopters and non-adopters. The area cropped with groundnut is estimated to 2.7 ha ie, about one-third of the cultivated area. The stocks of cultivable and cultivated land are not significantly different for users and non-users of modern varieties as well as the groundnut growing area. However, land values of users of modern varieties are estimated to be significantly higher than that of non-users. This may be explained by the fact that users of modern technologies are more receptive to new technologies and may have been investing more in land improvement options such as fertilizers or other production enhancing technologies such as pesticides.

The average values of livestock, equipment or draught animals owned by households surveyed is estimated to $1237, $273 and $560 respectively.

However, there are no significant differences between users and non-users of non-modern varieties. Similarly, the proportion of households using inorganic fertilizers, organic and pesticides do not differ between users and non-users. On average, users of modern varieties use 74 kg/ha of inorganic fertilizers against 87 kg/ha for non-users. However, the organic fertilizer use intensity is estimated to 1858 kg/ha for non-users which is significantly less than 2444 kg/ha for users of modern varieties.

Compared to the baseline data in 2003/04, the average cultivated land has marginally increased from 7.38 ha to 7.51 ha in 2006/07. Similarly, the proportion of area planted with groundnut has slightly increased from 33% in 2003/04 to 36% in 2006/07. Although marginally significant, this may result from project intervention (Ndjeunga 2006).

Mali. Households cultivate on average 5.23 ha. However, users of modern varieties cultivate significantly more land on average (5.50 ha) than non-users (4.73 ha). The same trend is observed with cultivable land where users have on average 9.28 ha against 8.88 ha for non-users.

The average values of equipment and animal traction owned by households are higher for users of the technologies than non-users. On average users owned equipment worth about $349 against $208 for non-users and the value of traction animals is almost double for users ($645) than non-users ($355). However, the value of livestock owned is not significantly different for users and non-users. The proportion of households using inorganic and organic fertilizers or pesticides is very small and not significantly different between the two groups.

Niger. The average size of land cultivated by households is estimated to 7.6 ha with no significant differences between the two groups. However, users own more cultivable land than non-users (10.84 ha against 8.77 ha).

The values of land, equipment, animal traction and livestock are not significantly different between the two groups. On average, the value of land owned by households is estimated to $1009, the value of equipment to $259 and the value of animal traction to $446. The value of livestock owned by household is estimated to $2519 on average.

The proportion of households using fertilizers is still low with differences between users and non-users. The proportion of households using inorganic fertilizers is estimated to 10%, and that of households using inorganic fertilizers to 27%. About 35% of households surveyed use pesticides.

Compared to the baseline data in 2003/04, the average cultivated land has significantly decreased by 13.38 ha against 7.64 ha in 2006/07. However the proportion of area planted with groundnut has slightly increased from 27% in 2003/04 to 29% in 2006/07. This may have resulted from project intervention (Ndjeunga 2006).

Table 9. Household level characteristics by uptake of modern groundnut varieties in Nigeria, Mali and Niger in 2006/07 – Physical Assets.

Variable	Overall sample (n=477)	Use of modern varieties				
		Did not use (n=217)		Used (n=260)		
		Mean	Std	Mean	Std	F value
Nigeria						
Cultivated area (ha)	7.51	7.21	7.43	7.77	8.26	0.58
Cultivable area (ha)	8.41	8.16	8.25	8.63	10.16	0.30
Groundnut area (ha)	2.73	2.83	4.15	2.64	2.22	0.45
Total land value ($)	2568	1910	2434	3116	8941	3.72b
Value of livestock ($)	1237	1237	2461	1236	2502	0.00
Value of equipment ($)	273	252	343	290	1388	0.16
Value animal traction ($)	560	575	832	548	920	0.11
Mali						
Cultivated land (ha)	5.23	4.73	2.78	5.50	2.92	5.65b
Cultivable land (ha)	8.88	8.16	5.53	9.28	6.44	2.58c
Value equipment ($)	299	208	246	349	286	21.09a
Value traction animals	542	355	631	645	678	15.09a
Niger						
Cultivated area (ha)	7.64	7.60	8.14	7.72	6.16	0.02
Cultivable land (ha)	9.45	8.77	7.92	10.91	10.84	4.59b
Total value of land ($)	1009	977	1269	1079	1897	0.37
Value of equipment ($)	259	237	316	304	815	1.29
Value of animal traction ($)	446	448	648	442	689	0.01

a. significant at 1%, b. significant at 10%, c. significant at 10% probability level.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Household commercial transactions

The household commercial transactions are presented in Table 10.

Nigeria. The value of household sales is significantly higher for users of modern varieties than non-users. On average the value of total sales is estimated to $1063 for non-users against $1874 for users. The same trend is observed for crop sales and off-farm gross revenue. However, there are no significant differences between users and non-users based on livestock sales. However, the value of groundnut sales is estimated to $541 for users versus $141 non-users of groundnut varieties. It accounts for 69% of total crop sales for non-users against 72.64% for users of groundnut varieties.

Proportionally, while livestock represents a larger share of sales for non-users estimated to 38% of total sales, crop sales represent a larger share of sales for users of the technologies estimated to about 37% of total sales.

Mali. The total value of household cash sales is estimated to $261 with significant differences between the two groups. Users of the modern varieties sell more on average ($285) than non-users ($215). However, the proportion of crop sales to total sales is lower for non-users than users, ie, 38% against 61% respectively. A similar trend is observed for livestock (14% for non-users against 20% for users of modern varieties). The share of groundnut sales to total crops sales is estimated to 61% for non-users significantly less than users estimated to 76%. However, non-users of modern varieties generate proportionally more gross revenue from off-farm activities than users, 48% against 19%.

Niger. The value of household cash sales is estimated to $512 with no differences between the two groups. Similarly, there are no differences between users and non-users on the value of crop sales and off-farm gross revenue. However, non-users sell more livestock on average than users of modern varieties, $182 against $109 respectively. Groundnut sales represent a large share of crop sales. In 2006/07, groundnut sales accounted for 80% of total sales in pilot sites with no significant differences between users (82.27%) and non-users (79.38%).

Table 10. Household level characteristics by uptake of modern groundnut varieties in Nigeria, Mali and Niger in 2006/07 (all transactions in USD).

Variable	Overall sample (n=477)	Use of modern varieties				F value
		Did not use (n=217)		Used (n=260)		
		Mean	Std	Mean	Std	
Nigeria						
Total crop sales	470	243	526	660	1342	18.51a
Off-revenue	403	225	552	552	1663	7.70a
Livestock sales	530	496	685	555	1048	0.36
Mali						
Value crop sales	141	82	124	174	173	26.85a
Value off-farm revenue	71	102	376	54	93	3.36c
Livestock sales	48	30	104	58	113	5.01b
Total cash sales ($)	261	215	453	285	236	3.64c
Niger						
Crop sales	171	153	206	211	631	1.74
Off farm revenues	188	206	513	149	247	1.29
Livestock sales	159	182	292	109	187	6.06b
Total cash sales	512	540	653	469	722	0.89

a. significant at 1%, b significant at 10%, c. significant at 10% probability level.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Social capital

Social capital is defined as the number of institutions in which the household is connected to and the number of members of household who belong to associations. Table 11 presents the social capital and regional characteristics of households.

Nigeria. On average, households are connected, each to one association. However users of modern varieties belong significantly to more associations on average than non-users, ie, 1.39 against 0.867. Similarly the number of household members that are connected to different associations is significantly higher for users, 9 members against 4 members for non-users.

Mali. There are differences between the group of users and non-users of groundnut varieties based on their connection to associations or institutions. On average, users of the technologies belong to more associations (1.5) than non-users (1.1).

Niger. Households using modern varieties are significantly more connected to institutions than non-users (1.52 against 1.35). However, there are no significant differences in the number of members belonging to associations in a household.

Overall, it can be noted that in the three countries, adopters of modern groundnut varieties are better connected to institutions than non-adopters.

Awareness, adoption and dis-adoption of groundnut varieties

Farmers' awareness of the existence of an improved technology is a criterion for evaluating the diffusion pathway plan or strategy. The decision to use a technology requires prior information on its existence or knowledge.

Table 11. Household level characteristics by uptake of modern groundnut varieties in Nigeria, Mali and Niger in 2006/07 – Social capital and regional characteristics.

Variable	Overall sample (n=477)	Use of modern varieties: Did not use (n=217) Mean	Did not use (n=217) Std	Used (n=260) Mean	Used (n=260) Std	F value
Nigeria						
No. of institutions by household	1.149	0.866	0.749	1.385	1.068	36.22a
No. of members per household	6.851	3.732	6.763	8.973	25.279	6.27a
Control village	0.266	0.415	0.494	0.142	0.350	49.40a
On-farm trial participation	0.465	0.184	0.388	0.700	0.499	171.28a
Use of fertilizers	0.719	0.700	0.459	0.735	0.442	0.68
Use of manure	0.805	0.820	0.385	0.792	0.406	0.59
Use of pesticides	0.30	0.262	0.441	0.327	0.470	2.34
Mali						
Social capital	1.48	1.06	0.24	1.56	0.88	5.72b
Technologies						
Use of fertilizers	0.2	0	0	0.4	0.6	0.55
Use of manure	5.25	4.10	19.91	5.88	23.58	0.50
Use of pesticides	1.75	1.64	12.75	1.81	13.36	0.10
Niger						
Social capital						
No. of institutions	1.41	1.35	0.67	1.52	0.79	3.00c
No. of members in household	4.37	4.06	9.12	5.04	10.75	0.57
Technologies						
Use of inorganic fertilizers	10.27	8.69	28.23	13.67	35.65	2.15
Use of organic fertilizers	27.02	28.85	45.40	23.08	42.31	1.31
Use of pesticides	35.41	32.01	46.75	42.73	49.68	4.04b
Qty of fertilizer used (kg)	7.44	7.33	56.10	7.65	30.51	0.00
Qty of manure (kg)	800	756	1642	896	3115	0.32

a. significant at 1%, b. significant at 10%, c. significant at 10% probability level.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Knowledge of varieties and sources of first information and seed

Sources of first information

Nigeria. About 59% of households reported to be aware of the three improved groundnut varieties (SAMNUT 21, SAMNUT 22 and SAMNUT 23). The rates of awareness were not different between the three varieties. The rate of awareness of SAMNUT 21 is estimated to 34.38%, that of SAMNUT 22 to 35.01% and that of SAMNUT 23 to 32.70%. Other varieties were fairly well known. These include 55-437 known by 73.38% or the local known by 72.12%. In contrast, other varieties were less known such as RMP12 (9.85%), RMP 91 (3.56%) or RRB (18.03%) (Table 12).

Table 12. Main source of first information on groundnut varieties in Nigeria, Mali and Niger.

Source of information	Proportion of households (%)					
	Nigeria		Mali		Niger	
	OV	MV	OV	MV	OV	MV
On-farm trial on own farm	1.42	22.54	0.68	2.51	0.00	0.00
On farm trial on another farm	5.16	13.52	7.01	13.37	2.47	3.67
Field days	1.92	2.66	0.23	0.28	0.10	0.00
Farmer-to-farmer interaction	34.78	10.25	29.86	23.40	26.70	23.39
Relatives	21.44	1.43	36.65	4.18	40.41	7.34
Demonstrations/PRAs	2.02	2.66	0.91	0.28	0.51	0.92
ADPs/Extension services	25.68	39.14	0.68	0.28	10.93	26.61
Farmers' association	0.81	2.25	0.00	0.00	0.00	0.00
Research institutes	0.00	0.00	23.53	55.71	4.12	21.10
Development projects/NGOs	1.41	2.72	0.23	0.00	9.48	11.93
TV program	0.00	0.00	0.00	0.00	0.10	0.00
Not specified	0.00	0.00	0.00	0.00	0.41	0.00
Others	3.94	1.02	0.00	0.00	4.74	5.05

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

The major sources of information according to respondents were Agricultural Development Projects (ADPs) by 53.17%; other farmers (53.52%), relatives (36.27%), and on-farm trials (Table 12). About 83.10% of farmers who were aware of the modern varieties tested it. In effect, 59.76% of farmers aware of SAMNUT 21 tested the variety, 70.66% of farmers aware of SAMNUT 22 and 71.79% of farmers aware of SAMNUT 23 tested those varieties. The major reasons for not testing these varieties were poor access to seed for 76.83%, followed by lack of cash to purchase the available seed (15.94%).

Mali. About 71% of respondents were reported as being aware of the modern varieties. The variety Fleur 11 has the highest rate of awareness, 45% followed by JL 24 (31.40%), ICG 7878 (15.70%), ICGV 86 124 (14.83%) and ICG (FDRS) 4 (14.53%). Other varieties such 47-10 are well known to 78% of farmers and others are lesser known such as 55-437 (9.30%), 28-206 (3.78%), TS32-1 (5.52%) and CN 94 C (2.91).
Niger. About 38% of farmers were aware of the new varieties. The variety RRB has the highest rate of awareness (25.61%), followed by ICG 9346 (11.05%), T 169-83 (6.20%), T 181-83 (4.58%), T 177-63 (4.31%), J 11 (3.23) and Fleur 11 (2.16). Other varieties introduced more than three decades ago are known. These include 55-437 known by 33.15% (Table 12).

Reasons for not testing modern varieties

Table 13 summarizes the reasons for not testing new groundnut varieties.
Nigeria. The majority of farmers (78%) who have not tested new modern groundnut varieties reported seed availability and accessibility to be the major constraint. Other constraints although minor include lack of money to purchase seed or lack of information on crop management practices.
Mali. No reason was cited as a constraint for not testing new varieties because of large investments in the promotion of modern groundnut varieties in pilot sites. However, it can be noted that the major reasons for dropping other varieties are susceptibility to drought and pest and foliar diseases.

Table 13. Reasons for not testing groundnut varieties reported by households in Nigeria, Mali and Niger.

Constraint/reason	Proportion of households (%)					
	Nigeria		Mali		Niger	
	OV	MV	OV	MV	OV	MV
Seed availability	41.41	77.78	0.00	0.00	48.98	61.90
Small seed size	0.00	0.00	0.00	0.00	0.00	0.00
Late maturity	2.02	0.00	0.00	0.00	0.00	0.00
Consumed seed	0.00	0.00	0.00	0.00	0.00	0.00
Drought	0.00	0.00	30.00	0.00	4.08	0.00
Pests and diseases	0.00	0.00	60.00	0.00	0.00	0.00
Low yield	0.00	0.00	0.00	0.00	6.80	0.00
Lack of money	23.23	5.56	0.00	0.00	4.76	0.00
Poor seed color	2.02	0.00	0.00	0.00	1.36	0.00
Lack information crop mgt practices	5.05	4.17	0.00	0.00	0.68	4.76
Low market value/low oil content	0.00	0.00	0.00	0.00	4.08	9.52
Others	7.07	4.17	0.00	0.00	10.05	0.00
Not specified	3.03	8.33	10.00	0.00	13.61	23.81

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Niger. As in Nigeria, seed availability was cited as the major reason for not testing new groundnut varieties. Other reasons include the lack of information on crop management practices, low oil content or low market value.

Sources of first seed reported by households

Table 14 presents the sources of first seed of groundnut varieties in the three countries.

Nigeria. The same institutions are reported as being the major sources of first seed. For example, 55.97% of the farmers interviewed claimed that other farmers were their main source of first seed, followed by ADPs for 52.67% of the farmers interviewed and relatives by 30.04%. Other sources included on-farm trials (22.22%), IAR (15.23%) and ICRISAT (2.06%).

Mali. The major sources of first information on the modern varieties are research institutes (46.73%), friends and relatives (47.25%) or observed in neighbors' fields (23.12%). Few farmers reported on-farm trials as their first source of information (3.52%). About 98% of those aware of the new varieties actually tested the varieties. The major sources of first seed reported by respondents are: research institutes (48.74%), other farmers (57.79) and family members (46.23%).

Niger. The major sources of first seed of modern groundnut varieties are extension services and research institutes accounting for 26.66% and 27.18% respectively. Farmer to farmer exchange is also another major source representing about 20.51%. Other sources although minor include rural development projects, NGOs and relatives.

Table 14. Source of first seed of groundnut varieties in Nigeria, Mali and Niger.

Source of first seed	Proportion of households (%)					
	Nigeria		Mali		Niger	
	OV	MV	OV	MV	OV	MV
On-farm trials	2.74	23.40	0.00	0.00	0.00	0.00
Farmers	33.26	17.49	37.50	28.16	19.93	20.51
Relatives	21.83	1.97	0.00	0.99	32.60	7.18
Neighboring villages	0.00	0.00	0.93	0.00	4.43	2.05
Village market/Seed trader	2.29	0.00	0.46	0.00	10.09	4.10
Research institutes	2.06	15.27	25.24	57.66	5.07	26.66
ADPs/Extension services	26.06	36.95	1.39	0.00	11.93	27.18
Others	4.68	0.74	0.00	0.00	3.69	2.05
Projects – NGOs	0.00	0.00	0.00	0.00	9.35	8.72
Not specified	5.37	1.23	0.46	0.00	3.83	1.54

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Groundnut variety adoption, dis-adoption and non-adoption

The rate of adoption remains the key impact indicator of any applied breeding research and extension program. It shows the degree of acceptance, diffusion or rejection of new research outputs. The rate of adoption is here defined as the share of farm area utilizing the new varieties (Feder et al. 1985). It is believed that this method of assessing adoption rate provides a better quantitative measure for forecasting yields and economic rates of returns to research and extension programs (Masters et al. 1996). The proportion of farmers using the technology is a social indicator of farmers' interest in the new varieties. This section starts with reasons for not planting modern varieties during the season 2006/07.

Reasons for not planting modern varieties during the 2006/07 season

In Niger and Nigeria, seed access and availability were the major reasons for not planting seed of modern varieties during the 2006/07 cropping season. However in Mali, drought and pest and diseases are cited as the major reasons for not planting modern varieties (Table 15).

Table 15 . Reasons for not planting seed of groundnut varieties during the 2006/07 season in Nigeria, Mali and Niger.

Reason for not planting this season 2006/07	Proportion of households (%)					
	Nigeria		Mali		Niger	
	OV	MV	OV	MV	OV	MV
Consumed seed	4.03	2.27	0.00	4.00	0.94	0.00
Drought	0.57	12.50	55.91	56.00	9.69	9.09
Pest and diseases	15.80	0.00	15.45	18.00	0.94	0.00
Low yield	17.23	0.00	2.94	2.00	13.12	6.06
Lack of money	7.47	4.55	0.00	0.00	3.75	3.03
Seed access or availability	28.45	69.32	9.56	2.00	39.06	51.51
Low oil content	1.15	0.00	0.00	0.00	2.81	3.03
Low market value	4.31	5.66	0.00	0.00	2.19	3.03
Lack of information on crop management	1.72	1.14	0.74	0.00	0.00	0.00
Small sized seed	2.59	1.14	0.00	0.00	0.00	0.00
Others	3.16	4.55	7.36	4.00	25.62	18.18
Not specified	4.02	2.27	1.47	0.00	2.50	6.06

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Rate of adoption of new varieties

Table 16 presents the adoption rate by variety in the three countries. Adoption is the proportion of area planted with modern groundnut varieties.

Nigeria. The rate of adoption of new varieties in and around the pilot sites is estimated to 31.84% of groundnut area cropped. The rate of adoption was estimated to 11.75% for SAMNUT 22, 10.54% and 9.55% for SAMNUT 21. Varieties introduced more than four decades ago such as 55-437 had the highest rate estimated to 25.98% with local varieties accounting for 36.18% of groundnut area. On the whole, about 55% of the farmers planted new varieties.

The reasons for not planting new varieties during the 2006/07 season were reported as poor access to seed (34.64%), low yield (22.21%), pest and diseases (15.69%), lack of cash to purchase seed (14.38%) and 'consumed all seed' (11.77%).

The main sources of seed planted in 2006/07 were farmers' own-saved seed (57.63%), ADPs (31.78%), other farmers (19.92%), on-farm trials (7.63%) and relatives (6.78%). The major types of trade transactions are cash purchase (34.58%), gift or free (28.39%) and credit (5.93%). Seed exchange is limited to 4.66%.

Mali. The rate of adoption of new varieties here is estimated to about 43.71% of groundnut-cropped area. The rate of adoption is higher on Fleur 11 estimated to about 16% of groundnut area planted, followed by JL 24 (12.46%), ICG 7878 (5.25%), ICG (FDRS) 4 (5.06%) and ICGV 86124 (4.95%). The variety 47-10 which was introduced some four decades ago accounts for 41.07% of groundnut cropped area. The major reasons for not planting new varieties this season are low access to seed of new varieties for 46% of farmers who did not plant; susceptibility to diseases and pests (35.12%), and the fact that seed was consumed before it could be planted (10.80%). On the whole, a large proportion of farmers, about 62.4%, are planting new varieties.

The major source of seed planted during the 2006/06 is by far farmers' own saved seed with 90.85%, followed by ICRISAT (9.86%) and other farmers (5.63%). The major types of seed transactions are: credit (62.8%) followed by cash transactions (38.89%), barter (9.15%) and seed exchange (7.04%).

Niger. The rate of adoption of new varieties is estimated to about 13.67% of groundnut area. The rate of adoption was highest for ICG9346 with 6.67 % of groundnut area, followed by RRB (5.84%) and T 177-63. Other varieties are at various stages of uptake. The oldest variety 55-437 is reported to be grown on 24.19% of groundnut cropped area. On the whole, 31.81% of farmers are planting new varieties.

Table 16. Proportion of area planted to new varieties relative to total groundnut area planted by selected farmers in pilot sites of Nigeria, Mali and Niger.

		Average proportion area planted	
Country	Variety	Average area (ha)	Proportion of area (%)
Nigeria	55-437	1.03	25.98
	RMP 12	0.064	2.29
	RMP 91	0.26	1.19
	RRB	0.171	2.53
	SAMNUT 21	0.393	9.55
	SAMNUT 22	0.499	11.75
	SAMNUT 23	0.411	10.54
	New varieties	1.30	31.84
Mali	ICG (FDRS) 4	0.07	5.06
	47-10	0.42	41.07
	ICG 7878	0.07	5.25
	Fleur 11	0.20	15.98
	Mossitiga	0.05	0.79
	55-437	0.02	2.63
	ICGV 86124	0.06	4.95
	JL 24	0.13	12.46
	ICG (FRDS) 10	0.00	0.00
	28-206	0.01	0.46
	TS 32-1	0.02	2.50
	Other ICGV	0.01	0.58
	New varieties	0.53	43.71
Niger	O-20	0.00	0.00
	55-437	0.41	24.19
	T 169-83	0.00	0.2
	ICG 9346	0.12	6.67
	T 181-83	0.00	0.09
	T 177-63	0.00	1.05
	TS 32-1	0.00	0.00
	RRB	0.11	5.84
	J 11	0.01	0.6
	Fleur 11	0.00	0.2
	44-16	0.00	0.0
	47-16	0.00	0.06
	JL 24	0.00	0.02
	New varieties	0.2451	13.67

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Sources of seed planted and seed transactions during the 2006/07 cropping season

Table 17 presents the major sources of seed planted in 2006/07. In all the three countries, farmer-saved seed is the major source of seed accounting for 37% in Nigeria, 43% in Niger, and the figure is very high in Mali at 84%. The latter is largely explained by the large investments made in disseminating the technology in Mali. In Nigeria and Niger, extension services and research institutes are major sources of seed.

Table 17. Main source of seed planted this year (2006/07) in Nigeria, Mali and Niger.

Source of seed planted	Proportion of households (%)					
	Nigeria		Mali		Niger	
	OV	MV	OV	MV	OV	MV
On-farm trials	2.86	6.19	0.32	1.17	1.30	3.52
Other farmers	9.10	6.78	3.23	3.52	6.06	5.63
Relatives	6.25	2.95	1.29	0.39	2.16	0.70
Own saved seed	65.89	36.58	89.03	84.37	58.03	42.96
Seed trader	1.25	0.29	0.65	0.00	0.00	0.00
Extension services/ADPs	10.18	22.45	0.65	0.00	3.24	20.42
Research institutes	1.25	11.21	1.93	1.95	0.86	4.23
Village markets	0.00	0.00	0.97	0.00	17.06	7.10
Seed companies	0.18	0.00	0.00	0.00	0.00	0.00
Cooperatives/NGOs/projects	0.18	0.84	0.65	10.54	6.48	4.93
Others	0.89	0.00	0.00	0.00	0.00	0.00
Not specified	2.68	2.65	0.97	0.00	3.24	2.82

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

In the three countries, gift transactions are very important followed by cash transactions. There are, however, differences from country to country. In Mali, credit transactions are equally important. In Nigeria, credit transactions are important only with other varieties ie, non-modern varieties. In Niger, cash transactions are very important for other varieties. The relative importance of these transactions reflects the states of the diffusion of modern varieties. In effect, in Niger, farmers are at early stages of experimentation where seed exchange is still important, whereas in Mali, where farmers have been largely exposed to modern varieties and value the product, credit and cash transactions are predominant (Table 18).

Table 18. Means of acquiring seed this year 2006/07 (except for own saved seed) in Nigeria, Mali and Niger.

	Proportion of households (%)					
	Nigeria		Mali		Niger	
Seed transaction	OV	MV	OV	MV	OV	MV
Gifts/free	31.19	51.30	24.07	10.62	65.21	72.87
Credit in kind	1.49	2.60	27.78	57.87	1.38	5.43
Credit in cash	15.84	2.60	1.85	1.33	3.00	2.33
Cash on delivery	35.15	35.06	26.85	27.88	21.66	7.75
Payment in kind	1.98	0.65	9.72	2.21	1.15	0.00
Seed exchange	8.42	3.90	9.72	3.10	1.15	0.78
Barter	8.42	3.90	0.00	0.00	0.00	0.00
Other transactions	5.96	3.90	0.00	0.00	7.37	11.63

OV=Other Varieties; MV=Modern Varieties.
Source: Regional Survey, ICRISAT/NARS, 2006/07.

Trends in adoption of modern groundnut varieties in Nigeria, Mali and Niger

Figures 3, 5 and 7 depict the proportion of area planted to new varieties during the last three years. In Nigeria, there is an increase in area planted to modern varieties from 2004/05 to 2005/06 which drops in 2006/07. This drop may be explained by rainfall conditions that were not favorable to modern varieties.

However, the cumulative number of farmers adopting modern varieties has been increasing steadily signaling farmers' interest in the new varieties (Figure 4). In addition, the uptake of modern varieties has already started in 1996 in Northern Nigeria with the ICRISAT groundnut improvement program. The dissemination was enhanced through GGP up to 2002. However, with GSP, using on farm participatory methods for technology dissemination and exposure to modern varieties, the number of adopters almost tripled.

In Mali, the area planted with modern varieties decreased from 2004/05 to 2005/06 and then increased in 2006/07. This was for similar reasons as in Nigeria, for 2005/06 was a drought year with poor crop establishment and subsequently for production as well.

As in Nigeria, the cumulative number of farmers adopting modern varieties in Mali has been increasing steadily, signaling farmers' interest in the new varieties (Figure 6). Using on-farm participatory methods for technology dissemination and exposure to modern varieties, the number of adopters increased significantly and nearly doubled from 2003 to 2004.

In Niger, the pattern is similar to that of Nigeria with large increase in proportion of area planted with groundnut varieties from 2004/05 to 2005/06 then a decrease in 2006/07 (Figure 7). This was due to similar reasons as in Nigeria: 2005/06 was a drought year with poor crop establishment and production.

As is the case in Nigeria and Mali, the cumulative number of farmers adopting modern varieties in Niger has been increasing systematically signaling farmers' interest in the new varieties (Figure 6). In addition, the uptake of modern varieties had started in 1996 in Niger with GGP. However, with GSP using on-farm participatory methods for technology dissemination and subsequent exposure to modern varieties, the number of adopters has more than doubled from 2003/04 to 2004/05.

In all countries, drought stress had a significant effect on the area covered by modern varieties. This signals the inability of modern varieties to cope with drought.

Are modern groundnut varieties spreading beyond the pilot sites?

Table 19 presents the adoption rate in the three countries based on the three categories of farmers: participants in on-farm trials, non-participants and farmers in the control villages. While the spillovers are moderate in Mali and Nigeria, it is rather limited in Niger.

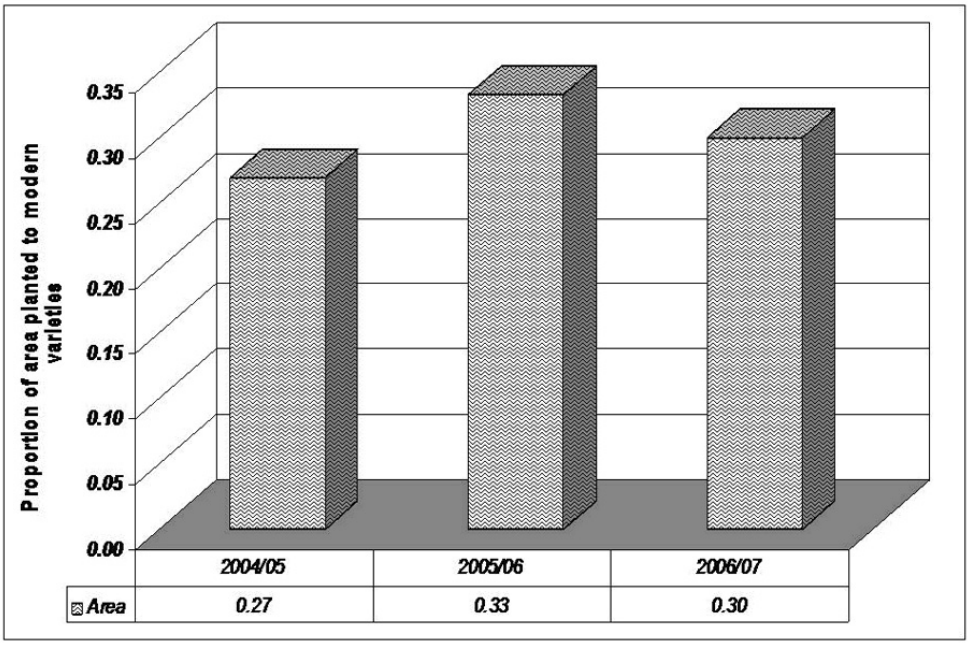

Figure 3. Proportion of area planted to modern groundnut varieties in Nigeria.

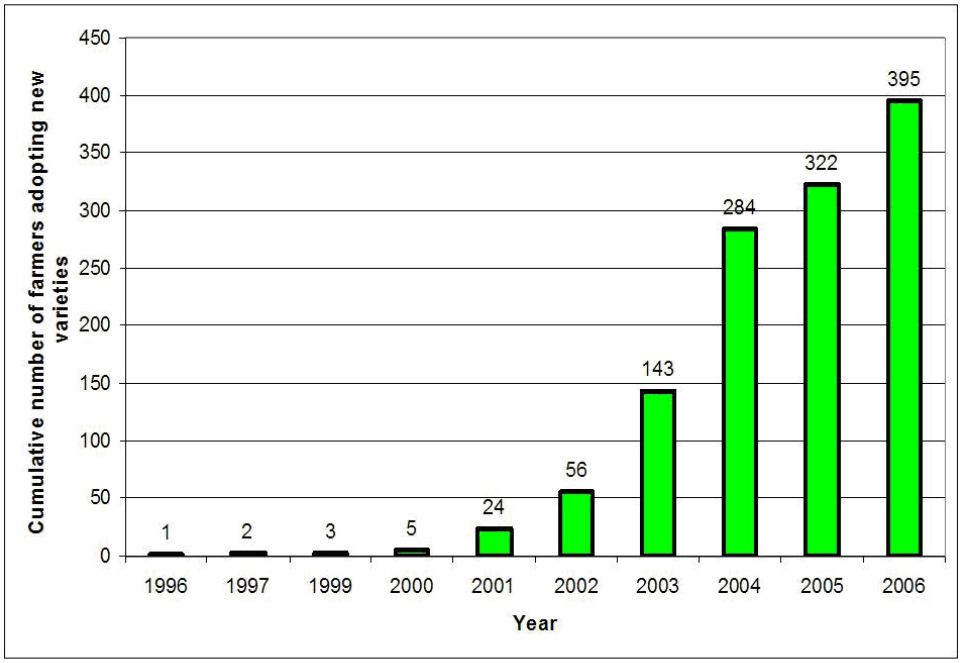

Figure 4. Proportion of farmers adopting new groundnut varieties in Nigeria.

Table 19. Adoption rate in village project sites and control sites in the three countries.

Country		Village project sites		Control villages	Total
		Participants	Non-participants		
Mali	% farmers	88.52	56.91	43.43	64.24
	% area	62.75	34.83	31.52	43.70
Niger	% farmers	50.00	25.31	24.55	31.84
	% area	15.52	13.59	12.04	13.67
Nigeria	% farmers	81.98	32.03	29.13	54.51
	% area	47.99	17.62	17.09	31.84

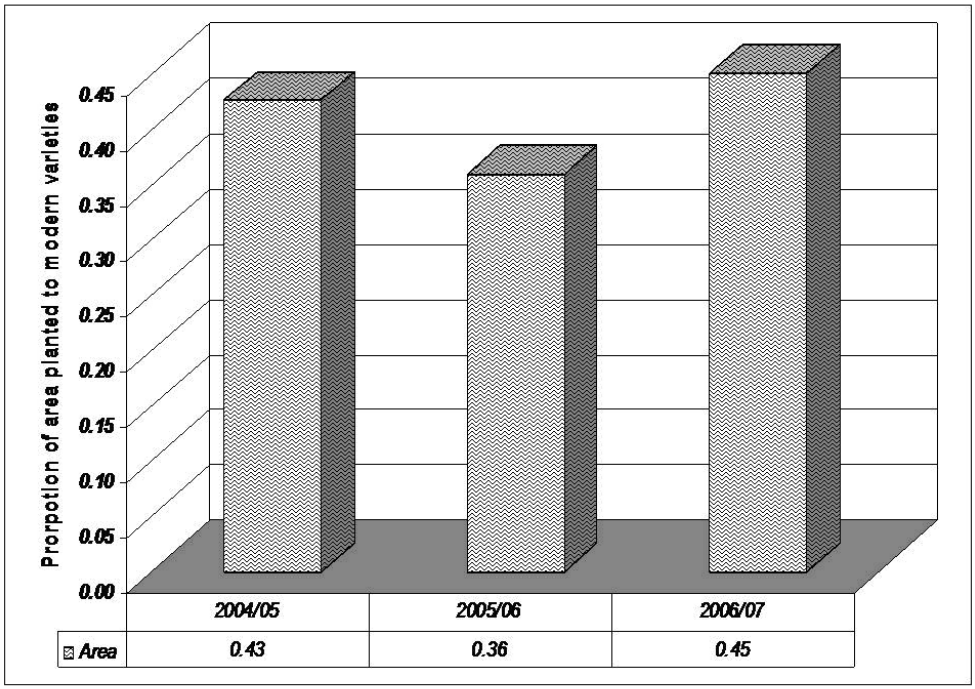

Figure 5. Proportion of area planted to modern groundnut varieties in Mali.

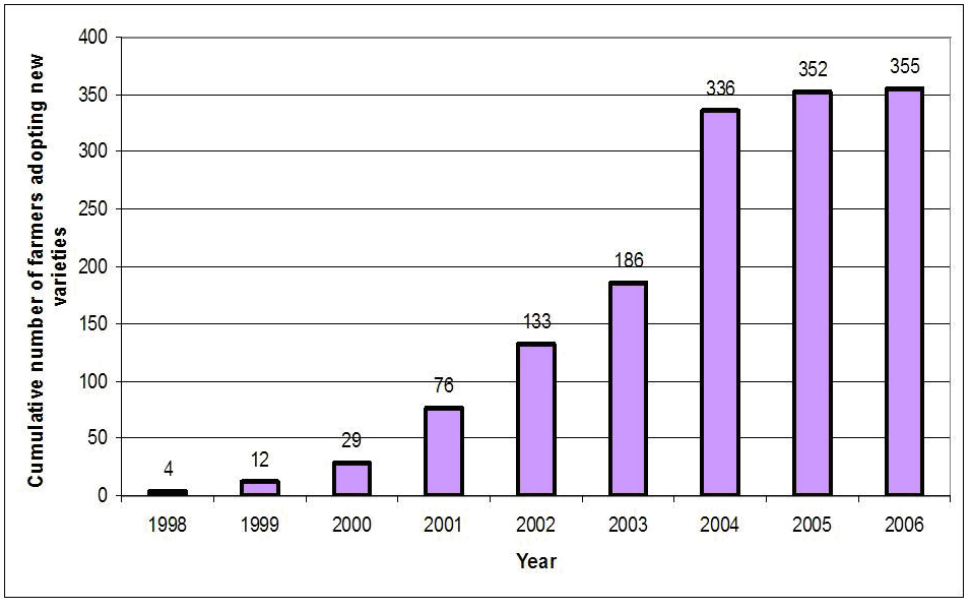

Figure 6 . Proportion of farmers adopting new groundnut varieties in Mali.

Desirable traits sought by farmers on new varieties

A thorough knowledge of the range of plant, seed and processing traits are valuable for crop improvement programs. The demands for improved groundnut varieties will likely increase if among others, varieties are designed to include producers and consumers' preferred traits. Therefore, improving the performance of varieties accounting for all significant traits will contribute to the productivity, efficiency and profitability of groundnut production in West Africa. Market prices also may be linked to desirable traits. In this study, farmers in Nigeria, Mali and Niger were asked to rate their most important preferred traits. The results are presented in Tables 20, 21 and 22.

Nigeria. Overall, the traits most preferred by farmers are high yield (27%) followed by resistance to rosette (10.60%), high market value (9.51%), early maturity (8.69%), resistance to other pest and diseases (7.23%) (Table 20). Other traits such as drought tolerance (6.86%), high oil content (6.68%), and color (6.53%) are also relatively important. Some of these traits are highly correlated. Varieties associated with high market value are those with high oil content preferred by oil processing companies. Likewise, drought tolerance and early-maturity may be strongly correlated because all varieties that mature earlier escape drought and farmers would perceive them as being drought resistant. The same trend is observed in the three varieties.

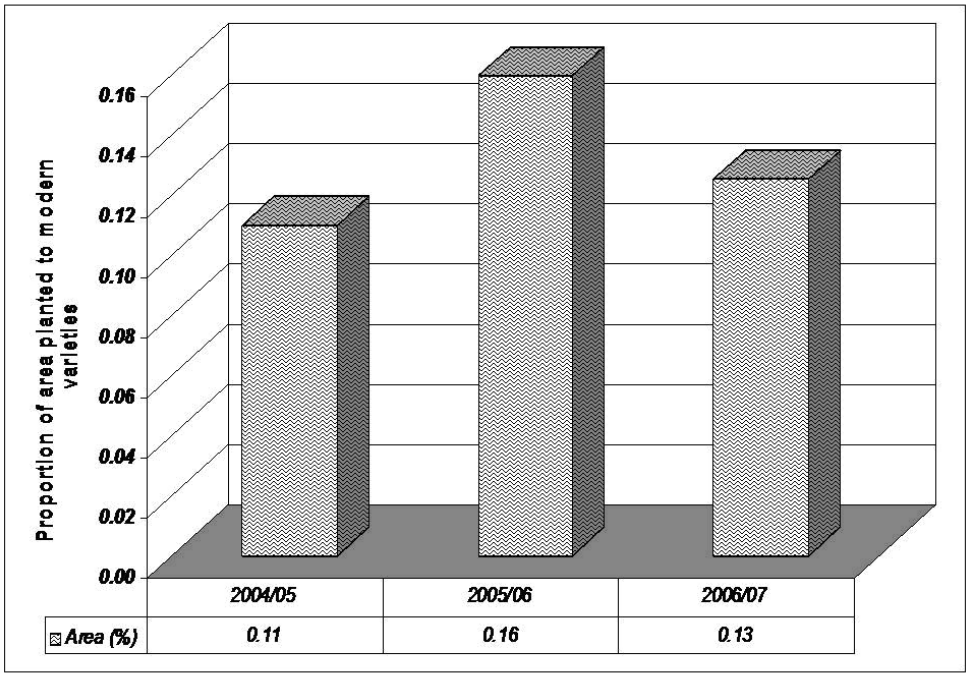

Figure 7. Proportion of area planted to modern groundnut varieties in Niger.

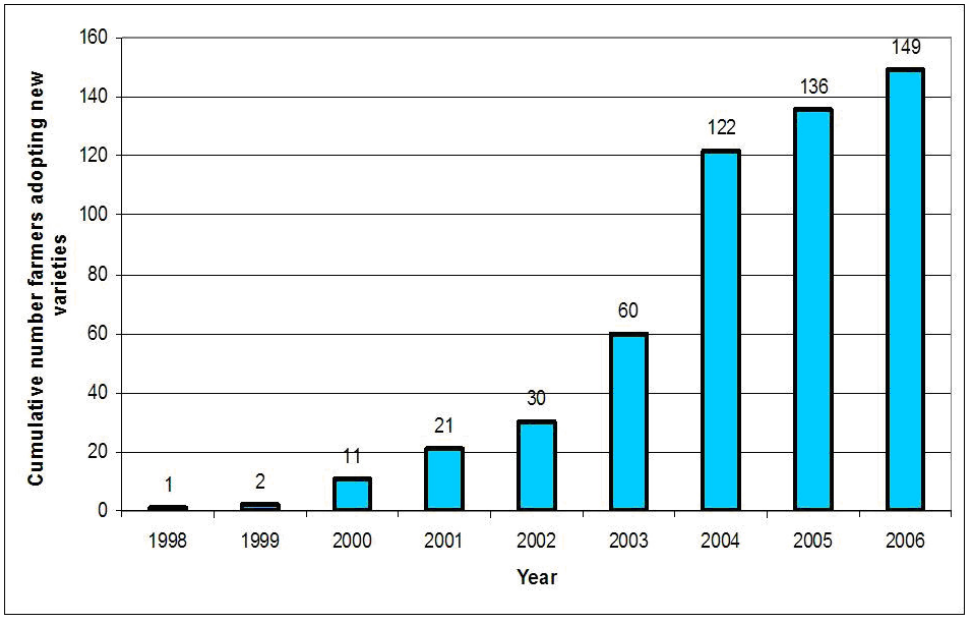

Figure 8. Proportion of farmers adopting new groundnut varieties in Niger.

Table 20. Preference for traits reported by farmers in Nigeria in 2006/07.

	Variety				
Trait	Samnut 21	Samnut 22	Samnut 23	Average	Rank
Color	8.89	4.56	6.14	6.53	8
High yield	27.73	25.16	28.33	27.08	1
Resistant to Rosette	10.24	10.48	11.09	10.60	2
Resistant to pests/diseases	6.48	8.20	7.01	7.23	5
Uniform maturity	5.54	6.41	5.87	5.94	9
Drought tolerance	6.27	8.44	5.85	6.86	6
Early maturity	7.95	9.07	9.04	8.69	4
Large seed	5.42	4.01	1.75	3.72	10
High market value	9.65	10.39	8.49	9.51	3
Easy to process	2.58	0.91	2.05	1.85	11
High oil content	4.50	8.23	7.32	6.68	7
High fodder	2.22	2.37	6.16	3.58	12
Easy to lift	0.76	1.50	0.88	1.04	13
Other traits	1.77	0.28	0.00	0.69	14

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Mali. The traits most preferred by farmers are high yield for 23%, followed by early maturity (20.04%), disease and pest resistance (12.74%), high market value (9.73%), large pods (8.25%) and drought resistance (6.50%) (Table 21). However, there are differences between varieties. The variety ICG 7878 is largely preferred for its large pod size, disease resistance and high market value; ICG (FDRS) 4 is preferred for its higher yield, disease resistance and high market value. Fleur 11, ICG 86124 and JL 24 are largely preferred for higher yield, early maturity and high oil content.

Table 21. Preference for traits reported by farmers in Mali in 2006/07.

	Variety						
Trait	ICG (FDRS) 4	ICG 7878	Fleur 11	ICG 86124	JL 24	Average	Rank
Color	0.00	0.81	0.00	0.00	0.00	0.16	11.00
High yield	21.05	8.95	29.78	27.11	28.26	23.03	1.00
Resistance to pests/ diseases	34.21	27.65	1.01	0.00	0.81	12.74	3.00
Uniform maturity	5.26	1.63	6.07	9.60	6.91	5.89	8.00
Drought resistance	7.02	7.32	6.10	4.29	7.78	6.50	7.00
Early maturity	0.00	0.81	32.87	33.16	33.36	20.04	2.00
Large pods	7.02	30.08	1.33	0.00	2.82	8.25	6.00
High market value	20.18	17.89	4.00	4.14	2.44	9.73	5.00
Easy to process	0.88	0.00	2.04	1.11	1.62	1.13	9.00
High oil content	1.75	0.81	16.80	22.61	15.57	11.51	4.00
High fodder	2.63	2.44	0	0	0.41	1.10	10.00
Other traits	0	0	0	0	0	0.00	12.00

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Niger. Resistance to disease and pests, high yield, early maturity, high oil content and uniformity in maturity are the first five traits preferred by farmers in Niger (Table 22). There are differences between varieties. While RRB is preferred on parameters of high yield, disease and pest resistance, early maturity, high oil content and color; ICG 9346 is preferred mainly for early maturity, disease and pest resistance and large pods. The variety J 11 is largely preferred for high oil content, high yield, uniform maturity and early maturity.

Overall, higher yield, disease and pest resistance, early maturity, high market value and high oil content are the most common variety traits sought by farmers in the three countries.

Table 22. Preferences for traits by farmers in Niger, 2006/07.

Variety	T 169-73	ICG 9346	RRB	J 11	Average	Rank
Color	3.33	0.00	8.54	0.00	2.97	11
High yield	23.33	8.33	27.68	16.67	19.00	2
Resistance to pests/ diseases	54.92	33.33	12.47	8.93	27.41	1
Uniform maturity	4.76	0.00	5.16	13.69	5.90	5
Drought resistance	0.00	8.67	3.48	8.33	5.12	7
Early maturity	0.00	33.33	11.46	13.10	14.47	3
Large pods	0.00	16.67	6.73	0.00	5.85	6
High market value	4.76	0.00	8.64	0.00	3.35	9
Easy to process	3.33	0.00	5.72	4.76	3.46	8
High oil content	0.00	0.00	9.77	21.43	7.80	4
High fodder	5.56	0.00	3.14	4.17	3.22	10
Other traits	0.00	0.00	0.00	8.93	2.23	12

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Farm costs and returns structure

Net returns analysis

Agricultural research is expected to develop products that give high returns when adopted by users. The survey was used to compute and compare the costs and returns structure of groundnut production using local and improved varieties. Table 23 shows the costs and returns for both local and improved varieties. Overall the major costs are borne on seed and labor. However, in Nigeria, fertilizers and pesticides account for significant share of the costs. The level of fertilizer use was found to be higher for modern varieties than local varieties. This partially explains the higher yield obtained apart from the genetic potential of modern varieties.

The costs of production are lower for local varieties. For example, the cost of production is estimated to $297/ha for local against $332/ha for modern varieties in Mali. Similarly, the cost of production is estimated to $207/ha for local varieties against $242/ha for modern varieties in Nigeria. The average cost of production of modern varieties was estimated 12% higher than the local varieties in Mali, 27% higher in Niger and 17% higher than the local varieties in Nigeria. This cost may be assumed to relatively high especially in Niger

where farmers may be cash constrained. In this case farmers do not adopt new varieties without some form of financial assistance.

The economic returns were considered generally high mainly due to substantial yield advantage. Gross income was obtained by summing seed and haulm values and the net return was calculated by deducting total costs from gross revenues. The net income (returns/ha) was estimated to $153 for the local and $293 for the modern varieties in Mali. The same trend was observed in other countries. The net income of the modern varieties was 97% higher than that of modern varieties. The highest was found in Niger where improved varieties generate 166% more income than the local varieties. In Nigeria, the percentage increase in income from modern varieties was estimated to 87%. This signals the relative economic advantage from using modern varieties.

Table 23. Costs and returns of groundnut production in Mali, Niger and Nigeria.

	Country					
	Mali (FCFA)		Niger (FCFA)		Nigeria (Naira)	
Item	Local	Improved	Local	Improved	Local	Improved
Revenues						
Pod yield (kg/ha)	665	825	440	629	829	1090
Seed value	200165	278025	123640	172346	40345	61767
Haulm value	25021	34753	13738	19150	4483	6863
Gross Income	225186	312778	137378	191496	44827	68630
Gross Income ($)	450	626	275	383	359	549
Costs						
Variable cost						
Planting seed costs	29200	43800	28000	42000	4800	5600
Seed shelling	0	0	0	0	64	64
Pesticides	250	250	222	290	274	418
Fertilizers	0	0	911	957	2726	3521
Manure	0	0	3615	4540	750	750
Land rent	0	0	0	0	2000	2000
Labor costs						
Land preparation	NA	NA	NA	NA	2500	2500
Sowing	NA	NA	NA	NA	1500	1500
Weeding	NA	NA	NA	NA	4500	5000
Fertilizer application	NA	NA	NA	NA	500	500
Pesticide application	NA	NA	NA	NA	500	750
Harvesting	NA	NA	NA	NA	2500	3500
Assembling and packaging	NA	NA	NA	NA	2050	2600
Cost of bags	NA	NA	NA	NA	1250	1600
Labor all activities	107000	110000	70000	84000	NA	NA
Maintenance equipment	1500	1500	1500	2000	NA	NA
Maintenance traction animal	3000	3000	2500	2500	NA	NA
Fixed cost						
Depreciation on tractor equipment	7052	7052	3000	3000	NA	NA
Depreciation on small equipment	500	500	500	500	NA	NA
Total costs (LC)	148502	166102	110248	139787	25914	30303
Total costs ($)	297	332	220	280	207	242
Net returns (LC)	76684	146676	27130	51709	18913	38327
Net returns ($)	153	293	54	103	151	307

LC=local currency, 1US$=500 FCFA=125 Naira; NA= Not applicable.

Table 24 shows the summary statistics of the net income for adopters and non-adopters. The average income from adopters was estimated to $204/ha significantly higher than $123/ha for non-adopters in Mali. It was the highest in Nigeria where adopters generate on average $304 against $146 for non-adopters.

Table 24. Summary statistics of mean net income of adopters and non-adopters by country ($/ha).

		Country		
		Mali	Niger	Nigeria
Non-adopters	Mean	123	63	146
	Std	62	35	102
Adopters	Mean	204	109	308
	Std	46	41	740
% gains over non-adopters		66%	73%	111%
Overall	Mean	176	77	235
	Std	53	31	554
	F-value	71.30a	47.83a	9.88a

a. significant at 1% probability, b. significant at 1% probability, and c. significant at 1% probability.

Unit cost of production

Research should produce technically efficient outcomes, more output per unit of input use. The unit cost can be used as a measure of efficiency. Unit cost of production was calculated as the total costs divided by the total yield on a hectare basis. Table 25 presents the yield and unit cost assessment of groundnut production of one hectare of local and modern varieties. The results show that the unit cost of production was lower by 11% in Niger and Nigeria and by 10% in Mali. Though modest the yield advantage over the local was estimated to 43% in Niger, 31% in Nigeria and 24% in Mali.

Table 25. Yield and unit cost assessment of groundnut production, 2006/07.

		Country		
		Mali	Niger	Nigeria
Yield (kg/ha)	LV	665	440	829
	MV	825	629	1090
Yield gains (kg/ha)		160	189	261
Yield gains (%)		24.06%	42.95%	31.48%
Total costs	LV	148502	110248	25914
	MV	166102	139787	30303
Unit cost	LV	223.31	250.56	31.26
	MV	201.34	222.24	27.80
Unit cost reduction		21.98	28.33	3.46
% unit cost reduction		9.84%	11.31%	11.06%

LV=Local Varieties; MV=Modern Varieties.

Contribution to household's income and income distribution

As noted earlier, the improved cultivars have significant yield gains over the local varieties. Farmers growing modern varieties generate 160 kg/ha in Nigeria, 189 kg/ha in Niger and 261 kg/ha in Mali over local varieties. This has occurred despite the fact that farmers did not adopt the entire recommended package. Undoubtedly if they had adopted the entire package, yields could have been higher accompanied with significant reduction in the unit cost of production.

The net income advantage was substantial. The average net income of adopters was 665 higher than non-adopters in Mali, 73% in Niger and 111% in Nigeria (Table 24). These income impacts contribute to food security as many household see their revenues increasing and can access better food, goods and services to improve their livelihoods.

The distributive effects on household types were partially analyzed using the Gini coefficient. The Gini concentration ratios were computed for the sample of farmers interviewed in each country and also in the sub-groups of farmers classified into poor, average and rich farmers based on their assets endowments (cultivable land, value of equipment, value of livestock). The Gini concentration ratios based on the distribution of income derived from groundnut were estimated to be 0.395 in Mali, 0.501 in Nigeria and 0.488 in Niger. This ratio indicates that there is a better distribution of income from groundnut in Mali than in other countries (Table 26).

Table 26. Summary statistics of mean net income of households by type and by country ($/ha).

		Type of farmers		
Country	Statistic	Poor	Average	Rich
Mali	Mean	157	187	180
	Std	46	54	55
% over the poor		0%	19%	15%
Niger	Mean	79	74	73
	Std	34	25	26
% over the poor		0	-6%	-8%
Nigeria	Mean	162	242	261
	Std	28	552	700
% over the poor		0	49%	61%

Groundnut utilization and marketing

A large proportion of groundnut produced is sold. In Nigeria, 63% of groundnut produced was sold in 2004/05 or 2005/06 and less than 16% is sold and the remaining kept as seed. No significant differences were found between adopters and non-adopters. This is partially explained by the fact that farmers are still at an early stage of adoption. In Niger, 74% and 78% of groundnut production was sold and the remaining consumed or kept as seed. The situation is somewhat different in Mali where 47% and 55% of groundnut produced was sold in 2004/05 and 2005/06 respectively. There has also been a slight imperceptible increase in the proportion of sales in Niger and Mali reflecting the introduction of modern varieties that have in turn increased the quantity produced (Table 27).

Table 27. Commercialization of groundnut by households in pilot sites in Mali, Niger and Nigeria (proportion of transactions).

Selling points		Country					
		Nigeria		Mali		Niger	
		OV	MV	OV	MV	OV	MV
	Village markets	67.97	72.30	55.43	43.03	37.15	14.71
	Urban markets	14.99	10.81	21.11	15.16	28.64	45.59
	Farm gate	2.90	5.41	0.00	0.82	0.65	0.00
	Local dealers	4.43	1.69	0.29	1.64	1.31	2.94
	Home	8.01	6.76	21.70	37.30	30.11	32.35
	Not specified	1.02	1.35	0.00	0.00	2.13	4.14
	Others	0.68	1.69	1.47	2.03	0.00	0.00
Perception of price	Good	42.08	34.12	64.22	84.84	32.24	29.41
	Fair	28.28	38.85	32.26	5.74	31.10	18.38
	Poor	2.55	0.68	2.05	8.20	14.08	8.09
	Not specified	26.41	26.35	1.47	1.23	22.58	42.12
Distance to selling points	Long	21.98	26.01	29.91	18.85	28.31	52.21
	Near	70.53	63.18	68.33	77.46	68.09	44.85
	Not specified	7.50	10.71	1.76	3.69	3.60	2.94
Readiness to sell	Sometimes	12.61	17.57	5.87	1.23	22.42	21.32
	Always	87.22	82.43	92.96	97.95	76.27	78.68
	Not specified	0.17	0.00	1.17	0.82	1.31	0.00
Buyers	Consumers	22.83	16.55	14.08	2.87	8.18	8.82
	Brokers	29.64	22.64	0.28	0.00	14.24	2.94
	Local traders	13.29	11.49	19.94	13.93	26.35	34.56
	Oil processors	0.34	1.01	0.29	0.41	14.73	16.91
	Urban traders	4.77	6.42	37.24	33.20	15.22	18.38
	Wholesalers	14.48	30.74	0.59	0.00	4.91	0.00
	Retailers	4.60	1.01	0.29	0.00	1.15	1.47
	Others	1.36	4.39	27.27	49.59	4.58	11.03
	Not specified	1.36	0.34	0.00	0.00	0.00	0.00

OV=Other Varieties; MV=Modern Varieties.

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Nigeria. The proportion of sale transactions made through village markets (69%) is higher than those made in urban markets (14%), home (8%) or farm gate (4%). There are no differences between modern varieties and other varieties

(Table 27). The results reveal that short distance trade is very important. About 68% of the transactions are made across a short distance, and 23% over long distances. Less than 5% of the transactions are made at the farm gate. Farmers claimed to easily find buyers of groundnut for 86% of the transactions made. About 21% of the sale transactions are made with consumers, 27% with brokers, 20% with wholesalers and a few with oil processors.

Mali. More than 50% of sale transactions are made in the village markets, 19% in urban markets and 28% at home. As in Nigeria, 72% of the transactions are made within short distances while the remaining are made across long distances. Farmers reported to always find buyers for 95% of the transactions. About 17% of the sale transactions are made with local traders, 36% with urban traders and about 9% with consumers.

Niger. The proportion of sale transactions made through village markets is estimated at 33%, almost equivalent to those made through urban markets (32%) and home (31%). There are not very many differences between modern varieties and other varieties (Table 27). Short distance trade is again very important. Nearly 64% of the transactions are made within short distances, and 33% at long distances. Less than 5% of the transactions are made at farm gate. Farmers claimed to easily find buyers of groundnut for 77% of the transactions made. About 28% of the sale transactions are made with local traders, 25% with processors, 12% with brokers and 16% with urban traders.

Price of groundnut products

Nigeria. For about 39% of the sale transactions made by farmers, the prices were judged good, 32% fair and very few were categorized poor. Table 28 presents groundnut selling prices reported by farmers in 2006/07 in the three countries. Prices here reflect the aggregate value of traits characterizing the varieties. In Nigeria for example, SAMNUT 23 was sold at a higher price than other varieties probably because of its high oil content and early maturity. Overall, modern varieties were sold at 10 cents more than local varieties.

Mali. Farmers reported 73% of the sale transactions to be good, 21% to be fair and the remaining poor. In Mali, the variety ICG 7878 was sold at high rates. In effect, its large pod size, taste (edible) and disease resistance justify its high market value. This is followed by other modern varieties such as ICG (FDRS) 4, Fleur 11 and JL 24. Overall, modern varieties were priced 8 cents more than other varieties.

Niger. The scene in Niger is different from the other two countries. While ICG 9346 is priced high in the local market, followed by J 11 and TS 32-1, overall the price of modern varieties was lower than that of local varieties. Farmers especially expressed a strong preference for 55-437, an old variety introduced some 40 years ago.

Table 28. Price of seed by country and variety, 2006/07.

		Local currency/kg		$/kg		
Country	Variety	Mean price (local price/ kg)	Std dev.	Mean price ($/kg)	Std dev.	No. of transactions
Nigeria	55-437	85	19	0.68	0.15	78
	SAMNUT 21	78	7	0.62	0.06	35
	SAMNUT 22	86	16	0.69	0.13	56
	SAMNUT 23	89	22	0.71	0.18	45
	Other varieties	73	24	0.58	0.19	179
	Modern varieties	85	17	0.68	0.14	136
Mali	ICG (FDRS)4	336	28	0.67	0.06	55
	47-10	270	33	0.54	0.07	133
	ICG 7878	358	46	0.72	0.09	58
	Fleur 11	327	40	0.65	0.08	121
	ICG 86124	306	48	0.61	0.10	26
	JL 24	321	39	0.64	0.08	69
	Other varieties	301	46	0.60	0.09	334
	Modern varieties	337	41	0.67	0.08	234
Niger	55-437	242	87	0.48	0.17	132
	ICG 9346	280	122	0.56	0.24	13
	TS 32-1	227	138	0.45	0.28	7
	RRB	206	96	0.41	0.19	34
	J 11	229	58	0.46	0.12	4
	Other varieties	204	93	0.41	0.19	399
	Modern varieties	199	90	0.40	0.18	65

Source: Regional Survey, ICRISAT/NARS, 2006/07.

Factors affecting adoption of modern varieties

Adoption of innovations has attracted considerable literature among development economists because it is a key driver for promoting economic development in less developed economies. Adoption is defined as the degree

of use of a new technology and its potential. Aggregate adoption, on the other hand, is measured by the aggregate level of use of a new technology within a given population or geographical area.

The rate of adoption is a critical variable in estimating the returns to research and development investments. It is the relative speed with which an innovation is accepted and utilized by members of a social system (Rogers 1962). It is defined as the proportion of the area planted with modern varieties over the total area planted to the crop. Many farmers have hypothesized factors driving adoption decisions to include: (1) human capital involving socio-personal characteristics such as age and education, household size, total work force etc, (2) technological attributes; for instance, varieties may not have characteristics sought by farmers or required by the market, or farmers perhaps cannot afford to implement the recommended technological package, (3) socioeconomic factors such as farm size, endowments in physical assets, access to credit, and (4) poorly functioning input supply and delivery systems, underdeveloped product markets, poor access to credit facilities etc.

Econometric models often used to derive quantitative measures of farm technology adoption behavior include binary choice models such as the logit or probit models where the dependent variable is a dummy that takes the values of 0 or 1. Generally the value 1 indicates that the farmer possesses particular characteristics to belong to the group of adopters and 0 represents those who do not do belong to the group of adopters. The tobit model is also frequently used in which the dependent variable is the proportion of area planted to new varieties over the total area planted with the crop.

Dependent variables

The dependent variable in the logit model is a dummy variable (0, 1) with 0 representing the group of households that have not planted modern groundnut varieties in 2006/07and 1 for farmers who have planted modern varieties. In the tobit model, the proportion of area planted to modern varieties relative to the groundnut area planted with groundnut is the dependent variable. The latter dependent variable is censored at zero.

Explanatory variables

The explanatory variables used in logit and tobit models included the following:

- Household level variables: value of assets owned (equipment, traction animals, other animals); total area cultivated; dependency ratio; total cash sales as proxy to access to financial resources; characteristics of the household head – educational attainment (none, primary, secondary, literacy training, other); age; occupation (agriculture as main occupation) or labor

participation (full-time, part-time, or not engaged in labor), household size, work force proxy by adult equivalents, etc.;

- Technology attributes (drought, diseases and pests, yields, market value);
- Institutional environment (number of household members who belong to a farmers' association as a proxy for social capital, affiliation to seed institutions, number of training in seed production, participation in seed activities, on-farm trial participants and pilot village);
- Regional characteristics – dummy variable for each region. In Nigeria, there are dummies by state (Jigawa, Kano, Katsina), in Niger (Dosso, Maradi and Zinder) and Mali (Koulikoro and Kita) dummies by region.

Tobit and logit results

Mali. The results from the logit model of adoption of modern groundnut varieties in Mali (Table 29) suggest that most determining factors for the probability of adoption are the participation in on-farm trials (+), distance to on-farm trials (-), the location in Kolokani relative to Kita (+), affiliation of farmers' associations producing seed (+), disease and pest resistance (+), social capital (+), family size (-) and the age squared (-). Other variables had the expected signs but were not significant.

Table 29. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Mali.

	Tobit model		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Age of household head (years)	0.0184874	0.028315	0.088183	0.131651	0.0135747	0.02047
Age squared	-0.0001974	0.000287	-0.00116	0.00134	-0.0001778	0.00021
Family size	-0.0380217a	0.014763	-0.1285876c	0.07073	-0.0197944a	0.01151
Illiterate	0.1141026	0.127089	-1.01372	0.673727	-0.156049	0.1051
Primary school	0.153319	0.113048	-0.19372	0.523872	-0.0309888	0.08713
Secondary school	0.0641092	0.276976	0.040607	1.05033	0.006176	0.15786
Cultivated area	-0.0281889b	0.014585	-0.04282	0.069245	-0.0065917	0.01077
Marital status	-0.1091968	0.072386	0.052469	0.320802	0.008077	0.04936
Work force	0.0410566	0.026927	0.148113	0.123533	0.0228	0.01939
Agriculture main occupation	0.1076893	0.277716	0.289514	2.19291	0.0484575	0.39628
Dependency ratio	-0.0103619	0.061366	-0.15488	0.251188	-0.0238418	0.03903
Distance to on-farm plot	-0.0412886	0.222638	-13.64161a	0.861441	-2.099953a	0.42491
Project site	0.2213189	0.277507	14.51756a	0.909939	2.234795a	0.4565
On-farm trial participation	0.6669511a	0.214003	15.73656a	0.94658	2.422445a	0.48907
Value of equipment	0.0001604	0.000206	7.69E-05	0.001108	0.0000118	0.00017
Total cash sales	-0.0001458	0.00017	-0.0009	0.000856	-0.0001378	0.00014
Value of livestock	-0.0000183	2.15E-05	0.000121	0.000141	0.0000187	0.00002
Value of animal traction	0.0002099a	7.54E-05	0.000531	0.000359	0.0000818	0.00006
Koulikoro (ref.)	0.678581a	0.140001	1.753072b	0.625497	0.3011006b	0.12736
Seed availability	-0.3581332b	0.149655	-0.06812	0.683082	-0.0106809	0.10904

Table 29. cont'd. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Mali.

	Tobit model		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Seed consumption	-0.0666898	0.195349	-0.11675	1.098192	-0.0185873	0.18064
Affiliation to seed institutions	0.186444b	0.094938	1.903131c	1.103425	0.3705806c	0.21011
Disease and pest resistance	0.0240893	0.128092	2.497377b	1.119163	0.1964827a	0.05617
Low yield	0.4027793	0.2596	1.513322	1.237556	0.143582a	0.06967
Social capital	0.2144221a	0.053116	2.018282b	1.006585	0.310689a	0.11288
Number of demonstrations	0.1073412b	0.053104	0.126393	0.356586	0.0194565	0.05506
Always sell	0.0337655	0.116181	0.179566	0.470724	0.0270276	0.06946
Low market value	1.166621c	0.585399	-	.-		
Training in seed production	-0.1280937c	0.063571	-	-		
Constant	0.930499	1.408881	68.88562	101.5688		
σ	0.5365761	0.030551				
Number of uncensored	153					
Total number of observations	341		341			
Pseudo R2	0.271		0.3849			
LR chi(32)	181.56a		159.18a			

a. significant at 1% probability level, b. significant at 5% probability level and c. significant at 10% probability level.

Participation in on-farm trials is a significant variable that increases the probability of adoption. In effect, farmers who have experimented and tested new varieties are likely to adopt because they have learned and identify themselves the desired traits. Likewise, those who are next to experimental plots have observed these varieties also during the crop cycle and have obtained information from on-farm trial participants on some non-observable traits on those varieties. The affiliation to farmers' associations dealing with seed production is an ideal forum of exchange of information on seed and varieties. Likewise, the number of institutions in which farmers are connected may explain farmers' exposure to information on new varieties.

Disease and pest pressure were perceived as significant constraints to adoption of modern varieties even prior to research and development intervention in the pilot sites. Research institutions have therefore introduced varieties that are resistant/tolerant to diseases and pests. This may largely explain the uptake of modern varieties in those sites and the fact that this trait increases the probability of uptake by farmers.

The negative sign on family size implies that large families decrease the probability of adoption of modern varieties. This may be explained by the fact that large families are more vulnerable than smaller families and may not want to take the risk of jeopardizing food security by using modern varieties. The negative and significant sign on age squared shows that there is an optimum age below and above which the probability of adoption decreases.

Compared to Kita, the location of farmers in Kolokani increases the probability of adoption. This is largely explained by more than 10 years of testing and exposure to modern varieties in Kolokani compared to Kita where farmers were less exposed to modern varieties.

Intensity of adoption

Similar results as above are recorded on the intensity of adoption. The factors that most determine intensity of adoption of modern varieties are family size (-), cultivated area (-), participation in on-farm trials (+), value of animal traction (+), seed constraint (-), affiliation to farmers'associations dealing with seed (+), market value (+), the number of household members who belong to an association (+), the number of demonstrations in which the household head has been involved (-), the number of training in seed production (-), and location in the Kolokani region (+). Other variables although not significant had the expected signs.

Large families are less likely to intensify with modern varieties compared to smaller families. This may be explained by the need for less exposure to risk of failure that may have an adverse effect on food security. A decrease in cultivated area may be a response to intensification thus using modern varieties that yield more per unit area. Participation in on-farm trials is essential to intensification

as farmers know the potential of varieties and are ready to plant proportionally more modern varieties.

Farmers who own animal traction power are more responsive to modern technologies and can already cultivate large areas and thus more likely to intensify with modern varieties. Seed availability is a significant constraint to intensification as seed supply is limited compared to the current demand in the pilot sites. Some significant traits imbedded were reported to be significant in intensification for example, the varieties with high market values. Other institutional factors such as social capital, affiliation to farmer association focusing on seed multiplication, training in seed production were found to be significant in explaining the intensity of adoption.

Nigeria. The results from the logit model of adoption of modern groundnut varieties in Nigeria suggest that factors that most determine the probability of adoption are participation in on-farm trials (+), the distance to pilot sites (-), total cash sales (+), value of livestock (-), the state of Kano relative to Jigawa (+) and the state of Katsina relative to Jigawa (+); seed availability (-), affiliation to seed institutions (+), pest and disease resistance (+), social capital (+) and part-time farming (+) (Table 30).

Participation in on-farm trials is a significant variable that increases the probability of adoption. In effect, farmers who have experimented and tested new varieties are likely to adopt because they have learned and identify themselves the desired traits. Likewise, the closer farmers are to experimental plots the higher will be the probability of adoption. The affiliation to farmers' association dealing with seed production is a nice forum of exchange of information on seed and varieties. Likewise, the number of institutions in which farmers are connected may explain farmers' exposure to information on new varieties.

Disease and pest pressure was found to be a significant constraint to adoption of modern varieties. This may be explained by the resurgence of GRD that wiped out groundnut production in the 1970s and 1980s. Farmers are likely to shift to rosette resistant varieties if the latter have other characteristics sought by farmers.

Compared to Jigawa, extension services (ADPs of Kano and Katsina) have been largely involved in on-farm trials and seed multiplication and distribution. This may explain why uptake is low in Jigawa compared to Kano and Katsina.

Table 30. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Nigeria.

	Tobit results		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Age of household head (years)	-0.0324457b	0.016641	-0.00331	0.110678	-0.000708	0.02368
Age squared	-0.0002842c	0.000153	-1.9E-05	0.001058	-4.15E-06	0.00023
Family size	-0.0145964b	0.00732	-0.012708	0.045466	-0.0027185	0.00973
Illiteracy	-0.0041735	0.391367	-0.65229	1.845155	-0.1528494	0.45808
Primary school	0.0556291	0.104449	0.225607	0.5567	0.0465134	0.11058
Secondary school	0.0006717	0.098085	0.2184	0.595403	0.0481151	0.1349
Cultivated area	-0.0022152	0.005195	-0.01197	0.030012	-0.002561	0.00641
Marital status	0.1928913	0.11468	0.983116	1.121847	0.2103014	0.23974
Work force	-0.018278	0.012691	0.016503	0.079079	0.0035302	0.01692
Dependency ratio	-0.0005433	0.001098	-0.00114	0.005933	-0.0002431	0.00127
Distance to on-farm plot	-0.0094866	0.097214	3.647984a	0.506316	0.7803513a	0.10838
On-farm trial participation	-0.6169685a	0.157909	2.992048a	0.809765	0.640038a	0.17194
Value of equipment	0.0000442c	0.000024	7.2E-05	0.000389	0.0000155	0.00008
Total cash sales	0.0000127	1.26E-05	0.0002112c	0.000115	0.0000452b	0.00002
Value of livestock	-0.0000346b	1.55E-05	-0.0002116b	9.95E-05	-0.0000453b	0.00002
Value of animal traction (Naira)	0.0000167	3.29E-05	-6.1E-05	0.0002	-0.000013	0.00004

Table 30. cont'd. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Nigeria.

	Tobit results		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Kano (ref. Jigawa)	0.2916916a	0.083904	1.395688a	0.498849	0.2715103a	0.0859
Katsina (ref. Jigawa)	0.5722092a	0.094637	3.437469a	0.63285	0.4802208a	0.06246
Seed access and availability	0.0483362	0.075172	1.957636a	0.459104	0.3230381a	0.06092
Consumption of seed	-0.4103967b	0.211686	-1.03442	1.294292	-0.2473863	0.31897
Affiliation to seed institutions	0.0913501	0.07067	0.9071509b	0.432491	0.1793392b	0.0785
Drought	-0.4016682	0.300818	1.147226	2.638514	0.1865735	0.29279
Pest and disease resistance	0.4086437a	0.097278	2.466724a	0.677916	0.3181679a	0.05279
Low yield	0.1228544	0.100967	0.05859	0.684762	0.0124224	0.14393
Cash to purchase seed	0.0155831	0.154806	0.232205	0.848393	0.0476017	0.16602
Social capital						
Members of farmers' seed associations	0.1563273c	0.090752	1.524371b	0.658942	0.2813357a	0.10683
Training crop management	0.0260107	0.052525	0.297141	0.385181	0.0635624	0.08257
Full time (ref. not on farm)	0.0647805	0.103217	0.332435	0.531013	0.0711879	0.11357
Always sell (0=no, 1=yes)	0.0081605	0.099205	0.44247	0.586852	0.0999467	0.13807
Part-time farmers (not on farm)	0.1847856b	0.095588	1.098122b	0.536445	0.210301a	0.09066
Constant	1.107695	0.705567	b-16.32562	4.112086		
σ	0.4547677	0.026112				
Number uncensored	154					
Total number of observations	334					
Pseudo R2	0.33		0.5519			
LR chi2 (32)	194.24a		239.49a			

a. significant at 1% probability level, b. significant at 5% probability level and c. significant at 10% probability level.

Intensity of adoption

The factors most determining intensity of adoption of modern varieties are age of household head (+) and age squared (+), family size (+), participation in on-farm trials (+), value of equipment (+), value of livestock (-), family size (-), the state of Kano relative to Jigawa (+), Katsina relative to Jigawa (+), pest and disease resistance (+), social capital (+), participation in seed activities (+), number of training on seed production (+) and part-time farming (+).

Niger. The results from the logit model of adoption of modern groundnut varieties in Mali suggest that determining factors for the probability of adoption are the rate of illiteracy (-), marital status (-), total cash sales (+), Maradi and Zinder regions relative to Dosso region (-), seed availability (-), affiliation to farmers' association seed producers (+) and social capital (+) (Table 31). Other variables had the expected signs but were not significant.

As in Nigeria, participation in on-farm trials, social capital, affiliation to farmers' associations and the region explain the adoption of modern varieties. In addition, the volume of total cash sales was found to be a driver to adoption. The contraints included education of household heads, marital status, the location in the regions of Maradi and Zinder, and seed availability. Other variables had the expected signs but were not significant.

The locations in Maradi or Zinder were perceived to drive down the adoption of modern varieties. In effect, on-farm trials started in the Dosso region more than a decade ago. In addition, during GSP, farmers were exposed to modern varieties through participatory variety selection trials involving both mother and baby trials. In regions such as Maradi and Zinder, it is just recently with the inception of GSP that farmers started to be exposed to modern varieties. This may partially explain why uptake has not been very important in those two regions. Seed availability is still a major constraint to adoption, requiring more efforts in empowering community based systems at producing seed and making it available at affordable price to end-users.

Intensity of adoption (Tobit model)

Similar results are recorded in Niger on the intensity of adoption. The most determining factors for the intensity of adoption of modern varieties are illiteracy rate (-), marital status (-), the value of equipment (+), the region of Maradi relative to Dosso (-), seed consumption (-), affiliation to seed institutions (-), low yield (-), social capital (+), and training in crop management. Other variables although not significant had the expected signs.

Table 31. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Niger.

	Tobit results		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Age of household head (years)	0.026177	0.029655	0.0828979	0.067767	0.016267	0.01325
Age squared	-0.00021	0.00029	-0.0007632	0.000667	-0.00015	0.00013
Family size	-0.00704	0.017832	-0.0429952	0.042813	-0.00844	0.00839
Illiterate	-0.3404658c	0.206152	-0.8249858c	0.480202	0.1618816c	0.09402
Primary school	0.25125	0.197762	0.0989256	0.410312	0.01909	0.07782
Secondary school	0.5558704c	0.290546	0.2234435	0.621356	-0.04181	0.11049
Cultivated area	-0.01631	0.010433	-0.0157993	0.021725	-0.0031	0.00426
Marital status	-0.2558012b	0.12282	-0.5772254b	0.29788	-0.1132652b	0.05821
Work force (adult equivalents)	-0.03906	0.033226	0.0089204	0.080057	0.00175	0.01571
Agriculture main occupation	-0.12641	0.231973	-0.1042035	0.506061	-0.02087	0.10328
Dependency ratio	-0.00141	0.001366	-0.0003304	0.003038	6.48E-05	0.0006
Distance to on-farm plot	0.462259	0.510512	0.7537636	1.053832	0.147906	0.20687
Project site	0.704854	0.574244	1.10218	1.215742	0.216274	0.23846
On-farm trial participation	0.067978a	0.03987	0.581273	0.25496	0.11406	0.20092
Value of equipment	0.0003393a	0.000136	0.0004631	0.000338	9.09E-05	0.00007
Total cash sales	0.00015	0.000117	0.0004851b	0.000282	0.0000952c	0.00006
Value of livestock	2.82E-06	6.23E-06	-2.07E-06	0.000018	-4.06E-07	0
Value of animal traction	3.17E-06	0.000113	0.0002642	0.000251	5.18E-05	0.00005
Maradi (ref. Dosso)	-0.9339927a	0.226854	-1.586922a	0.483364	a-.2420027	0.05297

Table 31. cont'd. Tobit and logit results on intensity and probability of adoption of new groundnut varieties in Niger.

	Tobit results		Logit model		Marginal effects	
Variable	Coef.	Std. Err.	Coef.	Std. Err.	dy/dx	Std. Err.
Zinder (ref. Dosso)	-0.18757	0.1846	0.1273284	0.433559	0.025526	0.08869
Seed availability	0.17581a	0.132061	0.8962309a	0.301239	0.1900108a	0.06666
Seed consumption	1.008297b	0.502927	1.802205	1.41413	0.421049	0.30452
Affiliation to seed institutions	0.3320777b	0.130401	0.6893935b	0.298957	0.1281861a	0.05222
Disease and pest resistance	0.193933	0.634725	-0.7104452	1.612258	0.116064	0.2107
Low yield	-0.4273822b	0.214728	-0.5290748	0.467962	-0.09346	0.07328
Lack of cash	-0.30996	0.255468	-0.186596	0.522252	-0.03521	0.09451
Social capital	0.2476739a	0.0766	0.3253601c	0.179497	0.0638433c	0.03505
Participation in farmers' associations	0.13717a	0.063665a	0.8191688b	0.331192	0.1549424a	0.06006
Training crop management	0.1137655b	0.070044	0.2683058	0.198388	0.052648	0.03892
Always sell (0=no, 1=yes)	0.19164	0.14375	0.5084042	0.331429	0.0941372c	0.05737
Low market value	0.153295	0.396514	0.5739614	0.870382	0.125419	0.20631
_cons	-2.84842	2.692487	-4.453776	5.570192		
σ	0.732063	0.064558				
Number of uncensored	89					
total number of observations	363		363			
Pseudo R2	0.1677		0.1773			
LR chi2(32)	78.04a		81.88a			

a. significant at 1% probability level, b. significant at 5% probability level, c. significant at 10% probability level.

Conclusions and implications

The results show diffusion and adoption of groundnut varieties have increased significantly in GSP pilot sites in the three countries. The rate of adoption increased from 10 to 32% in Nigeria, from about 32 to 44% in Mali and from 3 to 13% in Niger. Adoption has spread beyond the pilot sites. In Mali, 88.52% households' on-farm trial participants are growing modern varieties, 56.91% among non-participants and 43.43% in the control sites. The same pattern is observed in Niger and Mali.

Adopters of modern varieties have generated significant yield and net income gains and the unit cost of production has been moderately reduced. The yield gains from adopting modern varieties were estimated to 24% in Mali, 43% in Niger and 31% in Nigeria. Similarly, the mean net income gains from adoption were estimated 66% in Mali, 73% in Niger and 111% in Nigeria. The percentage unit cost reduction was moderate estimated to 10% in Mali, 11% in Niger and Nigeria. The latter shows that yields are still very low. This is explained by the low use of inputs such as fertilizers to boost yields to its full potential under farmers' conditions.

The major drivers of adoption have been identified to be the exposure of farmers to modern varieties via on-farm trials, the development and empowerment of farmers' associations and the involvement of small-scale seed producers tasked at producing seed of preferred varieties and the involvement of research institutes at supplying breeder seed and/or foundation seed. A number of constraints to adoption remain. These include seed access and availability, pest and diseases problems and credit constraints.

To realize the full benefits of modern groundnut varieties, farmers in West Africa would have to adopt management practices that will significantly increase yields. There is still a wide gap between farmers' realization and yields on-station. In addition, there is a need to develop groundnut markets. Though farmers are not complaining of lack of markets for their sales, their products have so far targeted only the domestic markets, and the price they receive is often low.

Questions remain about the capacity of the domestic groundnut market to absorb additional production. There is a need to address aflatoxin issues through the use of proper crop management technologies and storage infrastructure so as to enlarge the demand base to allow farmers to access the broader regional and international markets.

Adoption of modern groundnut varieties will be enhanced if governments and donors could invest more in the development of institutions and institutional arrangements that will deliver seed at affordable cost to smallholder farmers. Arrangements have to be developed to ease access to credit to farmers and organize farmers through collective actions to benefit more from the sale of their products.

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On-farm management of aflatoxin contamination of groundnut in West Africa

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Abstract

Groundnuts are prone to infestation by two closely related fungal species, Aspergillus flavus *and* A. parasiticus. *Both fungal species produce a highly toxic group of mycotoxins known as aflatoxins. Health effects in humans and livestock due to consumption of aflatoxin-contaminated foods include impaired growth, liver and other cancers, immuno-suppression, synergisms and death. These toxins can contaminate an array of crops including maize, groundnuts, spices and tree nuts.*

ICRISAT and partners have developed several technologies that can reduce risks of aflatoxin contamination. These include genetic resistance and integrated crop management practices, agronomic practices, biological control and biotechnological interventions. This paper summarizes results from on-farm trials conducted in Mali during 2003-05 under a project supported by the Common Fund for Commodities (CFC). Some of the key achievements are as follows:

- *Eight resistant/tolerant cultivars were evaluated by 10 farmers in five villages of Kolokani under their own management practices. The tolerant varieties recorded significantly lower levels of aflatoxin compared to the susceptible check.*
- *A number of agronomic practices that minimize risk of pre-harvest infection by* A. flavus *were tested in two major groundnut growing areas in Mali (Kolokani and Kayes). These technologies included the application of lime, farmyard manure (FYM), crop residues (CR) and their combinations using aflatoxin resistant (55-437) and susceptible (JL 24) cultivars. The application of lime and FYM significantly reduced aflatoxin contamination, especially in the susceptible cultivar. The application of lime alone reduced aflatoxin by 79% and the application of FYM reduced the aflatoxin content by 74%.*

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- *Several best harvesting and drying technique such as avoiding damage to pods, harvesting at right maturity, proper drying of pods were also demonstrated in Kolokani and Kayes. The aflatoxin reduction under these practices varied from 69% to 88% at Kolokani, and 63% to 84% at Kayes.*

The above management techniques can significantly contribute to healthy groundnut production and need to be promoted widely. A number of information pathways were used to increase awareness about the importance of aflatoxin contamination in groundnut and other products. These include information brochures in various languages (French, English and Hausa), training workshops/seminars, radio and television programs, end of crop season meetings, farmer-to-farmer visits.

Introduction

Context

Groundnut (*Arachis hypogaea* L.) is one of the major sources for protein, livelihood for the rural poor and foreign exchange earnings for many West Africa countries. It generates 60%, 42% and 21% of rural cash earnings among groundnut producers in Senegal, Niger and Nigeria respectively, and accounts for about 70% of rural employment in Senegal (Ndjeunga et al. 2006). However, during the last four decades, West Africa lost its position in world groundnut production and export shares. Groundnut production share declined from 23% to 15% whereas export share declined from 55% to 20%. However, since 1984, groundnut production in West Africa has been increasing by about 6% annually, mainly due to expansion of groundnut production area. Senegal and Nigeria are among the world's largest groundnut producers (Ntare et al. 2005).

Low productivity, aflatoxin regulations, stricter grades and standards have limited the competitiveness of West African groundnut in domestic, regional and international markets. Relative prices of groundnut oils are higher in the international markets, making these products less competitive compared to palm oil, cotton oil and others. To regain its competitiveness, groundnut productivity and production need to be increased significantly, technologies to reduce aflatoxin contamination must be promoted, and grades and standards met.

***Aflatoxins in groundnut*:** Aflatoxins are natural toxic chemical substances produced by *Aspergillus flavus* and *A. parasiticus*. These toxins can contaminate an array of crops including maize, groundnuts and tree nuts. Health consequences related to consumption of aflatoxin-contaminated foods include impaired growth in children, liver cancer, immuno-suppression and synergism with hepatitis B and C viruses. In April 2004, one of the largest aflatoxicosis outbreaks occurred

in rural Kenya, resulting in 317 cases and 125 deaths; aflatoxin-contaminated homegrown maize was the source of the outbreak (Lewis et al. 2005). In West Africa many individuals are not only malnourished but are also chronically exposed to high levels of aflatoxin through their diets (Gong et al. 2002). Due to deleterious health hazards, aflatoxin contamination significantly restricts the volume of groundnut exports from sub-Saharan Africa (Freeman et al. 1999). International trade restriction is particularly serious, because of the European Union's (EU) imposition of a new aflatoxin regulation, which is stricter than that suggested by the Codex Alimentarius Commission (Ntare et al. 2005). The potential seriousness of the export-restricting effect of aflatoxin contamination in the groundnut sectors in many African countries has been documented in a number of studies (Otsuki et al. 2001). The impact analysis of the European Union's new harmonized aflatoxin limits on exports from Africa indicated that 1 percent lower maximum allowable level of aflatoxin contamination will decrease groundnut trade by 1.3 percent. The results of the study suggest that the implementation of the new (and more stringent) EU aflatoxin regulations will impact adversely on African exports of even cereals, dried fruits, and nuts to Europe. More specifically, the study suggests that even though the new EU standard would decrease health risk by roughly 1.4 deaths per billion a year, it will result in a $670 million (or 64 percent) reduction in African exports, in contrast to a regulation based on an international standard suggested by Codex guidelines.

Implementing programs to reduce the levels of aflatoxin contamination will generate social benefits. Boakye-Yiadom (2003) used an economic surplus model that incorporates trade, as well as, domestic production and consumption to assess the potential benefits from research into the aflatoxin-reducing program on high quality edible groundnut exports in Senegal. Several scenarios (from a 30% increase to a 60% increase in high quality groundnut) of program-effectiveness were examined. The results support that besides enhancing farmers' welfare, the adoption of the aflatoxin-reducing program is expected to yield an overall net-gain ranging between $0.56 to 4.25 million. This study does not account for benefits accruing from improved health, nutrition and livestock.

ICRISAT has developed promising technologies based on agronomic and cultural practices that can minimize the risk of aflatoxin contamination in groundnut and its products (Waliyar et al. 2005 and 2006). The technologies need to be demonstrated on-farm to realize their impact.

Objectives

The overall goal is to reduce aflatoxin contamination to improve health and incomes of groundnut farmers and consumers through the promotion of pre- and post-harvest technologies that minimize contamination, and information dissemination to increase awareness.

Approach and methods

Analytical framework: *Aspergillus flavus* infection of groundnut occurs under pre- and post-harvest handling and storage conditions (Mehan et al. 1991). Apart from biological and physical factors, farmers' practices that lead to contamination include: absence of sorting before marketing, use of damaged and shriveled kernels as seed, delayed harvesting after physiological maturity, retention of high quantities of moisture in pods, inadequate protection from rain, pest and disease attacks. Therefore aflatoxin management should start in farmers' fields with proper crop management and handling, postharvest storage, followed by marketing and processing conditions.

Several approaches have been recognized to minimize aflatoxin-contamination in agricultural commodities. These comprise breeding for resistance to fungal contamination, good agricultural production, processing, handling and storage practices. However, there has been little success in the development of resistant varieties of groundnut that are resistant to aflatoxins (Waliyar et al. 1994). Other agronomic approaches such as avoiding moisture stress, minimizing insect infestation and reducing the inoculum potential of the causal fungi have been suggested and these may not be appropriate under smallholder agricultural systems prevalent in most parts of West Africa.

Implementing good agricultural practices such as appropriate drying techniques, drying the produce to <10% moisture, maintaining proper storage facilities and limiting exposure of grains and oilseeds to moisture during transport and marketing would minimize the problem of contamination by aflatoxins. Indeed, segregating contaminated, moldy, discolored, small shriveled or insect-infested seeds from sound kernels has been particularly useful in minimizing the level of aflatoxin contamination in Senegal.

Methodology: The trials/demonstrations were initially conducted in selected villages of Kolokani and Kayes in Mali and later extended to Nigeria and Senegal. Farmers were given a package of selected technologies identified through on-station experiments and compared with farmers' management practices in their own fields. Aflatoxin content was measured in a bulk sample from each plot of each treatment by Enzyme Linked Immunosorbent Assay (ELISA) technique developed by ICRISAT. Each farmer was taken as a replicate. Field days were conducted to expose improved practices to other farmers in villages.

Harvesting techniques such as avoiding damage to pods during harvest, crop harvest at right maturity, proper drying of pods and good storage practices were also evaluated/demonstrated.

A number of information pathways were used to increase awareness about the importance of aflatoxin contamination in groundnut and other products. These include information brochures in various languages (French, English and Hausa), training workshops/seminars, broadcast and telecast of the relevant programs.

Selection of pilot sites and setting up demonstration plots

Kolokani and Kayes in Mali represent the major groundnut growing regions of Mali. Several of ICRISAT's on-farm experiments and socioeconomic studies have been conducted for many years at Kolokani, and the groundnut program of the Institut d'Economie Rurale (IER) is based at Kayes. In these locations, groundnut is grown extensively under rainfed conditions with limited or no external inputs and are prone to end-of-season drought. Groundnut based cropping systems constitute an important source of livelihood for farmers in these areas as groundnut pods provide the much needed cash income and the haulms are a valuable source of fodder for livestock.

Participation in the trials/demonstrations was open to all interested farmers within a village. Besides scientists and farmers, the local extension agents and NGOs were also involved. Field demonstrations were conducted on an individual basis. At the end of the crop season a meeting was held between the participating farmers and extension officials to discuss progress and get feedback. These meetings provided a forum for reviewing trial management and facilitated ongoing assessment of technologies being tested. The farmers managed the trials by carrying out all field operations from land preparation to sowing, weeding and harvesting. Visits were organized for surrounding farmers to promote the flow of information and knowledge between the farmers and scientists.

Training and information dissemination

Training is a key element to build capacity and strengthen the knowledge of farmers, partners and scientists in order to promote awareness about the risks of aflatoxin contamination. We used various tools such as farmer field days, brochures and flyers, workshops, exchange visits and field trips to strengthen and build human resources in the targeted villages/areas.

Collection and analysis of data

Periodic follow-up trips were conducted to supervise project activities, collect data, and provide technical support and advice to farmers. Groundnut pod

samples from the harvested crop were taken to the laboratory for determination of aflatoxin content.

Results and discussion

Participatory evaluation of tolerant varieties

Past research has identified and developed groundnut varieties that are tolerant to *Aspergillus flavus* invasion and subsequent aflatoxin contamination (Waliyar et al. 1994). The first task was to expose groundnut farmers to these varieties through participatory on farm trials/demonstrations.

Five varieties identified from on-station screening trials were tested in on-farm trials along with resistant, susceptible and local checks. Ten farmers (two each from five villages) in Kolokai, Mali, conducted the trial. The tolerant varieties showed significantly lower levels of *A. flavus* infection and aflatoxin contamination compared to the susceptible and local susceptible checks (Table 1). ICG 6101, ICG 7 recorded low aflatoxin content <1 μg/kg compared to 1.02 for the resistant check 55-437-S, and 92.49 μg/kg for the susceptible check Fleur 11 (Table 2). The yields were reasonable considering that no additional inputs were added. The results confirm the tolerance of the selected varieties to aflatoxin contamination and can play a significant role in the integrated management of the aflatoxin problem.

Table 1. Aspergillus flavus infection (%), aflatoxin content (μg/kg) and pod yield (t/ha) under farmer management in Kolokani district of Mali. Figures are mean of ten farmers in five villages (2004 and 2005 rainy seasons).

	2004			2005		
Variety/year	*A. flavus* infection (%)	Aflatoxin content (μg/kg)	Pod yield (t/ha)	*A. flavus* infection (%)	Aflatoxin content (μg/kg)	Pod yield (t/ha)
ICG 6101	1.90	0.86	0.82	6.20	4.62	1.05
ICG 7	1.60	0.36	0.92	5.10	2.62	1.03
ICG 6222	4.10	1.86	0.82	7.70	4.86	0.79
ICGV 88274	8.41	5.87	0.72	10.00	7.79	0.86
ICGV 93093	8.97	6.71	0.85	11.20	3.99	1.11
55-347-S	1.80	1.02	0.93	9.10	3.77	1.31
Fleur 11-R	52.10	92.49	0.94	57.00	114.53	1.00
Local	25.00	16.95	0.87	18.10	27.72	1.31
SE ±	1.175	1.920	0.064	1.221	1.813	0.076
CV (%)	29	36	23	25	27	23

Integrated management

Effect of agronomic and cultural practices

a) Pre-harvest

As end-of-season drought conditions favor aflatoxin contamination, several management practices have been developed to improve water retention after cessation of rains (Craufurd et al. 2005). Results of the on-station trials showed that various soil amendments could significantly reduce aflatoxin contamination in groundnut (Table 2).

Table 2. Effect of soil amendments on aflatoxin contamination in on-station trials.

Treatment	% reduction
Lime (L)	72
Manure (FYM)	42
Crop residues (CR)	28
L + FYM	84
L + CR	82
FYM + CR	53
L + FYM + CR	83

These treatments were tested in on-farm trials at Kolokani and Kayes in Mali during the 2003 and 2005 crop seasons. In each district, farmers evaluated the cultural practices in various combinations using resistant (55-437) and susceptible (JL 24) varieties. The cultural treatments involved a combination of application of farmyard manure (FYM), lime and crop residues (CR) at sowing and 50 days after sowing. Other than lime (a purchased input), FYM and CR were farmers' resources.

The treatments included application of FYM (2.5 t/ha) before planting, lime as source of calcium at 45-50 days after sowing, CR at 50 days after planting. Five farmers in Kolokani and eight in Kayes were selected to conduct the trials. Results presented in Table 3 indicate that all treatments significantly reduced aflatoxin contamination especially in the susceptible variety JL 24. No significant differences were observed in the resistant variety (55-437) at Kayes. Application of lime was the most effective, and it reduced contamination by 73% and 85% at Kolokani and Kayes respectively. However, the pod yield was not significant and it indicates that the technology may face difficulties in adoption. Lack of sufficient quantities of CR and FYM are major constraint.

Table 3. Level of aflatoxin contamination and pod yield under various agronomic practices in Kayes and Kolokani (2003-2005).

Kolokani* (2004)				
	Aflatoxin content (μg/kg)		Pod yield (t/ha)	
Treatment/variety	55-437	JL24	55-437	JL24
400 kg/ha lime 50dap	1.90	52.34	1.16	1.06
2.5 t/ha FYM	2.07	64.07	1.27	1.09
2.5 t/ha CR	3.28	126.59	1.14	1.03
L + CR	2.76	79.53	1.24	0.96
FYM + CR	4.20	90.64	1.39	1.18
No treatment	6.21	190.84	1.00	1.07
SE ±	1.22		0.87	
Kayes**(2003 and 2004)				
400 kg/ha lime 50 dap	6.00	12.10	1.98	2.06
2.5 t/ha FYM	8.20	34.80	2.05	1.99
2.5 t/ha CR	9.20	61.45	1.84	1.80
L + CR	6.80	12.10	2.08	2.08
FYM + CR	7.50	17.50	2.05	2.01
No treatment	8.00	82.32	2.05	2.11
SE ±	4.73		0.13	

* trials by five farmers

** trials by eight farmers

b) Postharvest

Soon after crop maturity, proper harvesting, handling and storage are essential to reduce the risk of contamination. Good drying requires plenty of air circulation. Poorly dried groundnuts enhance fungal growth and aflatoxin contamination. Groundnuts need to be harvested at the right time. Delays in harvesting results in over maturity which leads to mold infestation and subsequent aflatoxin contamination.

Two on-farm trials in each of the four villages (Tioriobougou, Mambabougou, Somon and Kolokani) were conducted to demonstrate the best harvesting and drying techniques. This essentially involves lifting the plants laying them with foliage directly on the ground in a circle with pods placed towards the inner part of the circle. Layers are built up gradually decreasing the inner part of the circle. The pods are then removed at the farmer's convenience. In Kayes,

demonstrations were done with 10 farmers. In Kolokani, the reduction of contamination on a tolerant variety ranged from 48-100% and 69-88% on the susceptible variety compared to the traditional random heaping by the farmers (Table 4). Results for Kayes are presented in Table 5.

Table 4. The effects of the drying method on aflatoxin contamination (μg/kg) in Kolokani (2004).

	55-437		47-10	
Farmer	Traditional method	Improved method	Traditional method	Improved method
Bagui	1.45	0.58 (60)	17.94	2.22 (88)
Mory	3.24	1.45 (56)	13.73	1.78 (87)
Seba	1.014	0.00 (100)	15.93	4.97 (69)
Demba	1.50	0.78 (48)	14.61	3.89 (74)
SE ±	0.776			
CV (%)	29			

Figures in parenthesis indicate % reduction over the traditional method.

Table 5. The effects of the drying method on aflatoxin contamination (μg/kg) in Kayes (2004).

	55-437		47-10	
Farmer	Traditional method	Improved method (% reduction)	Traditional method	Improved method (% reduction)
Madou	10.32	5.21 (50)	71.31	20.02 (72)
Savadogo	8.08	3.03 (63)	60.08	18.01 (70)
Yaya	5.70	2.17 (62)	58.01	21.53 (63)
Mamadou	11.65	8.96 (23)	79.52	28.31 (64)
Coumba	9.90	2.32 (77)	59.62	15.73 (74)
Djenaba	6.03	3.25 (46)	74.48	27.01 (64)
Kande	8.01	1.67 (79)	44.86	14.28 (68)
Seydou	5.78	0.31 (95)	12.32	1.96 (84)
SE ±	2.999			
CV (%)	43			

Effects of the timing of pod removal on aflatoxin contamination

An on-farm experiment was initiated to evaluate the effects of harvesting methods on *A. flavus* invasion and aflatoxin contamination using eight varieties that were selected by farmers in Kolokani. Two resistant checks (J 11 and 55-437) were included. The treatments were: removal of pods immediately after lifting, one week and two weeks after, picking pods remaining in the soil (gleaning the pods). These were compared to the traditional practice.
Differences among varieties were highly significant. With farmers' practice of removing pods nearly one month after harvest of the crop, the aflatoxin content ranged from 77 to 342 μg/kg compared to 9 μg/kg for 55-437 and 6 μg/kg for J 11. Removing pods immediately after lifting reduced aflatoxin contamination by 60% and levels were 30% for removing pods two weeks after. Pods left in the soil (gleaned pods) had the highest aflatoxin contamination, which ranged from 99 to 413 μg/kg in susceptible varieties compared to 7-11 μg/kg for resistant cultivars (Table 6).

Table 6. The effects of timing of pod removal on aflatoxin levels in Kolokani* (2003-2004).

	Aflatoxin content (μg/kg)			
	Resistant cultivars		Susceptible cultivars	
Time for pod removal	55-437	J 11	JL 24	Fleur 11
0 weeks	4.5	3.6	90.5	117.7
1 Week	6.3	5.7	152.4	199.5
2 Weeks	7.4	6.1	244.4	295.2
Farmers' practice	8.7	7.1	316.3	342.2

*averaged over five farmer trials.

Monitoring aflatoxin contamination in farmers' produce

In addition to on-farm trials/demonstrations, we also monitored for aflatoxin contamination in groundnut from farmers' produce and markets in the districts of Kolokani, Kayes, Kita and Bamako in Mali. Results in Table 7 and Fig. 1 show a significant reduction in aflatoxin contamination in samples from farmers who participated in the trials/demonstrations This is an indication of adoption of improved management practices that reduced aflatoxin contamination level in groundnut in Mali. The high levels of aflatoxin contamination in market samples are of concern and indicate that post harvest handling and storage are significant predisposing factors.

Table 7. Levels of aflatoxin contamination in the groundnut growing districts of Mali.

Location	Number of samples	Aflatoxin range (μg/kg)	% with ≤ 10 μg/kg	Trials
Farmers				
Kolokani	56	0.12-75	72	Yes
Kayes	20	6-1597	50	Yes
Kita	80	4-1152	45	Yes
Dioila	30	1.4-927	7	No
Markets				
Kolokani	9	88-612	0	NA
Kita	22	30-1648	0	NA
Bamako (kernels)	291	2-2666	14	NA
Bamako (paste)	69	5-2914	0.01	NA

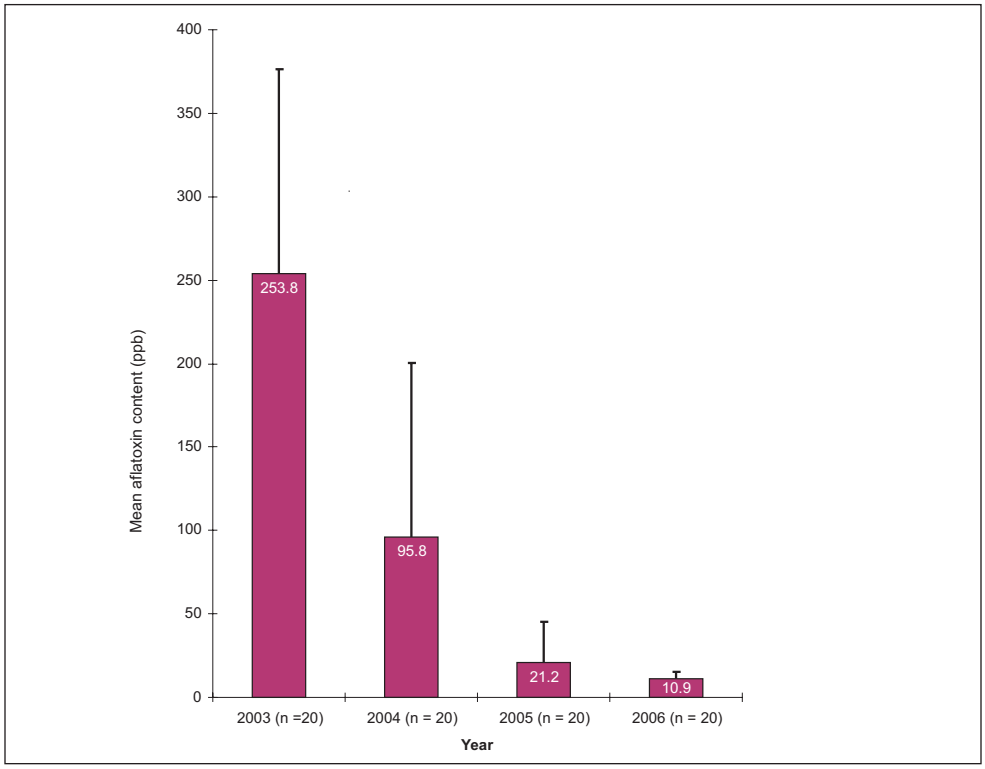

Fig. 1. Trend in aflatoxin levels in groundnut produced by 20 farmers from four villages of Kolokani, Mali (2003-2006).

Scaling-out

We have successfully developed and tested integrated management technologies to prevent pre-harvest aflatoxin contamination at the farmer level in Mali. However large scale dissemination of these technical packages, along with intensive sensitization campaigns across the commodity chain remains a major challenge. Awareness about aflatoxin contamination is improving and efforts were made to continue dissemination technology packages on the control of aflatoxin contamination at the production level.

On-farm trials/demonstrations of the best-bet harvesting and drying techniques were conducted in Nigeria for a second year and in Senegal for the first time. In Nigeria, the recommended method of drying the pods facing the sun reduced aflatoxin contamination by as high as 97% compared to the farmers' method of windrow drying. Aflatoxin content in seed ranged from 3.73 to 9.00 μg/kg under the recommended method compared to 6.00 to 337.00 μg/kg under the traditional method. These results are consistent with those obtained in the previous crop season. This simple management technique can significantly contribute to healthy groundnut production and needs to be promoted vigorously.

Farmers' awareness and perceptions of groundnut quality

Although no systematic awareness surveys were conducted in the study villages interacting with the groundnut growers, both women and men revealed that farmers' knowledge about aflatoxin is very low. The reason for such a situation is that nowhere in the production and marketing process are they ever asked to check or verify for aflatoxin contamination. None of the marketing channels where they dispose their groundnuts has any restriction on the sale of aflatoxin-contaminated products.

Farmers are normally are more concerned about good quality seed material and good marketable produce. The indicators for good quality material include: fully developed bold, big and spotless pods, clear color, good taste of kernels with high shelling percentage. Small shriveled kernels that taste bitter, have fungal growth, are rotten or sprouted and have bad odor are often discarded. However, small quantities of such inferior quality gleans (immature and shriveled seeds), broken shelled and other deformed kernels and pods are sold along with the rest of the good quality material or used in preparation of source for family consumption.

It is clear that farmers are not aware of the aflatoxin issue, and so do not perceive aflatoxin contamination as a problem in their groundnut production systems. They are oblivious of the fact that their current production and postharvest practices are likely to increase the chances of aflatoxin contamination. They do not perceive any economic risks in producing a groundnut crop that

may carry aflatoxin contamination since groundnut prices are neither influenced due to contamination nor are there any market restrictions on its sale. They also do not have information on health risks associated with the consumption of aflatoxin contaminated products including groundnut.

Enhancing awareness

In order to increase awareness about the dangers associated with aflatoxin contamination, field days were organized for more than 600 stakeholders, ie, farmers, extension agents, processors and traders. Awareness on the problem of aflatoxin was further enhanced through brochures in local (Bambara) and French languages in Mali and in Hausa in Nigeria. In Nigeria, a one-day workshop was held for extension workers and local government officials from the major groundnut growing states to increase awareness about the dangers of aflatoxin and how to minimize it. Over 100 participants attended the workshop. In Niger, a workshop was organized for researchers, extension workers, producers, traders and processors to sensitize them to the aflatoxin problems and its management. Sixty participants attended and the workshop was widely covered by local radios.

Lessons learned

- The results demonstrate that simple crop management techniques can significantly reduce aflatoxin contamination at the production level. However, technological adoption will not take place unless a series of interventions take place that give the necessary incentives to farmers and other stakeholders.
- Farmers work under several socioeconomic constraints, which are likely to become their primary concern before they are prepared for any changes to their current management practices. Introduction of new technologies entail certain conditions for adoption. Technologies that are labor intensive or that have higher financial implications to the farmer or are more input intensive are less likely to be accepted. New technologies must be simple cost effective (incur low or no costs) and must be easy to adopt.
- Though farmers pay considerable attention to the selection of seed from their own produce, lack of awareness about identification of contamination in general prevents them from using aflatoxin-free seeds. Interventions need to ensure that farmers use seeds free from contamination irrespective of the sources of supply. There is a need to build coalitions of interest for providing incentives and necessary structures that support contamination-free production and delivery for the entire food and feed chain.

- Institutional arrangements need to be explored to bring about common norms among all the stakeholders in the supply chain. Specific policy measures including legislation are required to enforce prevention of trade in aflatoxin contaminated products.
- Mass awareness campaigns are required to educate farmers, traders, processors and the consumers of groundnuts and groundnut products regarding the ill-effects of aflatoxin contamination. This may imply developing alternative marketing approaches such that the whole supply chain is intimately integrated into a single system.
- Providing incentives to farmers, health concerns, building up consumer demands for aflatoxin-free groundnuts, trade responsiveness and appropriate action research for technological change should be the operational focus of interventions.
- Effective aflatoxin control requires awareness among all stakeholders from production, through processing, to marketing and eventual consumption and consequent actions.
- Management of the risks associated with aflatoxin contamination can be controlled with an integrated system, and should involve strategies for advocacy (awareness), prevention, integrated management, policy support, and appropriate institutions linking producers to markets with quality assurance perspectives.
- Several aspects of aflatoxin R&D need further attention. These include strategies to reduce impact on trade, biological control especially adapted to specific ecologies, development of resistant cultivars using traditional and biotechnological approaches, and impact of aflatoxin management options and/or nutritional improvement on children's health in high-risk zones.
- Quality control requires appropriate legislations, regulations and standards. Compliance entails surveillance and laboratory analysis.
- The results from this study need to be scaled-out to larger geographical areas to include appropriate mechanisms and linkages to leverage changes in policy and institutions to effectively address the marketing constraints of groundnut.
- Consolidate efforts by major stakeholders in the field of aflatoxin research, with the aim to make a significant impact on reduction in contamination in high-risk commodities and improving access to markets that have been lost.

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Session IV:
Stakeholders' interventions

Farmers' voice

Rapporteur: Amadou Togo

Representatives of farmers and farmers' organizations were given an opportunity to present their experience by being involved in the project. Farmers of Wakoro represented by Mariam Coulibaly and Kolokani, represented by seed producers, Demba Traore, Boubou Traore, Bagui Traore, were enthusiastic about the new varieties introduced by ICRISAT and tested in a participatory manner. They stated that they benefited from the technical assistance and exposure to new varieties by project staff. This has raised their social status in their respective communities. The seed association of Kolokani was among the beneficiaries of a tractor provided by the state to help farmers expand their cropped areas.

The knowledge imparted has given them confidence in producing good quality seeds of groundnuts. The participatory approach used by the project staff has created a sense of ownership among the participating farmers who have become models in their communities.

However, farmers reiterated that the lack of a well organized commercialization system and poor or lack of appropriate storage facilities were major constraints hindering expansion of groundnut production. To alleviate these constraints, the Associatio'n of Farmers' Organisation in Mali (AOPP) is assisting in the construction of storage and conditioning infrastructure, disseminating information on the availability of seed, where to obtain it, how and at what price. This information is disseminated through rural radios and audio cassettes.

Experience in on-farm seed production of the NGO EUCORD in Mali

K Sako[1]

Objectives of the program

- To reinforce the capacity of farmers' organizations in the production and commercialization of groundnut seed
- Facilitate supply of high quality ground seed to small-scale farmers
- Put in place a network of seed distribution centers

[1] Coordinator, European Cooperative for Rural Development (EUCORD), BPE 457, Bamako, Mali.

General strategy

A participatory and progressive community-based approach involving adaptive variety trials, demonstration of performing varieties, training seed producers, organization and commercialization through the micro-finance scheme called warrantage.

Partners

The main partners are farmer organizations, agricultural research institutes (IER and ICRISAT), technical support units Office Haute Valle du Niger (OHVN), local NGOs (World Vision, Kilabo, Grat, and Adaf Galle); private sector and agricultural partners.

Intervention zones

Koulikoro: The federations of BalémayaTon consisting of the districts of Sanankoroba, Dialakoroba (25 villages); Mandé, Siby, Diago and Bancoumana; Ségou: The federation of YèrègnèTon comprising 32 villages; Mopti: the producer association of Sofara.

Varieties tested, demonstrations and seed production (2001-2006)

Introduced varieties from research institutions included QH243-1, Dembagnouma, Mossitiga, Saméké from IER and ICGV 91225, ICGV 92088, ICGV 92082, ICGV 92093, ICGV 92099, ICGV 92107, ICGS 11, ICGF (DRS) 4, JL24, ICGF (DRS) 10, Fleur 11 from ICRISAT.

The following varieties were selected by farmers: Fleur 11, ICGV 92093, ICGV 92099, ICGF (DRS) 10, ICGF (DRS) 4, ICGV 86124, Mossitiga and JL 24 were candidates for seed production in 2002, 2003 and 2004, In 2005/2006 the varieties multiplied were Fleur 11, Mossitiga and ICGV 86124. This program involved the federation of BalémayaTon comprising women's group of the village of Sonoria (25 members), two farmers (1 male and 1 female) in the village of Makona; 2 farmers in the village of Kanjan and 1 farmer in the village of Falanida. The quantities produced are presented in Table 1.

Table 1. Quantities of pod (kg) produced in 2005-2007.

	Fleur 11	Mossitiga	ICGV 92093	ICGV 86124
2005/06	750	350	-	320
2006/07	520	945	525	-
Total	1270	1295	525	320

Training seed producers

With the support of the GSP, the following training modules were developed and executed:

- Integrated crop management
- Quality control in the field and in the laboratory
- Seed certification
- Farmer-to-farmer visits involving farmers, extension workers and researchers to exchange ideas and learn from each other.

Program strengths

- Training farmers in crop management and quality control with support from GSP
- Creation of a women's group in Sonkoria for seed production and commercialization
- Commercialization of certified seed through micro-credit commonly known as warrantage
- Facilitating visits involving farmers, extension workers and researchers.

Lessons learned

Considering the difficulties faced, the sustainability of a community- based seed production system must consider:

- The value chain approach and gender in the conception and implementation of activities
- Enhanced capacity of producer groups and umbrella organizations for self promotion through a series of training for the capture of the market
- Access to credit within reach to facilitate production and commercialization
- Revisions of certification regulations so that farmer can benefit from their investment in seed production.

Private sector perspective

Y Attar[2]

Ingredients for sustainability

1. Organizing seed production to match demand:
    - Establish linkages between community producers and organized private seed players
    - Explore credit facilities for producers to facilitate meeting production volumes
    - Organize training and visit activities for the extension network
    - Carry out capacity-building activities to sustain and enhance quality
2. Creating the demand pull:
    - Identify industrial opportunities and create linkages to enhance demand
    - Encourage organized producer organizations
3. Identifying facilitating actors for various classes of seeds:
    - Breeder seeds: government to support activities for development and maintenance of varieties through NARS
    - Foundation seeds: National Seed Service and capable private seed companies that have been identified
    - Certified seeds: private seed companies and community based producers
4. Ensuring quality:
    - Certification and quality checks will be carried out by the national seed service

Key issues arising from the discussion

- The high cost of seed certification
- Poor information flow along the value chain
- Lack of communication channels in many rural villages
- How to ensure availability of seed close to producers

[2] Alheri Seed Company, Nigeria.

Session V:
Experiences from non-participating countries

The Gambia

ER Aubee[1] and K Trawalley[2]

Introduction

Agriculture is the backbone of the Gambian economy. It plays a very important role in the socioeconomic development of the Gambia, providing employment, rural income, foreign exchange earnings and food. The expansion of agricultural production constitutes a major pillar in national strategy for ensuring food security and poverty alleviation, as expressed in the Poverty Reduction Strategy Paper (PRSP), Millennium Development Goals (MDGs) and Vision 2020 development blueprint. Crop production in the Gambia is limited to rainfed subsistence farming and the production of short rainy season varieties from June to October. The main crops produced are groundnut, cotton, maize, millet, sorghum, rice, sesame and horticultural crops. Groundnut is the principal export crop, representing over 60% of export earnings. As with all other Sahelian countries, the unpredictable climatic situation has led to the decline in crop yields and caused acute seed shortage for most households.

The new agricultural policy of the Gambia places a lot of emphasis on improving agricultural production and productivity, agricultural diversification by introducing new high value export crops and the creation of appropriate policy and legislative framework that will facilitate the transformation from subsistence to commercial agriculture.

The groundnut economy

The groundnut sub-sector contributes about 6% of national GDP and accounts for up to 60% of export earnings and provides employment for about 80% rural farm households from an estimated 57,000 ha. Groundnut production uses between 40-45% of available arable land with up to 40% of marketable produce sold in local market (Lumos) and presumably consumed locally, providing valuable source of protein to the household diet.

Groundnut marketing, processing and export of an estimated 60% of national output provides gainful employment and a source of livelihood to a large number of urban and semi-urban settlers.

Varieties grown

Long cycle variety S28/206, short cycle duration varieties 73-33, 55-437, Fleur 11, Philippine pink and J 11 are currently grown in the Gambia. The formal seed supply system for groundnut like other crops is little developed.

[1] Savana Agricultural Research Institute (SARI), Tamale, Ghana.
[2] National Agricultural Research Institute (NARI), Banjul, Gambia.

The main suppliers of groundnut seeds in the Gambia over the recent years are Agricultural Business Services Plan (ASPA), an initiative of the Gambia Groundnut Cooperation (GGC) responsible for the coordination of various action for the recovery and development of the sub-sector.
Over the years, ASPA has undertaken the following activities:

- The implementation of an emergency seed program for the distribution of 1,000 tons of the GCC's best exportable seed to producers.
- The establishment of a seed multiplication program using planting material involving 30 tons and 200 contracted multiplier farmers selected and managed by the Gambia Groundnut Council, the Gambia Cooperation Union and National Agricultural Research Institute. The seed multiplication exercise was funded by the European Union.
- The GGC imported certified groundnut seeds from South Africa and India for testing and multiplication by NARI.

Government intervention

The Government of the Gambia in the recent past has intervened to provide groundnut seeds to Gambian farmers in order to address the recurrent seed shortages. Seeds are bought from neighboring countries and then distributed to farmers on credit.

There has been a growing concern about the quality of the seeds supplied, as they do not always meet the expectation of Gambian farmers. Such arrangements also cost the state a huge amount of money.

FAO intervention

FAO has periodically intervened in providing groundnut seeds to farmers, especially during emergency periods.

NGOs

In 1985, the Gambian government embarked upon an Economic Recovery Program in which agricultural subsidies were removed and the GPMB –GCU seed supply was discontinued. There was a policy shift towards seed production and supply by the private sector and NGOs. The role of governments through the Seed Technology Unit (STU) was limited to providing foundation seed to NGOs capable of undertaking seed multiplication. The STU maintained quality control responsibilities such as seed testing, inspection, processing and advisory services.

The NGOs obtain foundation seeds from the STU and distribute it to subsistence farmers located in various farming communities for multiplications on small plots of about one hectare.

Challenges of groundnut seed production and distribution

- There is limited public sector funding and private sector investment in groundnut seed production and distribution. The reliance on donor funding is not sustainable, but should be seen as complementary. The recommended list of varieties is limited to a few obsolete varieties that have lost their genetic integrity.
- The recurrent seed shortage is due to a variety of environmental and economic factors. There is no proper groundnut seed planning and coordinated multiplication system despite a 6-year multiplication plan proposed from basic, foundation seed, generation 1 and 2, registered seed, certified seed, generation 1 and 2.
- There is inadequate capacity to produce high quality groundnut seeds because of the lack of proper seed policy and regulatory framework. There is no coherent seed certification system.
- Marketing arrangements for groundnuts are not well organized. The use of improved seeds would also require the establishment of proper distribution networks and market-led pricing policy.
- Groundnut seed production and distribution is a specialized discipline which requires trained expertise. Capacity building of research, extension farmers and contract growers should be given due attention by policymakers.

The way forward

- Provide incentives to attract private sector operators to invest in the groundnut seed supply system. Local production of improved groundnut seeds using contract growers should be seriously promoted to private seed dealers in order to address the problem of seed insecurity in the sub-sector.
- Investments must be made in groundnut seed infrastructure eg, laboratories, irrigation facilities, multiplication sites and seed logistics.
- Critical areas for agricultural research must be pursued in close collaboration with IARCs.
- Improvements and economic application of improved techniques must be made to produce products for local consumption and export.
- Improved techniques must be developed in the areas of production, monitoring, storage, packaging and seed distribution.
- The recommended list for varieties of groundnuts must be broadened. NARI should make a concerted effort to introduce new varieties into the farming system following many years of varietal testing.

Ghana

FK Padi[1] and P Apullah[2]

The formal seed sector in Ghana

Agriculture contributes about 41% of Ghana's GDP, but it is mostly practiced by small-scale resource-poor farmers. The annual purchase of seed is not usually done, and farm level yields are less than 40% of genetic yield potential due in part to low quality seed. Annual estimates of certified seed are 30% maize, 20% soybean, 15% cowpea, 5% groundnut, 4% sorghum and 3% rice.

Policy and regulatory framework

- The main objective of this framework is to ultimately transfer seed production and supply functions to the private sector. This has gone through a number of decrees as follows:
  a. The Seed Decree of 1972 established the National Seed Council with seed certification as its major function.
  b. The 1972 Seed Decree amended to privatize certified seed production, with breeder and foundation seed remaining the responsibility of public institutions, and breeder seed still with state institutions.
  c. A new Seed Act is in advanced stages of preparation and seeks to streamline the functions of key actors.
  d. The 1991 amendment established the Ghana Seed Inspection Division (GSID) with a key function of quality control and certification of foundation and certified seed. The body also appoints manufacturers of seed packaging materials, and regulates its distribution to avoid packaging of fake seeds.

Constraints

- Lack of well trained staff to carry out the function of GSID
- Lack logistics for monitoring, particularly transport
- NGOs typically use certified seed for demonstrations, which is good, but they do not always adhere to recommended variety for a specific agro-ecology; poor performance tends to discourage seed use in subsequent seasons

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Prospects

- Various NGOs purchase certified seed to demonstrate agronomic practices, and yield potential
- Currently, the government of Ghana, under an Export Development and Investment Fund supports SARI to supply seed to vegetable oil companies
- Seeds are supplied to registered growers of each company
- Registered growers are supported with advice on various agronomic practices (capacity building for farmers)
- Foundation seed production will soon be the responsibility of the private sector with public institution retaining the role of supplying breeder seed
- Rockefeller Foundation and the Bill & Melinda Gates Foundation are to support the seed sector in Ghana
- SEEDPAG has initiated a vigorous public education campaign on the need to use high quality seed
- The Seed Act (Draft) will regulate the use of seed of GMOs, recognize breeders' rights and establish a legal framework to support key actors in the seed industry

Guinea

S Ngendakumana[1]

Groundnut seed multiplication and delivery system in Guinea-LAMIL project landscapes

Background

In an effort to ensure effective delivery and renewal of improved seeds, LAMIL (Landscape Management for Improved Livelihoods), a USAID funded project with the aim to improve livelihood and biodiversity conservation, is attempting to set up a system of community-based seed production to guide and organize farmers in seed production.

[1] Project Coordinator, Landscape Management for Improved Livelihoods (LAMIL), Guinea.

LAMIL-Guinea: Location of the four project intervention sites

Groundnut is among main crops in Guinea both economically and nutritionally; at second position is rice with about 200000 ha of cultivated area in 2002-2003. Groundnut occupies the first position among cultivated legumes and has done so with increasing enthusiasm for the past ten years. Groundnut is cultivated in association with other crops as it is an annual legume which improves soil fertility and is also used in animal feeding. The main groundnut growing areas are: Boke, Kankan, Dinguiraye, N'zerekore and Farannah. With the decrease of other cash crops, groundnut production in Guinea has doubled from 104000 t to 248000 t. This increase is mainly due to the rising number of producers involved: almost all households in Guinea cultivate some groundnut in all agricultural zones (16.41% of total cultivated area) although the farm sizes are very small on average ranging from 0.24- 0.37 ha/farmer. The average yields are very low and are estimated at 0.72 t/ha (2001) and 0.65-0.75 t/ha (2005) compared to the average world yield of more than 1300 kg/ha.

Production related challenges

The key constraints which hamper groundnut production in Guinea are:

- Lack of improved (high-yielding) varieties for farmers and no effort to differentiate varieties
- Low seed multiplication rate
- Inappropriate and traditional cultivation practices
- Pests and disease
- No input supply schemes exist and farmers are not organized around the crop
- Limited or no access to micro credit
- No seed storage facilities (postharvest losses are high)

Support activities carried out

In an attempt to set up a sustainable strategy to renew the aging groundnut planting material, the following activities were carried out:

- Thirty pilot farmers (innovators) were identified
- International research organizations – especially ICRISAT and national institutions such as ISRA were linked to to leverage solutions to some of the above constraints (acquisition of groundnut basic seed from ICRISAT-supported community-based organizations)
- Pilot farmers were trained on appropriate groundnut cultivation techniques in three landscapes

- Cost planning and benefit analysis were institutionalized to develop the entrepreneurship spirit among seed multipliers and support them with 17 kg seed each; this also extended to installing/monitoring testing plots

Considering importance of this crop to smallholder farmers, the project is attempting to set up a system of community-based seed production to guide and organize farmers in seed and market production.

Results achieved by the first farmers through the improved seeds (Fleur 11 and ICG (FDRS) 4 in 2006 created a very high interest.

Table 1. Key output on groundnut seed testing and multiplication in Guinea for the 2006 season.

Landscape	Sincery	Balayan	Souti Yanfou	Total
Total Production (kg)	3410.5	2627	510.5	6548
Average yield kg/ha (Fleur 11 & ICG)	2268	1322	1600	1730
Average yield kg/ha (local variety) for the season	700	700	-	700

From a modest beginning of 30 pilot farmers gradually more than 500 potential producers were identified though the participatory planning sessions. Expressed seed demand was estimated at about eight tons. The groundnut seed planting material harvested in October 2007 was assembled by the project and supplemented with supplies from ICRISAT-Mali and ISRA-Senegal.

Hence, input supply mechanisms put in place since the past months led to the acquisition and distribution of about 5000 kg of foundation and basic seed of groundnut Fleur 11 and ICG (FS) 4 to about 350 farmers including interested CBOs for the 2007 season. The interest on groundnut in target landscape is increasingly high that Nyalama has been added to the other three sites (Souti, Sincery and Balayan). The current dissemination process is still not meeting the farmers' demand in all the landscapes. The farmer-to- farmer dissemination approach is yielding long lasting results.

The Kilissi Research Center has been supported to reconstitute a seed bank for varieties introduced from Senegal. On the same lines, the scaling-up project component continued to strengthen the strategy to render sustainable improved groundnut germplasm. Nine prominent farmers selected among the pilot ones are being technically and materially empowered to professionalize in seed multiplication in communities while supporting the hundreds of enthusiastic farmers in surrounding villages. The first planted plots are doing well as farm maintenance operations are ongoing.

The way forward

- Improved varieties of groundnuts have been tested but need to be adopted by a critical mass of beneficiaries, which is vital for significant and sustainable impact
- Involvement of the Civil Society (NGOs, CBOs, Research, etc.) is essential to support the young seed delivery schemes in catalyzing and financing entrepreneurship and marketing
- It is important to create a platform including seed multipliers and CBOs and link them to germplasm producers to render sustainable the challenge of periodic seed renewal in Guinea.

Burkina Faso

A Miningou[1]

Introduction

Groundnut (*Arachis hypogaea* L.) is largely cultivated in the northern region of Burkina Faso except in the extreme north. Rainfall levels in cultivated areas are around 300 mm. Production in the last five years has varied between 220000 to 358000 tones of pods from an area of 250000 to 450000 ha. Groundnut is a food as well as a cash crop which is extensively used locally. A small proportion of 3 to 10% is exported. Despite the high demand both locally and regionally, groundnut is predominantly grown by small-scale farmers with limited resources. In certain areas, it is purely a women crop, which is only planted after the main cereals. The demand and supply of seed is not well structured: it is often sporadic with variable requirements from year to year.

Demand and supply

In the 1960s, groundnut seed production was assured by public institutions with bilateral or multilateral support. This was however not sustainable as at the end of each project, everything stopped. With the current decentralization, associations and farmer organizations are now responsible for all aspects of agricultural development in their localities including seed production. Seed producer groups have been created in each department, province and region with umbrella organizations coordinating their actions.

An example of such an organization is the national union of seed producers of Burkina Faso with responsibility to provide advisory services to the oil seed

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crops of the country. However these cannot guarantee the revitalization of the groundnut sector which needs to be organized. It is therefore essential to empower such structures but more important, develop a well organized seed sector in order to have positive results.

Support from development partners is essential to reinforce the various structures, to ensure that local demand, which is on the rise, is met. Equally important is to increase the productivity of the crop so that there is surplus for export for income generation that will go a along way in contributing to the fight against poverty. This offers us an opportunity to appeal to this assembly that future seed projects should include Burkina Faso.

Currently we have a program integrating the different components of the sector with but focusing on the production of nucleus and breeder seed. We seek your support.

Session VI:
Sustainability issues

In order to become sustainable in the longer term, several of the interventions initiated and financed under the project will have to be funded from local resources in the future. This will require further mobilization of resources. This secession was devoted to identify mechanisms for sustaining the achievement of the project in the project countries. Participants from each of the project participating countries elaborated on these mechanisms and were presented in the plenary. These are summarized below.

Mali

Introduction

The importance of improved seeds in the productivity and intensification of crops cannot be overemphasized. The government has tried to develop seed multiplication and distribution programs in Mali through governmental projects and a lot of investments have been made. With economic liberalization and structural adjustment programs, the government is gradually disengaging from such programs. Therefore there is a need to reflect on alternative sustainable schemes for the production and distribution of seed.

A coherent national policy on seed multiplication and distribution is imperative to enhance access to quality seed by the farmers. There is political will to develop appropriate institutional, legislative and regulatory frameworks to revive the seed sector in Mali.

Approach

The national seed policy is within the general national policy framework. This policy is anchored on the following:

1. Sustainable financing mechanisms for seed activities. This is an essential condition for attaining the objectives of producing and distributing good quality seed to satisfy the demand. It is important to reflect on and evaluate the sources of financing the sector. Currently the principal source of financing in the Seed Systems Support Project is financed by the African Development Bank.
2. Actors, and their responsibilities in the production, collection and commercialization. These include:
    2.1. The producers, who are responsible for producing good quality seed under the current seed regulations. They themselves assure the primary collection and commercialization of the seed produced. This activity is in collaboration with local traders and processors. They participate in the execution and evaluation of public programs within

their capacity of competence. Collectively they verify the coherence of their schemes with the agricultural development plans.

2.2. The Public Sector, through whose agricultural services the state provides a public service function. The main role is to develop and conserve varieties, provide breeder and foundation seed, and assure quality control. The government must also assure a favorable legal environment for the community based seed system formed by cooperatives and associations.

2.3. Farmer groups and producer groups, who play a leading role within the framework of decentralization. They execute and evaluate the agricultural schemes and programs in their localities in collaboration with professionals.

2.4. NGOs, who normally support seed producers financially and logistically in their zones of intervention respecting the current regulations.

2.5. Banks and other decentralized financial institutions that provide agricultural credit to producers.

3. Professionalization of seed activities. In production of breeder and foundation seed, the public will continue to play an important role. The private sector will exclusively produce the first (R1) and second (R2) generations of certified seed, which are organized in cooperatives, associations, federations etc. In Mali it is only well structured groups that can access credit from financial institutions to enable them produce seed and sell the produce.

4. Regulatory framework. The agriculture ministry in Mali has legislative and regulatory texts in the framework of seed production, which need to be adopted by the council of ministers. These have to be in line with sub-regional organizations such as ECOWAS and the West Africa monetary union (UEMOA). Regional seed trade is defined by separate texts.

5. Institutions involved in seed production. A number of institutions are indispensable to putting in place a national seed policy. Some of these already exist but are not operational. These need to be restructured to make them operational in the context of reorganization of the seed sector.

5.1. The National Seed Council, which is composed of the principal institutions in the agriculture sector. This council advises the minister in charge of agriculture on seed policy.

5.2. The National Committee on species and varieties is responsible for the updating of the national variety catalog. It makes an inventory and publishes the availability of seed, approves the objectives of seed production selected based on the species and variety, quantities and production required, registers new varieties and brings out a new official variety catalog.

- The institutions involved are L'Institut d'Economie Rurale (IER), the Department of Agriculture and farmers' groups. IER is responsible for the development and conservation of genetic resources and production of breeder and foundation seed. The Department of Agriculture, through services attached to it such as the National Seed Service and the Quality Control Laboratory, is responsible for training and advisory services for the producers of R1 and R2 seeds, quality control, variety registration and certification, and construction of storage infrastructure for each cooperative.
- Seed producers are responsible for crop season activities, and provide funds to execute the activities, make provisions for agricultural inputs, produce R1 and R2 seeds, collect the seed produced, assure commercialization with involvement of the private sector, provide information on the variability of seed, develop inter cooperative exchanges and disseminate information.
- NGOs and farmer organizations provide advisory support and training.
- Financial institutions provide credit to bonafide groups.

Strategies

1. Seed production

   1.1 Breeder and foundation seed. This remains the responsibility of the public institutions responsible for developing and conserving genetic resources. The government is responsible for ensuring a favorable environment for the development of community based seed production and distribution system.

   1.2. Foundation seed (R1 and R2). This needs to the responsibility of the private sector, who should also take over the existing public infrastructure of the National Seed Service. A system of contractual arrangements with traders and processors need to be put in place.

2. Minimizing aflatoxin contamination

   Positive results have been obtained in the demonstration of practices that minimize aflatoxin contamination. These need to be scaled-up to other areas. Considering the negative effect of aflatoxin on human health, policymakers need to be sensitized to put in place food safety regulations. Plans are underway to execute a national campaign and sensitization involving the health sector on the dangers of aflatoxin.

3. Capacity building

   To support the development and expansion of seed production to other regions, short duration training sessions in other regions of the country will be organized.

4. Information dissemination pathways already developed will be extended to other areas.
5. Seed commercialization will be assured by the private sector and traders will be involved in the process.
6. Seed quality controls will remain the responsibility of services responsible for this activity.
7. IER will play the role of coordinator.

Niger

I. Steps taken as part of seed production and commercialization by seed producer organizations of Kalgo, Sia, Gabi:
   - Constitution of seed stocks for seed production and a revolving fund initiated by the project (credit refunded in form of seed)
   - Training, technical assistance and warrantage provided by organized private entrepreneurs or local extension services who benefited from the GSP training
   - Commercialization: re-buying of seed by the seed unit or private entrepreneurs linked to buyers
   - Producer organizations empowered by other structures and projects such as Gidan Gaba, Madarounfa and Tajaé
   - Revolving funds available
   - Support has been forthcoming from DRDA, FAO and Seed unit–INRAN
   - Commercialization: private sector has been linked to buyers

II. INRAN seed unit
   - Continuous availability of foundation seed: research will produce breeder seed and the revolving fund will permit further multiplications
   - Contractual arrangements with producer organizations
   - Initiation public–private partnership, providing capacity building of new private producers
   - Linking producer organizations to the market

III. National forum
   - Regrouping all the actors in the sector
   - Articulation of a national groundnut strategy in line with the Strategic Rural Development Plan
   - Dissemination of GSP results to all actors in the seed sector through various pathways (brochures, technical guides, manuals and information about aflatoxin contamination).

Nigeria

The Groundnut Seed Project has been executed in Nigeria successfully for the last four years. During the project period there has been, and quite expectedly too, a few logistic problems in the actual implementation. We are however convinced that the GSP is going to impact on the lives of the target communities.

Lessons learnt:

- There is increased awareness among farmers and other entrepreneurs in seed matters
- Individual farmers and community-based associations especially women groups can produce good quality seed if offered training and assured of markets for their seeds
- Empowering the rural farmer and reinforcing farmer groups/associations through training and increased access to information can be used in scaling up the success from this project for greater impact

Sustainability

In order to sustain the achievements of the project and increase the impact on the smallholder farming community, there is a need to identify the major tasks to be carried out and the drivers. These are:

- To strengthen the partnerships that have been created during the execution of this project and the positive synergies therein. This is a task that should be led by the organized private sector.
- To scale out successful results. Since Seed Units already exist in the Agricultural Development Projects, which are the Agricultural Extension arms of the government in Nigeria, these should be used to maintain the cohesion that has been created within farmer groups who are responsible for community seed production.
- NARS will continuously promote improved groundnut varieties that meet farmer's needs and market requirements, reinforce the capacity of farmers and other entrepreneurs in seed production, processing and marketing.

Senegal

Many positive results have been obtained and include:

- Farmers have been empowered to select varieties of their choice
- Farmers have skills in seed production and postharvest technologies
- Rural entrepreneurs have been trained in small-scale seed business management

- Many farmers are aware of the dangers posed by aflatoxin contamination on trade and health
- Farmers are aware of techniques of good crop husbandry and their benefits
- Farmers are becoming aware of market opportunities
- Linkages between the various actors have been initiated
- Research will continue to develop new varieties and produce nucleus seed of promising lines
- Producer organizations involved in the production of quality seed need to be further organized
- Involvement of the private sector in seed production must be sustained
- Sensitization of actors along the value chain on aflatoxin must continue and extend integrated management techniques to a much wider area

Institutions involved

- ISRA, which will coordinate research
- NGOs, Council of Agriculture and Rural Development, Ministry of Agriculture are participating
- ASPRODEB, which is financed by PSAOP, is involved. This is fostering partnership between research for training, multiplication trails and good crop husbandry; producers of high quality grains in the groundnut basin; producers of foundation seed under irrigation; producers of certified seed in the groundnut basin and the creation of networks of grain producers organizations and seed producers.

Conclusions and recommendations

There are opportunities to regain groundnut's share in local, national, regional and even international markets. Small farmers are responding to the new opportunities, but have not been able to fully exploit them. This is largely due to a number of factors: the lack of human and financial resources to maintain improved varieties, the weak extension services with no means to accomplish their tasks, state interventions that discourage private sector initiatives, the persistence of constraints such as poor transport infrastructure, and communications, the absence of accurate and up-to-date market information and lack of capacity among growers to organize themselves to market their produce effectively. There is also lack of awareness among many farmers of the opportunities for value addition through agro-processing; for example through peanut butter production and oil extraction.

The project's contribution to the development of the groundnut sector as a whole varies from country to country and remains subject to resource limitations and factors that are beyond the project's direct control.

Interventions are needed to improve both groundnut productivity and the value chain. To realize this, farmers in West Africa have to adopt management practices that will significantly increase yield. There is still a wide gap between farmers' and on-station yields. An important role can be played by farmers' organizations, with coordination at the national level, to facilitate collective action and reduce transaction costs. This is particularly important to improve marketing systems so that farmers have stronger influence on pricing and get a better return for their investment. Ultimately, however, the dissemination of improved seed on a sufficiently large scale to have a major impact in reaching poor farmers relies on the involvement of the private sector in seed production and marketing. This requires collaboration between public research organizations which generate improved varieties as public goods and private companies that are able to obtain adequate returns from their investment.

Groundnut seed is bulky (involving high transport costs to a large number of dispersed farmers); has low multiplication rate (requiring a large amount of seed to plant); is self-pollinated (can be grown for many years without loss of purity) and is fragile. For such a crop, seed supply arrangements should emphasize schemes that entail low transaction costs investments. Therefore, targeting the improvement in the capacity of village seed systems to maintain and distribute seeds is essential to ensure sustainability.

Greater efforts are needed to encourage governments to deregulate seed systems in their countries and provide incentives for private companies to invest in the production of seed generated by public research organizations. Pressure also needs to be exerted on countries which permit the import of other vegetable oils leading to unfair competition and undermining capacity in the region.

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About CFC

The Common Fund for Commodities (CFC) is an autonomous intergovernmental financial institution established within the framework of the United Nations. The Agreement Establishing the Common Fund for Commodities was negotiated in the United Nations Conference on Trade and Development (UNCTAD) from 1976 to 1980 and became effective in 1989. The first project was approved in 1991.

The CFC forms a partnership of 106 Member States plus the European Community (EC), the African Union (AU) and the Common Market for Eastern and Southern Africa (COMES A) as institutional members. Membership is open to all Member States of the United Nations or any of its specialized agencies, or of the International Atomic Energy Agency, and intergovernmental organizations of regional economic integration, which exercise competence in the fields of activity of the Fund.

CFC's mandate is to enhance the socio-economic development of commodity producers and contribute to the development of society as a whole. In line with its market-oriented approach, the Fund concentrates on commodity development projects financed from its resources, which are voluntary contributions, capital subscriptions by Member Countries. Through cooperation with order development institutions, the private sector and civil society, the Fund endeavors to achieve overall efficiency in and impact on commodity development.

About ICRISAT®

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a nonprofit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 600 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

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