Enhancing groundnut productivity and production in West and Central Africa

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Summary

Globally, groundnut is one of the important grain legumes with Asia and Africa being the main producing continents. West and Central Africa (WCA) accounts for almost 70% of groundnut production in Africa. The crop plays an important role in ensuring livelihood of the farmers and significantly contributes to the export sector of the countries in the region. The groundnut productivity in the region is limited by the number of abiotic and biotic stresses, such as drought, foliar diseases, rosette and aflatoxin contamination. The gap between potential and realized yield is large in subsistence farming. Improving productivity at the farm level and bridging the yield gap require varieties that have farmer- and market-preferred traits, including those that enhance and stabilize productivity, increase profitability of the crop and thereby the income of smallholder groundnut farmers. ICRISAT has been working with national partners in the region since the 1980s to improve groundnut productivity. Consequently, improved technologies were developed and promoted. The ICRISAT – WCA groundnut improvement program participated in TL II funded by the Bill & Melinda Gates Foundation to enhance groundnut productivity and production in the region. The project is built on the achievements made by ICRISAT and partners in groundnut improvement in the last 30 years. The TL II project had two phases that lasted seven years (2007 – 2014), and this report highlights the progresses made during both the phases in WCA. During phase I of the project, Mali, Niger and Nigeria were the target countries. Burkina Faso, Ghana and Senegal were included during phase II. The report focuses on three aspects: firstly, socioeconomics or targeting studies, which were mainly conducted during phase I; secondly, variety development activities conducted during both phases I and II; and thirdly, seed systems activities conducted during both phases I and II.

Key achievements

Crop improvement

The project was implemented in three countries (Mali, Niger and Nigeria) during phase I, with the addition of three other (Ghana, Burkina Faso and Senegal) during phase II. The major activities focused on farmer PVS, breeding lines development and capacity building. Significant achievements were made in all the areas.

Farmer PVS

The demand for improved groundnut varieties will increase if varieties are developed with 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 production in West Africa. PVS using the mother and baby trial approach has been used to assess farmers' trait preferences for varieties and increase farmers' exposure to new groundnut varieties. PVS were carried out at various

locations in each country. The PVS started with 18 locations (six locations each in Mali, Niger and Nigeria) during the 2007 – 2008 cropping season and expanded to various locations over the years. In Mali, three pilot sites were identified in each region: Diankoute Camara, Sadiola and Dialafra in Kayes; Marako, Diorila and Faladie in Koulikoro. In Niger, the experimental sites were Doula, Guida Gaba, Koma Beri, Tanda, Tounga and Wassangou in the Dosso region. In Nigeria, the pilot sites were located in the states of Jigawa, Kano and Kastina that account for more than 50% of the total groundnut production. In each of the pilot sites a mother trial was set up in a randomized complete block design of five varieties with five replications (four new varieties and a local check). The plot size for each variety was 10 x 10 m per replication. The mother trials were implemented collectively by farmers selected by the village chief or farmers' associations. The PVS sites for Burkina Faso included Boulgou, Kouritenga and Koulpelego (Eastern region); Sanmatenga, Bam and Namemtenga (Northern region); and Boulkiemdé, Ziro and Sissili (Western region) while sites for Ghana included Wungu and Wulugu (Northern region); Sandema and Paga (Upper East); and Lawra and Tumu (Upper West). In Senegal, sites were spread in four regions: Baba Garage (North region); Darou, Paoskoto, Kayi, Nganda (Central region); Sinthioumaleme (Eastern region); and Sedhiou (Southern region).

Based on the PVS trials, the national program in Niger released four varieties (RRB, ICG 9346, J11 and Fleur 11) in 2010. In Nigeria, three short-duration rosette resistant varieties were released: SAMNUT 24 in December 2011 and SAMNUT 25 and SAMNUT 26 in December 2013. In Mali, eight varieties, including ICGV 86015 and ICGV 86124, were selected by the farmers for various regions and effort is being made for its official release. In Senegal, six varieties were released since 2007 while four varieties were released in Ghana during the same period. The released varieties as well as varieties proposed for release showed a yield advantage of up to 42% over the local varieties grown by the farmers with some of the varieties yielding over 3 t/ha in some of the locations. The on-farm trials by ISRA facilitated wide adoption of the extra-early maturing varieties (75 – 80 days) in Louga in the Northern region of Senegal where groundnut is grown by almost all the households with active participation of women. Farmer meetings were also organized in all the villages aiming at exposure to the new released varieties. The average yield for selected varieties included in PVS trials for the Kayes region of Mali from 2008 – 2010 is shown in Table 6.

In a particular year, 400 – 1,500 farmers directly or indirectly participated in the trials in each participating country. Participation of technology transfer/extension institutions and farmers organizations facilitated the access of farmers to new varieties, management practices and information dissemination. In Niger and Mali, groundnut farmers, especially women, are keen to adopt new improved varieties. Various pathways were used to share information, methodologies and outputs among the stakeholders. This was achieved through hosting workshops, annual planning sessions, progress reports, user-friendly brochures and flyers, on-farm and on-station field days, farmer-to-farmer visits and radio and television coverage. Each year, over 5,000 farmers were made aware of the availability of new improved varieties.

Table 6. An example of mean pod yield (kg ha^{-1}) of PVS varieties averaged over 2008 – 2010 from Kayes region in Mali.

	Diankounté Camara				Sadiola				Dialafra			
Variety	2008	2009	2010	Mean	2008	2009	2010	Mean	2008	2009	2010	Mean
Fleur 11	690	1,450	1,480	1,206	1,520	3,000	2,800	2,440	1,100	749	1,650	1,166
JL 24	550	990	1,450	997	1,700	2,800	2,800	2,443	1,100	646	1,015	920
ICGV86124	700	1,600	1,675	1,325	1,900	3,800	3,500	3,067	1,220	611	1,850	1,227
ICGV86015	550	1,700	1,380	1,210	2,200	3,600	3,150	2,983	1,180	589	1,750	1,173
Check	760	890	950	867	1,610	1,100	1,100	1,270	760	400	1,120	760
Mean	650	1,336	1,387	1,224	1,802	2,860	2,670	2,444	1,072	660	1,477	1,070

Breeding line development

Significant achievements were made in developing new breeding lines and it's sharing with the national partners. The intensive hybridization program was initiated at ICRISAT – Mali with various trait-specific (productivity, aflatoxin tolerance, rosette, drought, early maturity, early leafspot (ELS), late leafspot (LLS)) segregating populations developed over the years. The crossing program utilizes local or popular (ruling) varieties, improved varieties and newly identified sources of variability. Some of the parent varieties include ICG 7878, ICG 7, ICG 6222, ICG 4440, ICG (FDRS) 4, ICGV 00350, ICGV 86124, ICGV 91114, 55-437, J11, JL 24, Fleur 11, 47-10 and ICIAR 19 BT. Over the years, ICRISAT supplied more than 2,400 trait-specific advanced breeding lines (resistance to aflatoxin contamination, foliar diseases, rosette, early and medium maturing, confectionery types and drought tolerant) to the national programs of the project target countries and other countries in WCA (Table 7). Currently, ICRISAT – Mali groundnut breeding program is making selections on newly developed populations (more than 150) that are found at various stages of selection, from F_1 to F_6. Besides, over 700 advanced breeding lines are available from the breeding program that will be evaluated for yield and other traits in observation nurseries as well as replicated trials. These breeding lines will also be shared with NARES for evaluation in multi-location trials. Further, 179 lines are being genotyped and phenotyped for ELS-QTL analysis for marker-assisted breeding. The breeding program utilizes off-season seed increase under irrigation and main season evaluation of breeding materials for the traits of interest.

Table 7. Number of groundnut breeding lines distributed to NARES in WCA

	Years						
Countries	2008	2009	2010	2011	2012	2013	2014
Burkina Faso	–	–	–	–	74	–	58
Ghana	–	36	–	55	4	–	–
Niger	67	457	–	20	–	297	–
Nigeria	241	–	256	22	253	–	–
Senegal	–	–	–	5	43	3	–
Mali	380	19	–	–	46	–	–
Others	–	47	26	–	–	3	–
Grand Total	688	559	282	102	420	303	58

The distribution of advanced breeding lines to NARES partners is a continuing process. ICRISAT will continue to develop new populations for specific traits and their combinations (high yield, drought tolerance; disease resistance including ELS, aflatoxin and rosette; and human nutrition including oil content, Oleic to Linoleic acid (O/L) ratio). The program will benefit from the achievements of TL I and TL II to move forward with implementing integrated groundnut breeding in the region. The technological advancements including phenotyping platforms, genotyping tools (molecular marker-assisted selection, marker-assisted backcrossing, whole genome sequencing and genotyping by sequencing) and bioinformatics/data analyses and management tools will be utilized for increased efficiency of the breeding program. Efforts are going on to digitize the data collection and analysis process using hand held Samsung Galaxy Tabs and Panasonic Tough pads.

Seed systems

ICRISAT seed systems strategy in WCA is two-fold.

1. Improving access to seed for smallholder farmers that concentrate on subsistence production through the enhancement of local village seed systems;
2. Exploiting market niches where farmers produce for the commercial market by developing seed markets. Research on seed systems include: (a) identifying seed supply constraints and recommending options to improve its efficiency; (b) carrying out a range of market experiments to uncover the demand for seed and farmers' willingness to pay for seed; (c) to test a range of seed production and delivery options; and (d) search for options to scale-out and scale-up alternative technologies for seed production and delivery schemes. Alternative seed supply systems were characterized and tested, and cost-effective systems identified.

Identification of constraints for groundnut seed supply and delivery systems

The major constraints limiting the performance of groundnut seed systems in West Africa 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;
- Subsidized and inefficient seed production;
- Uncertain and thin seed demand;
- Missing, non-functional or irregular meetings of the National variety release committees;
- Weak integration between the seed and product markets; and
- Lack of enabling policy and institutional environments.

Strategies to enhance seed production and delivery schemes

To search for strategies to enhance seed production and delivery schemes, data on costs of seed production and delivery by all institutions involved in the seed chain were gathered. Basically, two schemes were pursued: the public seed multiplication and delivery scheme (NARES and traditional extension services) and community-based organizations (CBOs) including farmers' associations and small-scale seed producers. The results showed that seed production through the public sector institutions is very high. Direct foundation seed production through NARES in their farms and managed by NARES personnel is very costly, that is about $3.28 per kg. However, the seed production through contract growers can significantly reduce the cost of production. Farmers' associations and small-scale producers can produce high quality foundation seed at lower costs, ($1.10 per ha). The major cost items in seed production are manual harvesting, weeding, seed and land preparation. Opportunities for mechanization should be explored.

Based on the analysis of costs involved in seed production and delivery systems in West Africa, it is clear that the production of Breeder Seed should remain as the responsibility of NARES. However, the commitment of the government to support NARES in the production of breeder seed is considered essential. Revolving fund schemes within NARES should be supported by the government to ensure sustainability. The production of Basic Seed could be facilitated through contract farming with small-scale seed producers or farmers' organizations with technical backstopping from NARES. The production of certified seed should be entirely the responsibility of farmers' organization and small-scale seed producers.

Table 8. Trend in groundnut seed production (in tons) in Mali, Niger and Nigeria, Burkina Faso, Ghana and Senegal (2007 – 2013).

	Year							
Country	2007	2008	2009	2010	2011	2012	2013	Total
Mali								
Breeder	–	3.2	3.0	1.7	1.8	1.3	11.5	22.5
Foundation	–	6.3	5.1	8.6	28.2	32.7	34.5	115.4
Certified/QDS	1.2	28.3	57.5	79.4	72.0	88.0	120.0	446.4
Subtotal (1)	**1.2**	**37.8**	**65.6**	**89.7**	**102.0**	**122.0**	**166.0**	**584.3**
Niger								
Breeder	0.1	0.7	0.2	0.5	0.3	5.5	2.0	9.3
Foundation	0.9	7.7	10.4	14.2	13.3	20.8	23.0	90.3
Certified/QDS	–	11.8	27.0	25.7	62.6	147.6	215.0	489.7
Subtotal (2)	**1.0**	**20.2**	**37.6**	**40.4**	**76.2**	**173.9**	**240.0**	**589.3**
Nigeria								
Breeder	–	–	1.0	0.4	0.8	1.7	0.5	4.4
Foundation	–	1.3	10.8	2.8	–	4.5	4.0	23.4
Certified/QDS	0.8	20.3	41.0	88.5	111.6	945.9	1,061.8	2,269.9
Subtotal (3)	**0.8**	**21.6**	**52.8**	**91.7**	**112.4**	**952.1**	**1,066.3**	**2,297.7**
Burkina Faso								
Breeder	–	0.7	0.8	0.7	0.7	0.8	1.0	4.7
Foundation	–	6.0	8.0	7.0	7.5	8.0	10.0	46.5
Certified/QDS	–	80.0	78.0	71.0	75.0	77.5	85.0	466.5
Subtotal (4)	–	**86.7**	**86.8**	**78.7**	**83.2**	**86.3**	**96.0**	**517.7**
Ghana								
Breeder	–	1.2	1.1	0.9	1.8	1.6	1.4	8.0
Certified/QDS	–	9.5	12.0	14.5	11.8	12.7	10.3	70.8
Subtotal (5)	–	**10.7**	**13.1**	**15.4**	**13.6**	**14.3**	**11.7**	**78.8**
Senegal								
Breeder	–	–	–	19.0	20.0	15.0	18.0	72.0
Foundation	–	–	–	280.0	400.0	200.0	83.0	963.0
Certified/QDS	–	–	–	1,851.0	2,159.0	2,229.0	2,483.0	8,722.0
Subtotal (6)	–	–	–	**2,150.0**	**2,579.0**	**2,444.0**	**2,584.0**	**9,757.0**
Grand total	**3.0**	**177.0**	**255.5**	**2,465.9**	**2,966.4**	**3,792.6**	**4,164.0**	**13,824.5**

Efforts were made to enhance seed production of various classes (breeder, foundation and certified/quality declared seed) and delivery schemes. A total of 15,112 tons of quality seed of all classes were produced (Table 8) during the project of which 121 tons were breeder seed, 1,239 tons were foundation seed and more than 12,465 tons were certified/QDS.

Marketing strategies for tested seed

Developing a major marketing strategy for tested seeds include the sale of small pack groundnut seed. This scheme was largely successful. More than 10,000 small pack seeds were sold. The farmers revealed their preference for smaller pack sizes ranging from 0.5 kg to 1 kg of treated seeds. However, major differences in sales/profitability were found on the positioning of selling points, the level of knowledge of agro-dealers and small-scale retailers on marketing and business skills and agro-ecological zones. Sale were found to be lower in drier areas as compared to the less dry ones.

Training in seed production, marketing and management skills

More than 1,000 farmers and extension agents were trained on seed production techniques every year. And more than 55 retailers or local seed producers from Mali and Niger were trained in small-scale seed marketing and business skills with the technical backstopping from WASA-SEEDS. During the implementation of the project, Mr Diarra Mahamadou registered and obtained his MSc degree from the University of Ouagadougou, Burkina Faso. His thesis topic focused on the "Adoption of improved varieties in project sites in Mali".

Development and dissemination of information themes or programs

Supply and access to information by smallholder farmers remain a major constraint to adoption of technologies in West Africa. The baseline studies revealed that many smallholder farmers are not aware of new technologies and varieties. Even when they are aware of they do not have information on the modern varieties or seed supply sources. In an attempt to reduce the information constraints, the TL II project has contracted with rural radios in the intervention sites to offer information on technologies and innovations to smallholder farmers. Thus, four radio programs on crop management and seed production were developed by the RADIO Faraa in Gaya district and Radio Rounkououm in the Doutchi district of Niger. In addition to the information on crop management and seed production, during the small pack sales between April and June each year, information on improved varieties were also disseminated to the smallholder farmers. The supply of information has impacted the sales and access to seed by farmers in and around the project sites.

Adoption and impacts

This section summarizes the TL II project achievements targeting the promotion of groundnut varieties and drawing lessons from interventions in Mali, Niger and Nigeria. The groundnut outlook (ie, trends and market prospects) were studied and better understood; project sites were thoroughly characterized and varieties and traits preferred by farmers were identified. Adoption of improved groundnut varieties has increased as a result of farmers' exposure and access to seed of improved varieties.

In addition, a total of four reports have been generated:

a. Outlook for groundnut trends and market prospects in West and Central Africa;

b. Characterizing village economies in major groundnut producing countries in West Africa: Cases of Mali, Niger and Nigeria;

c. Farmer preferences for groundnut traits and varieties in West Africa: Cases of Mali, Niger and Nigeria; and

d. Early diffusion of groundnut varieties in the Dosso region in Niger.

A synopsis of results from the reports is presented below.

Outlook for groundnut trends and market prospects in WCA

WCA lost its world groundnut production and export shares during he last four decades. The groundnut production shares declined from 27% to 20% whereas groundnut oil export shares decreased from 55% to 24%. Senegal remains the lead groundnut oil exporter (19% of world exports) in WCA, followed by Nigeria (1.20%). Senegal exports significant amount of groundnut cakes accounting for 10% of the world total. WCA's contribution to confectionery groundnut exports fell by half from 43,956 tons to 27,495 tons from 1979 – 1981 to 2005 – 2007, respectively. Although its global share declined, groundnut production in WCA has been increasing since 1984 by about 4.6% annually due to the area expansion. Senegal and Nigeria remain among the largest world groundnut producers. Groundnut still remains a

major source of employment, income and foreign exchange in many WCA countries. Therefore, there is a need to reassess the market prospects and highlight opportunities for the region to regain its market share. The competitiveness of WCA groundnut in the domestic, regional and international markets has been limited by the low productivity, aflatoxin regulations, and stricter grades and standards. Relative prices of groundnut oils are higher in the international markets making these products less competitive as compared to the oil palms, cotton oil and other oil fruits. There are market niches for confectionery groundnut. Access to this market would require knowledge of market requirements, especially EU markets. To regain its competitiveness, significant increase in the groundnut productivity and production, promotion of technologies to reduce aflatoxin contamination and establishment of grades and standards are needed.

Baseline surveys in project countries

Three baseline studies were carried out from November 2007 to February 2008 in program and non-program sites in Mali, Niger and Nigeria, where the TL II project started its activities in 2007. A purposive random sampling was used to select program sites: Kayes and Koulikoro from Mali, Dogondoutchi, Dosso and Gaya from Niger, and Jigawa, Kano and Katsina from Nigeria. Next to every selected program site was a non-program site (a neighboring village) or the non-intervention area. In each program site, 10 on-farm trial participants were selected from the population of participants and five non-trial participants were selected from the population of non-participants. 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. In total, 298 non-trial participants and 494 trial participants were surveyed.

The survey results indicated that groundnut was planted in about 36% of total cultivated area in Mali, 15% in Niger and 34% in Nigeria. Groundnut contributed to 64% of household cash revenues in Mali, 66% in Niger and 54% in Nigeria. It accounted for 28% of the total value of crop production in Mali, 31% in Niger and 23% in Nigeria. No statistical differences were found between the program and non-program villages. The groundnut market participation was very high where many households sold groundnut in Mali and Niger and many purchased groundnut in Nigeria. In Mali, 46% of households were net-sellers with no differences between the program and non-program sites. In Niger, about 79% of households were net-sellers of groundnut with high rates in program versus non-program sites. In Nigeria, 72% of households were net-buyers of groundnut with significantly more households buying groundnut in program versus non-program sites. Gender wise, 85% of private or individual plots belonged to women in Mali and 35% in Niger. In Nigeria, there was little participation of women in groundnut production activities. However, women were largely involved in local groundnut processing activities. There were no differences based on program and non-program villages.

Modern groundnut variety uptake in surveyed sites was estimated to be less than 5% except in the Dosso region in Niger, where this was estimated to be 14% of the groundnut planted area. The survey results showed that about 40% of groundnut area was planted with the variety 47-10 in Mali. In Niger, 47% of area was planted with the variety 55-437 and in Nigeria the variety ex-Dakar (ie, 55-437) was planted on 41% of groundnut area. These are ruling varieties introduced at colonial times in the 1950s. Households sourced planting seed from past harvests, village markets, other farmers, family and parents. However, majority of the seed was sourced from the past harvest accounting for 80% in Mali, 86% in Niger and 71% in Nigeria. The major constraint in using improved varieties that has been reported by the farmers is the non-availability of seed for 83% in Mali, 60% in Niger and 56% in Nigeria. The households have little access to seed of the varieties released less than 20 years ago. Lack of cash was cited as a major constraint in Niger and Nigeria. Low grain and haulm yields, lack of information on crop management, fitness in association and undesirable color were also cited as the major constraints in Nigeria. The use of other inputs (credit, inorganic and organic fertilizers) remains limited in the surveyed areas where, on an average, farmers used less than $20/ha of inputs in Mali, $21 in Niger and $123 in Nigeria.

The major lessons drawn from the study include:

1. Groundnut is a major source of cash for smallholder farmers in WCA;
2. Groundnut is a major source of cash for women farmers;
3. Many households participate in the groundnut markets compared to other crops such as cereals;
4. Old ('ruling') varieties are still dominant;
5. The use of inputs, such as fertilizers in groundnut cultivation is very limited; and
6. Majority (71 – 86%) of the households still draw their seed from past harvests.

Recognizing farmers' preference for traits and varieties

The PVS trials revealed that the farmers were able to discriminate most of the major plant and seed traits. The trials enabled assessment of farmers' preferences for plant and seed traits of selected varieties using structured surveys administered to a panel of farmers in each of the pilot sites. The color of the leaves, maturity (short cycle), number of pods, pod size, constriction, pod yield, pod filling and taste were the important attributes explaining farmers ranking for varieties in Mali. In Niger, the color of the leaves, the number of pods, pod filling, pod beak, and pod yield were the most important traits sought by the farmers. In Nigeria, plant vigor, plant maturity, plant type, number of pods, pod size, haulm yield and pod yield were the important traits. For some traits, varieties selected for the PVS were similar or identical restricting the farmers to differentiate between the varieties based on those characteristics. The varieties selected by farmers can be site-specific, and attributes such as color of leaves, pod reticulation and pod beak tends to get neglected. The lessons learned include: (1) a better choice of varieties for PVS with different traits and (2) the need for targeting varieties to recommendation domains.

Early diffusion of groundnut varieties in the Dosso region, Niger

The contribution of groundnut to cash income of smallholder farmers has significantly increased in the surveyed areas that are attributed by the increase in the total value of groundnut sales. Sixty-six percent of household cash revenues contribution of groundnut during 2007 – 2008 has increased to 83% in 2009 – 2010. No statistical differences were found between the program and non-program villages. The groundnut market participation has also shown an increase. About 79% of households were net-sellers of groundnut in 2007 – 2008 against 93% in 2009 – 2010 while 39 and 42% of households were net-buyers of maize and pearl millet, respectively.

The uptake of modern groundnut varieties in the Dosso region in Niger has increased significantly from 14% (2007 – 2008) of groundnut area planted with improved varieties to 64% (2009 – 2010). Variety RRB accounted for more than 90% (ie, 56%) of the area covered with improved varieties. The use of other inputs (credit, inorganic and organic fertilizers) has not improved in the surveyed areas. But access to seed has significantly improved as a result of building seed supply systems in the project sites. Access to major productive resources is still limited for women, and female farmers still plant less groundnut area (0.77 ha) than men (0.94 ha). In particular, female farmers have almost no access to organic fertilizers. About 2.5% of surveyed female farmers used manure in their fields against 22% for men.

Capacity building

NARES in WCA lack human resources and infrastructure to execute an efficient groundnut breeding program. These weaknesses have limited the flow of improved varieties and farmers continue to grow old varieties that were developed or introduced more than half a century ago. One of the objectives of TL II project has been to enhance the capacity of some of the NARES to breed groundnut with multiple attributes.

Degree training

Ms Nana Mariama Idi Garba of INRAN, Niger, completed her MSc program in breeding at the University of Niamey in 2010. Mr Mamary Traore, IER-Mali, completed his MSc from the University of Ouagadougou, Burkina Faso in 2012. Mr Coulibaly Adama completed his PhD from Ghana in April 2014. Mr Adama Zongo from Burkina Faso and Mr Ousmane Sanogo from Mali started their PhD research on groundnut breeding in 2013. In addition to the graduate students, three undergraduate students conducted their final year bachelor's degree thesis work on groundnut breeding. These included Mr Prosper Gassinta and Mr Harara of the Polytechnic of Katibougou, Mali and Mr Youssouf Camara from the University of Niamey, Niger. Two PhD students (from Niger and Nigeria) at the West Africa Center for Crop Improvement (WACCI), University of Ghana, were also mentored to formulate and present their thesis research project proposals on groundnut breeding.

Non-degree training

NARES staffs managing the groundnut breeding programs were offered hands-on training on breeding principles and ways to manage a breeding program including priority skills such as hybridization, data capture and analysis. At the start of the project, ICRISAT – Mali conducted two day in-country training workshops in Mali, Niger and Nigeria on breeding methods and data capture. A total of 15 (five in Mali, two in Niger and eight in Nigeria) participants benefited from the training. A methods manual was prepared. A training module on crop management and seed production was also produced. This was shared with the project staff in the partner countries. A 10-day intensive training workshop on groundnut breeding methods and techniques was held at ICRISAT – Mali from 26 January to 6 February 2009 where four scientists from Nigeria, two from Mali and one from Niger were involved. The course covered a range of topics where a technical guide for groundnut breeding technologies of 10 training modules was compiled in English and French. Two technical guides in groundnut breeding and PVS were prepared and their soft copies were made available to the participants. The project also contributed to the training of research technicians from IER (Mali), INRAN (Niger) and ICRISAT – Mali in data capture and analysis using the GENSTAT statistical program from 9 – 20 February 2009. A total of 33 participants attended the training program. A breeder and pathologist from the six project countries (Mali, Ghana, Burkina Faso, Nigeria, Niger and Senegal) were involved in the one week training at ICRISAT – Mali conducted in October 2013 on groundnut breeding techniques and disease management. The phenotyping workshop was attended by 12 participants involving senior breeders, plant pathologists (Ghana, Nigeria and Senegal) and senior research assistants (Burkina Faso, Niger and Mali).

Physical capacity building

The phenotyping facilities (laboratory and field) in Mali, Niger and Nigeria were rehabilitated. In Mali, a half-hectare plot at the same research station of IER was fenced for drought and foliar disease screening or phenotyping. In Niger, the irrigation system at Maradi was rehabilitated to enable phenotyping for drought stress, generation advance and assurance of production of breeder seed. This involved purchase of two immersible water pumps and regeneration of wells to ensure constant water availability and an 18 KVA generator to ensure electric power supply. The pathology screen house was also rehabilitated to ensure disease phenotyping and maintaining inoculums for target diseases and insect pests. Other

infrastructure improvements included: renovation of the seed store, purchase of laboratory equipment, such as electronic balances, refrigerator, plastic sheeting, groundnut sheller, a motorcycle, a digital camera and office furniture. In Nigeria, screen house phenotyping facility for groundnut rosette disease and raising the aphid vector needed rehabilitation. The genotyping facility was enhanced by the purchase of an Alpha merger mini analysis system, digital thermal printer, alpha InfoTech computer and high gloss thermal paper. At the beginning of the project, no hybridization activity was conducted at any of the participating NARES. After the training of technicians in managing crossing blocks and the rehabilitated facilities, hybridization has been initiated at INRAN (Niger) and IAR (Nigeria).

Farmer's Training

Before the implementation of the PVS trials, a 1- to 2-day training session was conducted for the participating farmers in the respective locations. Group meetings were also held during field monitoring by the project staff. More than 2,000 persons including farmers and extension agents have benefited from the training by the end of 2009. In 2010, a total of 150 women from the farmer groups in five villages in Sanakoroba district of Mali participated in a pre-sowing 2-day training program in good practices of producing groundnut. In November 2013, a total of 48 women from farmer groups were trained in seed entrepreneurship including postharvest seed management, marketing, book keeping and related financial or business management aspects. In addition, 10 village agents (all men) and two staff (one woman and one man) of PLAN – Mali also benefited from the training. ICRISAT – Mali provided the required facilities. IER – Mali facilitated training of 75 farmers on integrated crop management at the sites in the Kayes region where demonstration plots were established.

Apart from the training, efforts were made to enhance the farmers' awareness of improved varieties through various pathways such as hosting workshops, annual planning sessions, progress reports, user-friendly brochures and flyers, on-farm and on-station fields days, farmer-to-farmer visits and radio and television coverage. Simplified brochures on varieties grown and crop management were prepared in French for eventual translation into the local language – Bambara for Mali. The field days targeting a range of clientele (farmers, researchers, development partners and private sector) were organized by ICRISAT and NARES in each country. On an average, 30 – 300 persons participated in the open field days every year and the events were well covered on state as well as local television and radio channels in each country. During the 2010 crop season, for example, six field days or farmer meetings were held in Nigeria at eight demonstration trial sites and one at Samaru, before the harvest. A total of 932 farmers, all men, participated in the field days. The number of participants ranged from 87 to 264 per location. IER – Mali organized an on-farm field day at Sadiola with 94 farmer participants. An on-station field day at *Same*, chaired by the regional governor attracted 150 participants. During all these events, the participants were familiarized with new varieties and other productivity enhancing technologies. A documentary film of 20 minutes was prepared in Niger based on the activities in the pilot sites to raise stakeholders' awareness of newly released varieties. This is expected to reach a wider audience.

Lessons learned

- The release of new breeding lines remains a very slow process, particularly in Mali. This is largely due to variety release committees not meeting or the NARES partners not being aggressive enough to promote new varieties through nationally coordinated trials and on-farm validation tests. However, through PVS the variety release process can be fast-tracked.
- The major challenge faced by the women groundnut farmers is the limited access to good land and farm equipment to reduce drudgery in the production and processing of groundnut.
- The project involves many sites, of which some are situated in isolated locations, making coordination and monitoring a challenge.

Constraints

The main constraints cited by the partners are as follows:

- Lack of reliable transport to monitor activities, thus, limiting the spread of activities;
- Lack of suitable cold storage to maintain seed in good conditions before planting;
- Poorly motivated technicians;
- Difficulty in identifying candidates for the graduate degree training programs and delays in starting the course work;
- A lack of a critical mass of scientists in Niger and Mali to carry out the groundnut breeding activities;
- Fund disbursement procedures coupled with different accounting systems in the NARES has created challenges that can have a negative impact on the full implementation of the project. This was the case for Nigeria.