Research Proposal: Peanut Varietal Development

Description

An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality

Project Investigator

Carl Deom
Professor
University of Georgia
Department of Plant Pathology
Plant Sciences Building
Athens, GA 30606
Phone: 706-542-1270
FAX: 706-542-1262
Email: deom@uga.edu

Co-Project Investigator(s)

Mark Burow
Lubbock Research and Extension Center
Texas A&M AgriLife Research
1102 East FM 1294
Lubbock, TX 79403
Phone: 806-746-6101
FAX: 806-746-6528
Email: mburow@tamu.edu

Rangaswamy Muniappan
Director, IPM Innovation Lab
Virginia Tech
526 Prices Fork Road
Blacksburg, VA 24061
Phone: 540-231-3516
FAX: 540-231-3519
Email: rmuni@vt.edu

Patrick Okori
Principle Scientist
Grain Legumes Research Program-Grain Legumes ICRISAT - Lilongwe

P.O. Box 1096
Lilongwe, Malawi
Phone: +265 1 707057/67/71
Mobile: +265 996777683
Email: p.okori@cgiar.org

Puppala, Naveen
Associate Professor
New Mexico State University
Agricultural Science Center
2346 State Road 288
Clovis, NM 88001
Phone: 575-985-2292
FAX: 575-985-2419
Cell: 575-693-9094
Email: npuppala@ad.nmsu.edu

Barry L. Tillman
Associate Professor
University of Florida
3925 Hwy. 71
Marianna, FL
Phone: 850-633-4082
Fax: 850-482-9917
Email: btillman@ufl.edu

Partner Scientist(s)

Barkley, Noelle A.
Geneticist Plants
Plant Genetic Resources Conservation Unit
USDA-ARS
1109 Experiment St.
Griffin, GA 30223-1797
Phone: 770-412-4035
Fax: 770-229-3323
Email: Elle.Barkley@ars.usda.gov

Bravo-Ureta, Boris
Agricultural and Rescource Economics
University of Connecticut
Storrs, CT 06269

Phone: (860) 486-3152
FAX: (860) 486-2963
Email: boris.bravoureta@uconn.edu

Dennis, Gayi
Entomologist
National Semi Arid Resources Research Institute (NaSARRI) Serere
P.O. Box Private Bag
Soroti, Uganda
Phone: +256-701 858768
Email: gayidennis@gmail.com

Denwar, Nicholas
Savannah Agricultural Research Institute
Box 52
Nyankpala, Northern Region, Ghana

MacDonald, Greg
Professor, Department of Agronomy
University of Florida
McCarty Hall
Gainesville, FL 32611
Phone: 352- 392-1811 ext 228
Fax: 352-392-1840
Email: pineacre@ufl.edu

Mohankumar, Subbarayalu
Professor
Department of Plant Biotechnology
Tamil Nadu Agricultural University
Coimbatore 641003, India
Phone:91-422-6611353
Mobile: 94-422-24572
Email: smohankumar65@yahoo.com

Muitia, Amade
Groundnut Breeder
Mozambique Agricultural Research Institute
Northeast Zonal Center
Nampula Research Station
Av. FPLM, Via Corrane, Km 7
Nampula, Mozambique

Phone: 258-825-523-65
Email: amademuitia@hotmail.com or amuitia@gmail.com

Okello, Kalule David
Plant Breeder-Geneticist
Head Uganda National Groundnuts
National Semi Arid Resources Research Institute (NaSARRI), Serere,
P.O. Box Private Bag
Soroti, Uganda
Phone: +256-753 858768
Email: kod143@gmail.com

Sankara, Philippe
University of Ouagadougou
Département de Phytopathologie
BP 7021, Ouagadougou
03, Burkina Faso

Simpson, Charles
Texas A&M AgriLife Research
1229 North U.S. Hwy 281
Stephenville, TX 76401

ICRISAT Partners: Partner scientists and contact information on partner scientists was requested multiple times by the P.I., but none was provided by ICRISAT-Malawi.

Geographical Locations

ICRISAT: Malawi, Mozambique, Zambia
NMSU: Mozambique, United States
TAMU: Burkina Faso, Ghana, United States
UF: Haiti, Malawi, United States
UGA: Uganda, United States
VT: Kenya, Malawi, Mozambique, Uganda

Project Duration

September 1, 2013 through August 31, 2017

Executive Summary

In many developing countries, peanut is the main source of digestible protein, cooking oil, and vitamins. Peanut can also represent a significant source of

income that contributes to food security and alleviates poverty. In developing countries, especially in Sub-Saharan Africa (SSA), women predominantly cultivate and manage the crop. Thus, peanut production has a direct bearing on the overall nutritional status, as well as economic and financial well-being of women and children. The average on-farm yield is approximately 880 kg/ha in developing countries of SSA in contrast to yields of 3000 kg/ha from well-managed research station plots. By comparison, the average yield for peanut the United States is approximately 3700kg/ha. Therefore, there are enormous opportunities for farmers to produce significantly higher yields.

A number of biotic and abiotic stresses have a significant negative impact on peanut yields and quality in developing countries. Improving yields through the use of inputs, such as fertilizer, herbicides and insecticides, are fiscally impractical for smallholding farmers that cultivate the crop with very limited resources. Therefore, the improvement and adoption of high yielding varieties with resistance and/or tolerance to the biotic and abiotic stresses is by far the most feasible and economically viable course to intensifying production. Similarly, the lack of desirable traits associated with nutrition and marketability have a significant negative impact on future peanut value chains.

The proposed research focuses on intensifying peanut production and enhancing quality by developing and improving high yielding varieties, including the release of new cultivars and the development of culturally preferred cultivars, through existing and established breeding programs. Biotic stresses are addressed by focusing on developing new and improving existing varieties with resistance to economically important pathogens and pests, while the primary abiotic stress addressed will be drought tolerance and avoidance, a trait that factors into mitigating aflatoxin contamination. The breeding program will also focus on value added traits, including high oleic content (nutritional), increased micronutrient density (Fe and Zn), high oil content (cooking oil, butter), and large seeds (edible market). Outreach programs will be used to stress technology transfer and the value of new cultivars and system considerations for utilizing management strategies. Considerable resources will be directed to host countries for capacity building, including student training, scientist training and infrastructure improvements. As advanced varieties become available, they will be distributed to PMIL target country collaborators and PMIL value chain projects for evaluation as well as other developing countries that request the material.

The outcome of the research will result in the development and adoption of improved cultivars that will result in increased yields and increased quality. Subsequently benefits will result in improved peanut value chains, increased food security, better nutritional and dietary traits and increased income throughout PMIL target countries as well as other developing countries. Capacity building will result in in-country knowledge, expertise and improved infrastructure, which will build a foundation to continue improving peanut yields and quality.

Project Description

Goal

The goal of the project is to use breeding and outreach to enhance the production, quality, and marketability of peanut in PMIL target countries, while also providing technology that can be widely adopted in developing counties worldwide.

Relevance and Justification

In many developing countries, smallholding farmers grow peanuts as a subsistence crop under rain-fed conditions. The crop requires few inputs and represents a principal source of digestible protein, oil, and vitamins. Peanut also provides cash income, giving high returns for limited land area, which contributes significantly to food security and alleviating poverty. As a legume, peanuts improve soil fertility by fixing nitrogen and increasing productivity of semi-arid cropping systems. Therefore, yields have a direct bearing on the nutritional and economic status of smallholder farmers in developing countries.

Factors that are major constraints to increased peanut production, marketability and the subsequent establishment of robust peanut value chains in PMIL target countries of SSA and Latin America (LA) include the lack of high yielding varieties, viral and fungal diseases, pest infestations, unreliable rainfall and drought, cultivation on marginal lands, poor seed supply chains, and political instability. Most peanut varieties traditionally grown by farmers in SSA, as well as developed countries elsewhere in the world, are landraces or varieties that were adopted long ago, are highly susceptible to biotic and abiotic stresses and lack certain nutritional and market friendly traits. Yield from such varieties in SSA average <1000 kg/ha of dry pods while yields of more recently released varieties and varieties presently under development can be greater than 3000 kg/ha. Similarly, the lack of desirable traits associated with nutrition and marketability from many of the varieties presently grown by farmers in less developed countries has

a significant negative impact on peanut value chains. Therefore, research and outreach is needed to intensify peanut production and to significantly increase peanut yields, which have historically been persistently low in developing countries, including PMIL target countries. In addition, with biotic and abiotic stress resistant varieties now becoming more available, value added traits to improve peanut nutrition and marketability can be introduced into the resistant varieties to enhance a healthy and robust production value chain.

Breeding, evaluation and development of improved varieties with resistance to biotic stresses, such as pathogens (primarily foliar) and pests, are a major requirement for intensifying peanut production. Groundnut rosette disease (GRD) is the most destructive disease of peanut in SSA (Naidu et al., 1999). The virus disease is endemic to SSA and is a major factor, in some years the most important factor, in limiting peanut production. Improved varieties with resistance to GRD are required in many of the production systems within SSA to avoid significant production losses. Indeed the impact that recently adopted GRD-resistant varieties are having on increasing production and alleviating poverty in Uganda has been discussed (Moyo et al., 2007; Kassie et al., 2011). Other major diseases that are constraints to peanut production worldwide, for which resistance varieties are becoming increasingly available, are early and late leaf spot diseases and peanut rust. These fungal pathogens can cause yield losses of greater than 50% (Subrahmanyam et al., 1985; Waliyar, 1990). Losses can be particularly large in developing countries where fungicides are not economically feasible. Likewise, a more recent emerging pest in SSA, the groundnut leaf miner, has the potential to impact peanut yields (Mukankusi et al., 2000). Where the pest has reached epidemic densities severe yield losses have been reported (Kenis and Cugala, 2006). Recent research in Uganda has identified the first variety with resistance to leaf miner. The development and release of additional improved varieties carrying resistance to these biotic stresses have the potential to marginalize the diseases and pests in the future and result in a significantly positive impact on peanut yields.

The major abiotic stress on peanut is drought, which has been reported to be a primary reason for low yields in many regions of Asia and Africa (Reddy et al., 2003), as well as increased mycotoxin contamination. Improved varieties with drought tolerance are available and have significant potential to increase yields, especially when drought tolerance is combined with resistances to the biotic stresses discussed above.

With the development of biotic resistance and varieties with drought tolerance comes the opportunity to add value thought the introgression of nutritional traits such as high oleic fatty acid content and high micronutrient (Fe and Zn) content, as well as traits to increase marketability, such as improved edible seed quality, high-oil content for cooking oil extraction, and large seed varieties for the edible market.

The proposed research will continue building on the past successes of the breeding and genomics programs of the former Peanut-CRSP program in SSA and LA, as well as the germplasm enhancement programs of ICRISAT in SSA. The research will merge the breeding and genomics programs to form a synergism that will intensify productivity. This will result in improved cultivars and production practices that will increase adoption and yields, which will subsequently increase food security, income, health and nutrition in peanut producing countries globally. Project sites in Southern Africa **(SA)** will be in Mozambique **(MZ)**, Malawi **(MA)**, and Zambia **(ZA)**; Uganda **(UG)** in East Africa **(EA)**; Ghana **(GH)** and Burkina Faso **(BF)** in West Africa **(WA)**; Haiti **(HA)** in Latin America **(LA)**; and Georgia **(UGA)**, Florida **(UF)**, New Mexico **(NMSU)**, and Texas **(TAMU)** in the United States **(US)**. Germplasm developed from the research will be freely shared with all regions to optimize adoption and enhance their breeding programs. The inclusion of Uganda in the breeding program is to take advantage of an extremely productive program (10 released cultivars in the last two years), two peanut growing seasons to expedite the breeding program, and consistent yearly high levels of GRD pressure to rapidly advance varieties with GRD resistance (an advantage lacking in Southern Africa where GRD incidence varies from very low to severe from year to year). To facilitate haring of unreleased germplasm among US institutions and ICRISAT, Material Transfer Agreements will be developed as needed.

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Research Plan

Objectives

1. Breeding for Improved Varieties
2. Develop and use Genomic Tools for Trait Breeding
3. Develop GRD Resistant Technology using Biotechnology
4. Survey of Technology Adoption and Impact
5. Promote Technology Adoption and Transfer, Capacity Development, and Infrastructure Development
6. Management of Groundnut Leaf Miner

Role of Each Scientist/Partner

Dr. Noelle Barkley
is a plant geneticist and curator of the USDA-ARS national peanut germplasm collection. She will assist in import and export of germplasm and will coordinate training/capacity building activities for seed preservation.

Dr. Mark Burow
peanut breeder/geneticist at Texas A&M AgriLife) will direct the West Africa project in breeding for abiotic and biotic resistance, genomics, and training, and develop new breeding lines in collaboration with collaborator Michael Baring, perform genomic analysis, and use DNA-based markers in selection.

Mr. Kalule Okello David
is the national peanut breeder in Uganda and will be responsible for coordinating and managing all aspects of the breeding program in Uganda and will assist in the research activities pertaining to the leaf miner IPM activities in Uganda.

Mr. Gayi Dennis
will coordinate all host country research activities pertaining to the leaf miner IPM activities in Uganda.

Dr. Nicholas Denwar
will perform evaluation for leaf spot and drought tolerance in Ghana, as well as develop new breeding lines.

Dr. Carl M. Deom
is a plant pathologist, biotechnologist, and molecular virologist that will manage and coordinate the overall project. In addition, he will assist in managing the breeding program in Uganda in collaboration with Mr. Kalule Okello David.

Dr. S. Mohankumar
will analyze GLM (leaf miner) populations from Eastern Africa to determine species complex involved.

Dr. Amade Muita
is groundnut breeder and will be responsible for coordinating and managing all aspects of the breeding program in Mozambique.

Dr. R. Muniappan
will direct and coordinate and implement all the objectives related to leaf miner IPM and identified as VT under the work plan.

Dr. Patrick Okori
The role of ICRISAT scientists and partner scientists was requested multiple times by the P.I., but none was provided by ICRISAT-Malawi.

Dr. Naveen Puppala
is a peanut breeder that will manage and coordinate the Valencia peanut breeding part of the project. He will also assist in managing the breeding program in Mozambique in collaboration with Dr. Amade Muitia.

Dr. Philippe Sankara/Bertain Zagre

will work on evaluation for leafspot and drought tolerance in Burkina Faso.

Dr. Charles Simpson

will work on introgression pathways for introduction of very high oil content from wild species, and development of wild species-based mapping populations.

Dr. Barry Tillman

Barry Tillman is a groundnut breeder and will be responsible for coordinating breeding efforts in the University of Florida with the aim of developing germplasm for testing in southern Africa and Haiti.

Annual Work Plan (by objective), Milestones and Timelines

For clarity, work plans are listed in each objective or sub objective under the institution of the PI (**UGA**, University of Georgia) or Co-PIs (**NMSU**, New Mexico State University; **TAMU**, Texas A&M University; **UFL**, University of Florida; **VT**, Virginia Tech; and **ICRISAT**, International Crops Research Institute for the Semi-Arid Tropics)

OBJECTIVE 1: BREEDING FOR IMPROVED VARIETIES

A. Breeding resistance to biotic stresses

NMSU

Goal 1

Evaluate Valencia germplasm, develop new populations, and continue with generation advance and testing of advanced Valencia breeding lines for yield and adaptation, and resistance to GRD and LLS in Mozambique.

Groundnut rosette disease (GRD) and late leaf spot (LLS) resistance: Six crosses involving Valencia C and a new breeding line M3 (a cross derivative from Valencia C and ICGV 87157) were crossed with three GRD resistant varieties (Serenut 2, Serenut 6T and Mali). Both Valencia C and M3 were also crossed with LLS resistant genotypes (ICGV SM 03590 and SGV AL). F_2 and BC_1F_1 generations from these crosses are now available for generation advance, and adaptation test in MZ. We will advance these populations using single seed descent method to derive phenotypically uniform Valencia breeding lines for yield and

adaptation in MZ. We will generate new Valencia- specific breeding populations, combining resistance to GRD, LLS and high oleate traits, adapted to MZ. In addition, we will evaluate advanced generation Valencia breeding lines (developed at NMSU) for adaptation and resistance to GRD/LLS.

Goal 2

Conduct large-scale on-farm trials involving two disseminated cultivars to popularize these amongst peanut farmers in Mozambique.

Two cultivars, Serenut 5R and Serenut 6T, recently released in UG with peanut-CRSP support have resistance to GRD and LLS. These varieties were recently sent to MZ (requested) for large-scale on- farm trials to determine acceptability of the improved varieties by peanut growers. We will organize on-farm trials across major peanut growing regions in MZ. In addition, 4 to 6 newly developed Valencia lines (see Goal 1) will also be multilocationally evaluated to identify promising candidate for on-farm evaluation and subsequent release.

Goal 3

Screen Valencia germplasm for resistance to pod rot disease complex to identify sources of resistance to pod rot and introgress this trait into improved Valencia background in the U.S.

Pod rot has become a major threat to peanut production in many countries including USA, and more specific to Valencia peanuts. Three major fungi (*Rhizoctonia solani*, *Sclerotium rolfsii* and *Pythium* spp.) are known in the development of pod rot disease complex. An effective glass house screening technique has been developed to isolate and screen for resistance to pod rot in peanut (Sanogo and Puppala, 2012, Phytopthology 100:S114). Using this technique, the Valencia germplasm and breeding lines will be screened for resistance to pod rot, and those found promising will be crossed with MZ-specific Valencia varieties/breeding lines for developing new breeding populations to derive highly productive and pod rot resistant Valencia varieties.

Milestone Goal 1

Advanced Valencia breeding lines with LLS and GRD resistance developed and evaluated for yield and resistance to diseases **(Months 24-36)**. New population's combining high oleate and resistance to LLS and GRD into Valencia genetic background developed **(Months 36)**.

Milestone Goal 2

On-farm performance of advanced breeding lines/cultivars assessed and few lines with high yield potential identified for seed multiplication (**Months 24-36 months**). Nationwide seed multiplication of promising Valencia breeding lines/varieties organized in collaboration with NGO's and private seed sector and seed distributed to growers for on-farm multilocation evaluation **(Months 48)**.

Milestone Goal 3

Valencia germplasm with resistance to pod rot identified, new populations developed with high oleate seed chemistry and resistance to LLS, GRD, podrot **(Months 36)**. Advanced breeding lines combining high oleate and multiple resistances in Valencia genetic background identified for multilocation evaluation **(Months 48)**.

TAMU

Goal

Develop leaf spot-resistant varieties.

Tasks

1. **Screen ICRISAT materials for yield and leafspot resistance in GH and BF.** Use leaf spot- resistant ICRISAT lines (31 accessions provided by Bonny Ntare and additional lines requested from Hari Upadhyaya) for evaluation. Evaluate for suitability for release as is, based on yield, shelling, and leaf spot ratings.
2. **Evaluate diallel cross progeny for leafspot resistance**. Diallel cross progeny developed by Bertain Zagré (BF) will be evaluated for yield, shelling, and leaf spot resistance and it will be determine whether materials are suitable for release.
3. **Combine high yield, high oleic fatty acid content, and disease resistance in GH, BF, HA, TX, and FL.**
    a. Erect types. Propagate existing F_1's (G18 x Schubert, PI468235 x Schubert, and Schubert x Nkatiesari), and evaluate populations for yield, oil composition, and shellout. Field evaluation will be performed in BF, GH, and TX.
    b. Spreading types. Will combine yield, early maturity, shellout, and resistance to leaf spot, rust, and (optionally) Sclerotinia blight, white mold, and tomato spotted wilt virus. Crosses will include (GH) GK 7 x GAF1665 (leaf spot resistant), (TX): B106 or 43-09-

03-02 x TAM advanced runner breeding lines, and crosses involving BC_3 interspecific lines with rust resistance using SNP-based markers for initial selection (see Genomic Obj below); (FL) crosses will be made using UF runner breeding lines to enhance leaf spot and rust resistance. Field testing will be performed in BF, GH (Nyankpala) or Kumasi (in collaboration with the NCSU program), FL, HI, and TX. Field evaluation will be made for yield, shellout, and disease resistance.

Milestones

Tasks 1 and 2 - perform increase of materials as needed (**months 1-15**), field evaluation (**months 10-39**, depending upon availability); Task 3 - increase erect types (**months 1-15**), perform field evaluation **months 22 to 48 [51]**; spreading types, make crosses (**months 10-27**), increase **months 18-39**), field evaluation (**months 46-48 [51]**).

UFL

Goal

Breeding for rust and leaf spot resistance

1. **Advance of segregating populations.** About 900 F2 plants growing in the field in Marianna will be evaluated for pod shape, pod size and general disease resistance. These 900 plants were derived from 5 crosses (3 unique, 2 reciprocal for 5 total) made in 2010 using parents discovered to have good leaf spot and rust resistance based on research from the previous Peanut CRSP. The crosses are 1) C-99R (84x9B-4-2-1-1-2-b2-B)/BayoGrande, 2) C-99R (84x9B-4-2-1-1-2-b2-B)/97x36-HO2-1-B2G-3-1-2-2, 3) C-99R (84x9B-4-2-1-1-2-b2-B)/BOL3-7, 4) 97x36-HO2-1-B2G-3-1-2-2/C-99R (84x9B-4-2-1-1-2-b2-B), 5) BOL3-7/C-99R (84x9B-4-2-1-1-2-b2-B). In order to expedite the breeding process, some of the selected lines will be sent to the winter nursery in Puerto Rico for generation advance.
2. **Evaluation of germplasm.** Several lines from ICRISAT were acquired as part of the last Peanut CRSP and these will increased in 2013 to provide seed for future evaluation of their reaction to rust and leaf spot. Additional peanut germplasm lines from host countries or CG centers which have novel traits such as disease resistance, drought, etc will be acquired and processed through the quarantine facility in Griffin, GA. Each line will be tested for peanut stripe and peanut mottle and subsequently released to the breeders for evaluation and crossing.
3. **Testing of breeding lines.** A goal of the project is to provide

germplasm for testing in HA and interested programs in MA, ZA, and MZ. In HA, this will be accomplished through a linkage with the Value Chain project of Dr. Greg MacDonald entitled "Production to Consumption – Technologies to Improve Peanut Production, Processing, and Utilization in Haiti". Their plan is to work with Meds and Food for Kids and their associates to develop peanut variety testing efforts in HA. In Africa, this could be accomplished through Dr. Patrick Okori, Co-PI on this project and ICRISAT Principle Scientist in Groundnut Breeding in MA, and peanut breeders in ZA and/or MZ. Co-PI Tillman will travel as needed to establish linkages in HA, MA, ZA, and MZ for peanut variety testing. Materials available for testing include several advanced lines known to have leaf spot and/or rust resistance including 1) York, 2) 97x36-HO2-1-B2G-3-1-2-2, 3) BOL3-7, 4) 99x33-1-B2G-2-2-2, 5) Bayou Grande, and 6) C-99R. Other materials suited for testing will be provided as needed and as capacity for testing is available.

Milestones

Task 1 will require 2-3 seasons (3-4 generations) to derive lines ready for first stage testing. Related to Task 3, seed for testing will be increased during 2013 and the appropriate arrangements will be made (import permits, phytosanitary certificates, etc.) to allow shipment of seeds to SA and HA. Testing will begin as soon as practical thereafter and include replicated trials in one or more locations as funding and seed quantities permit. Plans for 2014 include:

1. Field evaluation of the five populations mentioned in Task 1 for reaction to rust and leaf spot
2. Seed increase of five lines from ICRISAT (Task 2)
3. Making new crosses among US material and ICRISAT lines
4. Testing lines in HA, MA, ZA, and MZ (Task 3). During 2015 and 2016, field evaluations will continue in the US, HA, MA, ZA, and MZ. Additionally, breeding populations will be advanced to the stage of first yield test. Superior lines will be readied for testing beyond 2016 in anticipation of project continuation.

UGA

Goal

Complete Valencia (USDA/NMSU), Serenut 1R and Serenut 3R, and landrace improvements in UG

1. **Completion of the improvement program.** Introgression of GRD resistance into local varieties (Acholi white, Egoromoit, Gwerinut, and Erudurudu red) and Serenut 1R and 3R improvements. Serenut 1 (a very popular variety) improvements are for GRD resistance (ICGV 91707 x S1R; ICGV 89751 x S1R) and Serenut 3R (a popular variety with GRD resistance) improvements are for dormancy issues. Three on-station seasons of yield trials (PYT, IYT, AYT) in UG. This also acts as seed increase phases in preparation for NPT and PVS. Then NPT and on-farm (at least 100 farmers during NPT) for at least 2 seasons. Application for release and seeds shared with PMIL partners for testing and possible releases.
2. **Continue advancing USDA/NMSU Valenica x NaSARRI/ICRISAT materials.** Will provide GRD resistant Valencia varieties for adoption. Five lines from the USDA/NMSU core collection have been crossed with ICRISAT lines to introgress GRD resistance into the Valencia backgrounds. These early generation lines (F3-F4) will be advanced with eventual distribution of acceptable varieties to PMIL target countries.

Milestones

1. Improved Valencia varieties with GRD resistance evaluated and released in UG **(Months 36-48)**.
2. Improved Serenut 1R (GRD resistance) and Serenut 3R (no dormancy problems) varieties evaluated and released **(Months 36-48)**.
3. Local varieties and landraces improved with GRD resistance **(Months 36-48)**. Varieties disseminated to PMIL target countries and PMIL value chain projects **(Months 36-48)**.

ICRISAT

Goal

To complete and release new varieties of groundnuts resistant to GRD, ELS RUST with either local or new genetic backgrounds.

1. **Undertake advanced regional trials in MA, MZ and ZA.** Trials will be conducted in Nampula province-MZ, Eastern province-ZA and central region-MA. New populations derived from released popular materials in eastern and southern Africa will be evaluated under the national performance trials for release. The target populations are improved CG7-Malawi MGV4-Zambia Serenut 1R Uganda (ICGV-SM 83703), Malawi-Chalimbana ICGV-SM 01514- Mozambique.
2. **Evaluate new sources of resistance identified from ICRISAT**

mini-core collections at ICRISAT Malawi. These materials will be used to improve released and or popular but susceptible varieties for low aflatoxin accumulation and tolerance to drought and GRD. Partners will be supplied with advanced generations. ICRISAT will support MZ develop new populations. Improving Valencia genotypes for east African agro-ecologies will also be undertaken in partnership with NARO.

Milestones

1. Improved popular Spanish and Virginia groundnut varieties types generated and evaluated for release in MA, MZ and ZA. (**Months 24-35).**
2. New sources of resistance availed to NARS for groundnut breeding. (**Months 35-48).**
3. Advanced populations of improved materials provided to the NARS partners for use in their own breeding programs (**Months 35-48).**

B. Breeding tolerance to abiotic stress.

NMSU

Goal

Evaluate newly developed populations in Valencia for early maturity and drought tolerance.

Three crosses involving Valencia C (female parent) with ICGV 92267 (early maturity, tolerant to cold temperature and rust and leaf spot), JUG 03 (High SPAD chlorophyll) and ICG 7243 (drought tolerant) were generated and the populations were advanced to F6. We will evaluate these advanced populations for early maturity, rust, leaf spot, drought and cold tolerance; all trait evaluations will be done at NMSU. The promising lines will be tested for adaptation and yield potential at multiple sites in US (NM, TX, FL and OK), UG, and MZ to identify the adapted lines. In order to built-in resistance to GRD, we will cross selected lines from this program to integrate GRD resistance from Serenut 2 and Serenut 6T.

Milestones

Advanced Valencia cultivars with leaf spot and rosette resistant **(Months 24)**. Seed multiplied in collaboration with private seed companies and NGO's **(Months 24-36)**. Large scale seed multiplication and distribution **(Months 36-48)**.

TAMU

Goal

Develop drought-tolerant varieties.

Tasks

1. **Identify existing accessions with potential for rapid release of new cultivars, both on the basis of drought avoidance and drought tolerance.** Use erect-type, early-maturing and/or drought tolerant accessions provided by ICRISAT (35 supplied by Bonny Ntare, additional lines to be requested from Hari Upadhyaya) in GH, BF and TX and screen them along with the highest-yielding accessions already identified in the screen of the US peanut minicore in TX and BF under drought, and Tarapoto materials (up to 50 lines obtained by Charles Simpson) from South America. The best lines identified can also be incorporated into the crossing program. Materials will be grown under drought stress, and selection will be made for yield, shellout, and maturity.
2. **Develop and screen new populations with enhanced potential for drought tolerance.** Make crosses between breeding lines or cultivars and drought-tolerant accessions with research in GH, BF, and TX. Criteria for parental selection are: yield and association mapping markers for response under drought stress (Tamspan 90), local variety with aflatoxin contamination resistance (55-437), high-yielding high oleic peanut (Schubert or a sister line), early-maturing local variety (55-33), high harvest index (PI628529), high transpiration efficiency (TBD), heat and salt stress tolerance (COC080), and seed number per pod (TamVal OL13). DNA markers may be used to assist in selection in certain crosses (see Obj. 6).

Milestones Task 1

perform increase of materials as needed (**months 10-15**), field evaluation (**months 22-38**, depending upon availability), determine potential releases (**months 40-48**)

Milestone Task 2

make single cross hybrids (**months 1-13**), increase (**months 15-27**), field evaluation (**months 34-48 [51]**)

UFL

Goal

Evaluation of germplasm response to primed acclimation.

NOTE: Due to funding constraints, this objective has been truncated from what was originally proposed and is being presented within the PMIL as a leveraged project with another USAID project (iAGRI) underway at the University of Florida with three years remaining. Therefore, work plans and reporting under this heading are acknowledged to be partially attributable to PMIL.

Primed acclimation (PA) is a term used to describe the ability of plants to become acclimated to a future stress event when subjected to stress earlier in their phenology. Peanut has shown the ability to acclimate to late-season drought when, during the first 45 days of its life cycle, it is mildly stressed (60% of normally required water). Subsequently, it has been hypothesized that peanut genotypes respond differently to PA indicating the possibility for breeding for improved, or optimal, PA response in peanut. As part of the iAGRI program funded by USAID, a Ph.D. student is employed with the University of Florida to study PA for drought in peanut. Leveraging the support from iAGRI (student stipend and travel) with funding for materials and supplies from the PMIL, the project will be completed and reported within the PMIL and iAGRI programs. In brief, 5-15 peanut genotypes will be tested under three irrigation treatments-none, full and 60% of full in three locations (two in Florida and one in Texas) using 3 to 4 replications during 2013, 2014 and 2015. Data collection will include yield, grade, and various physiological measurements.

Milestones

The first season of testing occurred in 2013 and tests will continue in 2014 and 2015.

C. Value added breeding for improved oil traits, micronutrient levels and seed size and release.

UGA

Goal

Improve the GRD/late leaf spot resistance lines that have been recently released in Uganda by introgressing high oleic traits.

Crossing high oleic Spanish and high oleic Virginia with Serenut 5R, 6T,

7T, 8R, 9T, 10R, 11T, 12T, 13T, 14R and ICGV-SM 02501. Initial introgression of the high oleate trait into Serenut 5R and Serenut 6T backgrounds will be done in Costa Rica during the Summer and Fall of 2013 to expedite the program. F2s will be screened for high oleic traits using marker-assisted selection in the US. High oleic lines will be sent to UG for evaluation of GRD resistance/LLS resistances/high oleic traits. The introgression of high oleic traits into the ICGV-SM 02501 (Spanish/GRD resistance/LLS resistance/drought tolerance) and Virginia (Serenut 7T, 8R, 9T, 10R, 11T, 12T, 13T, 14R) backgrounds will be done on-station at NaSARRI. The preferred high oleic Spanish that will be used is "Schubert" (TxL054520-34) (M. Burow, TAMU). The preferred high oleic Virginia is "Brantley" (N. Puppala, NMSU). Schubert will be the high oleic pollen donor for Serenut 5R, Serenut 6T, and Spanish ICGV-SM 02501 whereas Brantley will be the pollen donor for Serenuts 7T, 8R, 9T, 10R,11T, 12R, 13T and 14R. The resultant F1s will be backcrossed to the recurrent female parents. Heterozygous BCnF1 will be used as pollen donors in a backcross program (BC3F1). Selfed BC3F2 plants resembling the recurrent parents with high oleic will be identified. Yield trials on-station will then be done in the 3rd year followed by NPT and on-farm in the 4th year. DUS and application for release of the first high oleic groundnut varieties in UG will be in the 1st season of year 5.

Milestones

High oleic/ GRD resistant/ LLS resistant Spanish and Virginia varieties generated, evaluated and at/or in the process of being released in UG **(Months 48)**. Distribution of varieties to PMIL target countries and value chain projects **(Months 36-48).**

TAMU

Goal 1

Develop peanuts with improved edible seed quality, oil composition and seed size.

Tasks

1. **Develop and evaluate erect-type populations developed for combining large-seeded type and the high-oleic trait.** Cross Tamnut OL06 x SH470, and propagate existing crosses (Tamnut OL06 x TS32-1, Tamnut OL06 x Nkatiesari, 55-437 x Tamnut OL06, and TS32-1 x Tamnut OL06), (GH). Make crosses between GK 7 High Oleic and Oboshie, Obolo (large- seed size in GH and TX.
2. **Develop high-oleic erect varieties.**

a. Evaluate existing high-oleic Spanish and Valencia accessions developed from the TX breeding program for suitability in GH and BF.
b. Propagate existing crosses (TS32-1 x OLin) between high-oleic parents and local cultivars.

Goal 2

Develop peanuts with high oil content for use as cooking oil.

Tasks

1. **Introduce alleles for high (≥60% oil) content from wild species.** Backcrosses will be made from *A. paraguarensis* bridge crosses to adapted Spanish and runner germplasm, and progeny screened for oil content. Hybrids may be backcrossed to recover *A. hypogaea* agronomic traits while selecting for high oil content. Research will occur in TX.
2. **Cross high-oil (54% - 55%) section Arachis peanuts by African cultivars to combine high oil content with adaptation to WA, and advance progeny of previous crosses.** Breeding and evaluation in TX, GH and BF. Cross UF435 x Nkatiesari, and selected high-oil BC_3 (TxAG-6 x Florunner) introgression lines x OLin, and evaluate for yield, oil %, and O/L ratio; also propagate population from existing UF435 x TS32-1 F_1's. DNA markers may be used to assist in selection from the BC_3 introgression lines (see Obj. 2).

Goal 3

Improvement of the seed release mechanism, multiplication of seed for varietal release, and distribution to farmers, and conduct field day demonstrations.

Tasks

1. **Proceed with release of cultivars,** and conduct field day demonstrations and follow up on release of G18 and B106 (BF), and demonstrate improved cultivars to farmers at field days (BF, GH, TX).
2. **Seed multiplication of new cultivars.** Multiply seed of G18 and B106 in BF, of Nkatiesari in GH, Tamrun OL12, Schubert, TamVal OL13 and Webb in TX.

Milestones Goal 1

Task 1-make crosses (**months 9-11**), perform increase of materials as needed (**months 9-34** depending on the cross), field evaluation (**months 34-48 [51]** depending upon availability); Goal 1, Task 2-increase (**months**

9-15), field evaluation (**months 22-48 [51]**).

Milestones Goal 2

Task 1- backcrossing (**months 7-27),** oil analysis (months 28 to 32), field evaluation for oil content and yield (**months 34-48 [51]**); Goal 2, Task 2- increase progeny (**months 15-27**), field evaluation (**months 34-48 [51]**); Goal 3, release (months 1 to 9), demonstrations (**months 10-27**); Task 2, seed multiplication (**months 10-48 [51]**).

NMSU

Goal

Evaluate germplasm and varieties for grain Fe and Zn in MZ and US.

Micronutrient deficiencies, mainly prevalent among preschool children and women in sub-Saharan Africa including the PMIL target countries, result in severe anemia and stunted growth. Known sources of high Fe and Zn germplasm/breeding lines and high oleate Valencia types will be evaluated for seed micronutrients and agronomic performance. Nutritionally dense germplasm will be moved into the breeding program in SA to introgress high oleate, high Fe and Zn, and resistance to GRD and LLS into improved genetic background of Valencia types. Seeds of new developed nutritionally-dense Valencia advanced breeding lines will be disseminated to the Peanut Value Chain project for evaluation in value added products (peanut butter or confectionaries) to fight micronutrient deficiency in PMIL countries. Protocol developed by former graduate student (Joseph et al., 2013) to fortified peanut butter with Orange Flesh Sweet Potato (OFSP) will be used in this study. Fortification with 5% and 15% OFSP flour resulted peanut butter containing ß-carotene of 627 and 1581 µg per 100 g peanut butter will be used in this study. Dr. Brandenburg will test the new product with high Fe and Zn fortified with provitamin A under Peanut Value Chain project in Southern Africa.

Milestone

Agronomic performance of nutritionally dense germplasm assessed and promising germplasm/breeding lines identified **(Months 24)**. High grain Fe and Zn trait introgressed into improved genetic background, Valencia types, combining high oleate, and diseases resistance (LLS and GRD).

ICRISAT

Goal

To develop eco-adapted varieties with high levels of essential fatty acids (oleic acid), micro- nutrients (Zn) as value added to the rich protein and energy base contributing to nutrition and income security outcomes.

1. **Improving popular materials for essential fatty acids.** Five popular selected genotypes across especially Virginia and Spanish types will be crossed with novel Valencia donor. ICGV-SM 83703 (CG7) and ICGV-SM 90704 the most popular varieties in the region will be used. CG7 has over just over 50% oil content. ICGV-SM 90704 is GRD and ELS resistant and will be used to improve other materials to limit linkage drag in local populations.
2. **Improving popular materials for micro-nutrients Zn.** From ICRISAT mini-core accessions, materials with high levels of zinc and other micro-nutrients have been identified. Five popular selected genotypes (Virginia and Spanish types) will be crossed with novel donors and evaluated. ICGV-SM 83703 (CG7) and ICGV-SM 90704 the most popular varieties will be used. This activity will require 4 years to reach regional evaluations in UG, ZA, MA and MZ.

Milestones

1. Improved popular Spanish and Virginia groundnut genotypes with high essential fatty acids generated for evaluation and release in MA, MZ and ZA. (**Months 35-45)**.
2. Improved popular Spanish and Virginia groundnut genotypes with high micro- nutrients generated for evaluation and release in MA, MZ and ZA. (**Months 35-45)**

*****Advanced breeding lines from objectives (A) through (D) will be evaluated in regional trials in collaboration with PMIL value chain projects as well as other countries requesting the material.

OBJECTIVE 2: DEVELOP AND USE GENOMIC TOOLS FOR TRAIT BREEDING.

TAMU

Goal 1

Association mapping to find SSR markers for drought stress and leafspot resistance.

Perform association analysis using existing SSR data and new SNP data to find additional markers for drought tolerance in the US peanut minicore collection using field data already taken in TX and BF for drought, and in TX for leaf spot resistance.

Goal 2

Use markers for drought tolerance, the high oleic trait, rust and leafspot resistance in the breeding program.

Where applicable, use AM (SSR) markers for drought tolerance, and Kasp primers for FAD2 alleles to make early generation (F_2, F_3) selections for these traits. Propagate selections for replicated field trials. Markers for LS and rust resistance may be used for crosses involving BC_3 introgression lines (and developed from the sequences of RFLP-based markers), or for select ICRISAT-generated materials.

Goal 3

Develop a SNP-based map of the peanut A genome.

This will be done as prelude to work in the tetraploid, and propagate the A genome mapping population as RILs. Either use resequencing of selected peanut SNPs identified from Solexa transcriptome sequencing, or RadSeq, to make a SNP marker map of the A genome of peanut. *A. duranensis* x *A. cardenasii* F_1's will be propagated by single seed descent to make a RIL population.

Goal 4

Develop a SNP-based map from the TxAG-6 x Florunner cross (BC_1 or BC_3) and map QTLs for rust and leafspot resistance with leafspot and rust resistance data from TX, BF, and GH.

Map the TxAG-6 x Florunner population, and perform QTL analysis. We have identified ca. 50 RFLP-based QTLs for disease resistance and agronomic traits already but need to map these as SNPs to be able to use these efficiently. Field data for leaf spot will be used for identifying additional QTLs for leaf spot resistance. This will be done with the goal of developing a strategy for marker-assisted backcrossing the BC_3 introgression lines for traits to include resistance to leaf spot, rust, and nematodes, and high oil content.

Milestone Goal 1

Task 1 - finish collecting marker data and analyze phenotypic data (**months 1-6**), association analysis using SSR data, then SNP data

(**months 7-24**).

Milestone Goal 2

marker analysis of F_2 seed or plant DNA (**months 7-34**, depending on the cross).

Milestone Goal 3

identification of candidate SNPs (**months 1-6**), genotyping and mapping (**months 7-12**); single seed descent – **months 7-48 [51]**.

Milestone Goal 4

DNA extraction (**months 13-18)**; genotyping and mapping (**months 19-30**), completion of phenotypic data (**months 31-36**), QTL analysis (**months 37-42**).

ICRISAT

Goal

Exploiting advances in genomics and bioinformatics for breeding.

Selected popular genotypes under (Objective 1D, ICRISAT, Goal 1, Task 2) alongside novel donors will be subjected to transcriptome analysis at critical developmental stages. Transcript analysis will be done to identify any correlation between specific transcripts and high nutrient content. Functional Single Nucleotide Polymorphism (SNP) markers will be further developed to facilitate selection for desirable nutrient levels in resulting developed populations. This activity will start in year two using populations generated. Other available molecular markers will also be validated alongside the newly developed ones.

Milestone

A SNP chip/array set for use in high throughput genotyping and selection of groundnut genotypes with novel micronutrient content (**Months 35-48).**

OBJECTIVE 3: DEVELOP A GRD RESISTANT TECHNOLGY USING BIOTECHNOLOGY.

UGA

Goal

Use biotechnology to stack transgenic GRD resistance onto aphid resistance in Serenut 4T.

Serenut 4T is resistant to the aphid that vectors GRD. This vertical

resistance to GRD breaks down under high aphid pressure and farmers are shifting to other varieties. Serenut 4T has a number of desirable traits, such as high shelling percentage variety (73%), early maturing (90-100 days), and represents a dual purpose variety for both confectionery and butter. Transgenic Serenut 4T lines have been generated to express RNAi resistance against GRD. These lines were transformed with a non- translatable groundnut rosette assistor virus (GRAV) coat protein (CP) gene.

Tasks

1. **Evaluate transgenic lines for transgene.** Transgenic lines or transgenic lines still being generated will be evaluated by PCR for the presence of the transgene and by RT-PCR for expression levels of GRAV CP RNAi. A number of lines have already been identified as being transformed.
2. **Uganda approval and glasshouse evaluations of transgenic plants.** All approvals will be obtained from Uganda agencies for evaluating the efficacy of the transgenic plants under controlled glasshouse conditions. This process has been initiated. Viruliferous aphid populations and healthy control populations will be maintained at the National Biotechnology laboratory at Kawanda (NARL) and will be used to evaluate GRD resistance in the transgenic lines.

Milestones

1. Transgenic lines identified and evaluated through molecular protocols **(Months 24).**
2. Approval for testing transgenic lines in controlled glasshouses **Months 12)**.
3. Transgenic lines evaluated and resistant lines identified **(Months 24-48)**.

OBJECTIVE 4: SURVEY OF TECHNOLOGY ADOPTION AND IMPACT.

UGA

Goal

To determine technology adoption and impact over the last ten years using a 10 year old survey as the baseline.

Part of the information to be used to accomplish this objective comprises an

already available dataset that was collected in UG in 2004 as part of a study conducted to assess the achievement of a groundnut seed multiplication project (Tino et al., 2004). The 2004 dataset will constitute the base- line for the present study and will be augmented by a second round of surveys to be applied to the same 2004 samples in the Fall of 2013. The latter will be the end-line. The specific indicators that will be evaluated include: 1) groundnut production practices; 2) income sources; 3) groundnut varieties planted; 4) variety preferences; 5) access to improved seed; and 6) area planted to improved varieties. Additional data will also be collected in the 2013 surveys in order to evaluate productivity, cost of production and relative profitability differential across alternative seed varieties used by the farmers interviewed.

Milestones

1. Survey completion **(Months 6)**.
2. Data analyzed and publication submitted **(Months 18)**.

OBJECTIVE 5: PROMOTE TECHNOLOGY ADOPTION AND TRANSFER, CAPACITY DEVELOPMENT, AND INFRASTRUCTURE DEVELOPMENT.

NMSU

Goal

Student training.

Support one master student from Mozambique for M.Sc. in Plant Breeding at University of Free State, Bloemfontein, South Africa to introgress GRD resistance in local peanuts grown in MZ. Support a second master student to identify SSR markers associated with resistance to GRD, using the genetic populations developed by the first student.

Milestones

First student developed MZ-specific breeding populations combining GRD resistance and good agronomic and seed quality traits **(Months 24)**. Second student identified SSRs associated with GRD resistance **(Months 48)**.

TAMU

Goal 1

Provide equipment and facilities to enhance the ability to perform breeding and selection.

Provide a weather station for Pobe, BF to use in drought tolerance work. Construct a greenhouse at Nyankpala (Tamale), GH for crossing.

Goal 2

Conduct short-term training of one graduate student enrolled at a university in West Africa in use of markers for selection in breeding.

Student will be sent to Texas for a 4-5 month internship. Will learn DNA extraction, SSR and SNP analysis, bioinformatics, use of the Integrated Breeding Platform, and use of marker data for selection in breeding.

Milestones Goal 1

purchase and ship weather station, (**months 3-6**), construction of the greenhouse (**months 13-24**).

Milestones Goal 2

ESL training, if needed (**months 27-32**), internship (**months 34-38**).

UFL

Goal. Capacity Building.

Access to viable peanut germplasm is an essential component to be able to harness genetic diversity within a crop in order to develop improved lines for each host country (SA/EA/WA/LA). Dr. Barkley will be responsible for working with the host countries to develop genebanks and train host country scientists or students on germplasm preservation and conservation, which is critical to any sustainable breeding program. Training will include appropriate storage conditions, germination testing, record keeping, collecting phenotyping data, and regenerations of stored material. In cases in which large germplasm collections can be maintained/evaluated, the concept of core collection development and evaluation will also be taught. A general guide will be developed to assist cooperators with critical components of germplasm maintenance. Further, suggestions of germplasm acquisition from the U.S. peanut collection or other CG centers will be shared with the host country to expand their existing seed banks and provide a diverse set of genetic resources for breeding and evaluation. Dr. Barkley will travel as needed to LA and African PMIL target countries in order to assess the facilities available, interact with host country collaborators, and suggest appropriate means to acquire, conserve, and maintain peanut germplasm. We also envision that students or scientists from the host countries will travel to the U.S. to visit the USDA germplasm facility, visit field sites in the Southeastern U.S.

where breeding lines are evaluated and/or germplasm is regenerated, and provide training on performing DNA extraction and genotyping.

Milestones

Capacity building activities will include bringing host country participants to the USA for short-term training programs during the 2014 and 2015 coordinating the development and compilation of best practices for germplasm storage and maintenance **(Months 12-36)**.

UGA

Goal 1

Promote adoption of new technologies. Intensifying production with the development and release of improved varieties will have little positive outcome if farmers do not adopt the new varieties. To facilitate adoption, we will take the following approaches, which have been used successfully in the past.

Participatory Varietal Selection (PVS): advanced lines undergoing mandatory National Performance trials will be performed with participating farmers and National program's agricultural/research and development institutes. Farmers and researchers jointly will select the superior lines for release. This approach assists in the wide adoption and dissemination of new technology. **(ii) Field days**: New technologies are showcased on-station or in farmers fields. **(iii) Demonstration plots**: They showcase available technologies for upscaling. This allows for validation, adoption and wide dissemination of new technologies near production communities. **(iv) Annual shows and fairs**: These events are attended by many stakeholders who come to witness the available technologies and collect relevant dissemination materials (factsheets, manuals, guides). **(v) Publications:** Will distribute Groundnut Production Guides and Aflatoxin Management Manuals, which are always in high demand. Will also distribute factsheets developed on pathogen diseases and their management and a compendium of released varieties.

Goal 2

Improve infrastructure at NaSARRI.

The glass house and insect-rearing house at NaSARRI (groundnut breeding station in UG) is in disrepair and will be refurbished for the breeding program and for aphid and leaf miner screening.

Goal 3

Student Training.

Partial support (supplies) will be provided for a student (UG) to analyze transgenic peanut. Partial support is also provided for a master student (UConn) to analyze the survey data from objective 4.

Milestones Goal 1

Well attended trials and outreach events with farmer feedback resulting in high variety adoption **(Months 48)**.

Milestone Goal 2

Glasshouse and insect-rearing house refurbished and functioning **(Months 12)**.

Milestone Goal 3

Student will have used support to have analyzed transgenic plants and will have a section devoted to their results in the dissertation **(Months 12-36)**.

VT

Goal

Conduct field days, workshops etc.

Periodic field days, workshops and other extension activities will be conducted throughout the duration of the project to disseminate information to fellow scientists, extension agents, NGOs and farmers.

Milestones

Farmers educated on leaf miner and leaf miner management schemes developed **(Months 48)**.

ICRISAT

Goal

To determine improve capability of participating NARS in medium to long term to generate and disseminate new groundnut innovations as well as in the short term disseminate new released varieties and their management.

1. **Knowledge management.** The subtasks to be done under this area include among others but not limited to:
    a. **Variety promotion**. Engage National and Regional Farmer associations in targeted variety promotions using mother baby trial approach as well as other result demonstrations.

b. **Information drives and seed fairs**: We plan to hold these activities yearly to promote the varieties targeted communities.

2. **Scientific and popular publications**.
3. **Training**
    a. **Graduate training.** 2 MSc students, one each for ZA and MZ will be trained at University of Zambia MSc breeding programmes. They will handle work in Objective 1A (ICRISAT, Goal 1, Tasks 1 &2).
    b. **Partner training**. Specific skills enhancement training for scientists will be held in appropriately identified places. This involves scientists, technicians and scientists as appropriate.
4. **Infrastructure improvement.** Limited infrastructure upgrade will be done for MZ (glass house construction) and in the case of ZA, an insectivory for aphid rearing will be built to support GRD screening on station**.**

Milestones

1. Learning platforms with communities established (**Months 6-35**).
2. Scientific publications (**Months 24-45**).
3. Graduate thesis (**Months 27-45)**.
4. Popular scientific publications (**Months 35-45**).
5. 2 graduate students trained (**Months 12-45**).
6. 2-4 project staff and partners trained (**Months 12-45**)

OBJECTIVE 6: MANAGEMENT OF GROUNDNUT LEAF MINER.

UGA

Goal

Evaluate and release of a leaf miner resistant line. Initiate breeding of the trait into Serenut5R and Serenut 6T.

Gwerinut x Serenut 2 progenies have good leaf miner resistance, The progenies are undergoing yield trials before sending them out in Multi-location trials

1. **Evaluate resistance through**
    a. Natural screening in 2013 B season and
    b. Carry out artificially screening using artificially reared leaf miner in cages in 2013B.
2. **Fast track seed increase and onstation yield testing of validated resistant lines** (PYT, IYT, AYT for 3 seasons); NPT 2 seasons at 10

sites with at least 10 PVS sites and 100 farmers. Upon selection of superior lines, then carry out DUS trial and release (one more season).

3. **Introgress LM resistance into Serenut 5R and Serenut 6T using identified parents in 2013B.** Use off season nursery for seed increase targeting 3 generations in a year giving rise to stable lines at F6(2015B). yield trials (IYT, AYT: 2015A&B); NPT (2016A and B); application for DUS and release (one more season). Seeds shared with partners for testing and possible releases.

Milestones

1. Know the strength of leaf miner resistance in progeny from Gwerinut x Serenut 2 from glass house studies **(Months 12-24)**.
2. Improved variety with GRD/leaf miner resistances, evaluated and released in Uganda **(Months 48)**. Disseminate the variety to MA, MZ, and ZA for evaluation **(Months 48)**. Advanced Serenut 5R and Serenut 6T backgrounds with LM resistance **(Months 48)**.

VT

Goal 1

Identification of GLM species complex in Uganda and Eastern Africa.

The groundnut leaf miner, *Aproaerema modicella*, a native of Asia, is a recent introduction to Eastern and Southern Africa. According to recent literature, there are more than one species of *Aproaerema* occur in these regions. To identify species involved, larvae and adults from different parts of UG and neighboring countries will be collected and CO1 analysis will be done. Similarly, population of *A. modicella* from India will be analyzed to compare the results with the African population. By these studies we will identify species complex of *Aproaerema* in Africa and possibly their geographical origin.

Goal 2

Temporal and spatial population dynamics of GLM in Uganda.

Pheromone traps developed for *A. modicella* population in India will be tested for attraction of GLM population in Uganda. If these traps attract GLM, they will be placed in different geographical locations in Uganda and adult moth catches will be monitored on a yearlong basis to understand the population dynamics. Population data will be correlated with groundnut cropping seasons, phenology of the crop,

and abiotic and biotic factors.

Goal 3

Identification of Natural enemies of GLM in Uganda.

Surveys will be conducted in various parts of UG to identify parasitoids and predators attaching egg, larval and pupal stages of GLM. For parasitoid identification, eggs, larvae, and pupae collected in the fields will be incubated in the lab, emerged parasitoids will be preserved in 70% alcohol, and sent to taxonomists for positive identification. Parasitoid emergence data will be used for determination of effective ones.

Goal 4

Survey of natural enemies of GLM in neighboring Countries.

Similar surveys will be conducted in neighboring countries of UG, if suitable collaborators are identified.

Goal 5

Augmentative biological control.

When effective egg parasitoids such as *Trichogramma* species are found, mass production and inundative field releases will be made and the efficacy of such releases in control of GLM will be determined.

Goal 6

Determine need for classical biological control.

Based on the data collected on efficacy of the local natural enemies of GLM, an assessment will be made for the need for classical biological control and also a literature survey will be made to identify effective exotic natural enemies of GLM, if they exist.

Milestones

Species of *Aproaerema* determination **(Months 18)**. Population dynamics of *A. modicella* **(24 months)**. Identification of local natural enemies **(Months 24)**. Mass multiplication and release of possibly *Trichogramma* spp. **(Months 36)**. Determination of the need for classical biological control and identification of exotic natural enemy **(Months 42)**. Publication and information dissemination **(Months 12 to 48)**.

Timeline (each year is divided into halves)

Objective 1	**Year 1**		**Year 2**		**Year 3**		**Year 4**	
NMSU-Mozambique	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**
Obj.1A, Goal1- Evaluate Valencia germplasm for adaptation, develop new populations, and continue with generation advance and testing of advanced Valencia breeding lines for resistance to GRD and LLS in MZ.	*	*	*	*	*	*	*	*
Obj.1A, Goal 1- Conduct large-scale on-farm trials involving two disseminated cultivars to popularize these amongst peanut farmers in MZ.	*	*	*	*	*	*	*	*
Obj.1A, Goal 3- Screen Valencia germplasm for resistance to podrot disease complex to identify sources of resistance to pod rot and introgress this trait into improved Valencia background in the U.S.	*	*	*	*	*	*	*	*
Obj.1B Goal-Evaluate newly developed populations in Valencia for early maturity and drought tolerance.	*	*	*	*	*	*	*	*
Obj.1C Goal-Evaluate varieties for micronutrient dense traits in MZ and US.	*	*	*	*	*	*	*	*

Obj. 5 Goal-Student training.	*	*	*	*	*	*	*	*
TAMU-Ghana-Burkina Faso								
Obj.1A Goal-Develop leaf spot-resistant varieties.								
Task 1. Screen ICRISAT materials for yield and leafspot resistance in GH and BF.	*	*	*	*	*	*	*	
Task 2. Evaluate diallel cross progeny for leafspot resistance.	*	*	*	*	*	*	*	
Task 3. Combine high yield, high oleic fatty acid content, and disease resistance in GH, BF, HA, TX, and FL.	*	*	*	*	*	*	*	*
Obj.1B Goal-Develop drought-tolerant varieties.								
Task 1. Identify existing accessions with potential for rapid release of new cultivars, both on the basis of drought avoidance and drought tolerance.		*	*	*	*	*	*	*
Task 2. Develop and screen new populations with enhanced potential for drought tolerance.	*	*	*	*	*	*	*	*
Obj.1C Goal 1- Develop peanuts with improved edible seed quality, oil composition and seed size.								
Task 1. Develop and evaluate erect-type populations developed for combining large-seeded type and the high-oleic trait.		*	*	*	*	*	*	*
Task 2. Develop high-oleic erect varieties.		*	*	*	*	*	*	*
Obj.1C Goal 2- Develop peanuts with high oil content for use as cooking oil.								
Task 1. Introduce alleles for high (≥60% oil) content from wild species.		*	*	*	*	*	*	*
Task 2. Cross high-oil (54% - 55%) section Arachis peanuts by African cultivars to combine high oil content with adaptation to WA, and advance progeny of previous crosses.		*	*	*	*	*	*	*
Obj.1C Goal 3-Improvement of the seed release mechanism, multiplication of seed for varietal release, and distribution to farmers, and conduct field day demonstrations.		*	*	*	*	*	*	*
Obj.2 Goal 1- Association mapping to find SSR markers for drought stress and leafspot resistance.	*	*	*	*				
Obj.2 Goal 2- Use markers for drought tolerance, the high oleic trait, rust and leafspot resistance in the breeding program.		*	*	*	*	*		
Obj.2 Goal 3- Develop a SNP-based map of the peanut A genome.	*	*	*	*	*	*	*	*
Obj.2 Goal 4- Develop a SNP-based map from the TxAG-6 x Florunner cross (BC_1 or BC_3) and map QTLs for rust and leafspot resistance with leafspot and rust resistance data from TX, BF, and GH.			*	*	*	*	*	
Obj.5 Goal 1-Provide equipment and facilities to enhance the ability to perform breeding and selection.	*	*	*	*				

Obj.5 Goal 2-Conduct short-term training of one graduate student enrolled at a university in WA in use of markers for selection in breeding.					*	*	*	
UFL-Haiti								
Obj.1A Goal-Breeding for rust and leaf spot resistance.								
Task 1. Segregating Populations	*	*	*	*	*	*	*	*
Task 2. ICRISAT lines	*	*	*	*				
Task 3. UF Lines			*	*	*	*	*	*
Obj. 2 Goal- Evaluation of germplasm response to primed acclimation	*	*	*	*	*	*		
Obj.5 Goal-Capacity building			*	*	*	*	*	*
UGA-Uganda								
Obj.1A Goal-Complete Valencia (USDA/NMSU), Serenut 1R and Serenut 3R, and landrace improvements in UG.	*	*	*	*	*	*	*	*
Obj.1C Goal-Improve the GRD/late leaf spot resistance lines that have been recently released in Uganda by introgressing high oleic traits.	*	*	*	*	*	*	*	*
Obj.3 Goal-Use biotechnology to stack transgenic GRD resistance onto aphid resistance in Serenut 4T.	*	*	*	*	*	*	*	*
Obj.4 Goal-To determine technology adoption and impact over the last ten years using a 10 year old survey as the baseline.	*	*	*					
Obj.5 Goal 1-Promote adoption of new technologies.	*	*	*	*	*	*	*	*
Obj.5 Goal 2-Improve infrastructure at NaSARRI (UG)	*	*						
Obj.5 Goal 3-Student Training.	*	*	*	*				
Obj.6 Goal-Evaluate and release of a leaf miner resistant line. Initiate breeding of the trait into Serenut 5R and Serenut 6T.								
Task 1. Evaluate resistance	*	*	*	*				
Task 2. Fast track seed increase and onstation yield testing	*	*	*	*	*	*	*	*
Task 3. LM resistance into Serenut 5R and Serenut 6T.	*	*	*	*	*	*	*	*
VT-Uganda								
Obj.5 Conduct field days, workshops etc.	*	*	*	*	*	*	*	*
Obj.6 Goal 1- Identification of GLM species complex in UG and EA.	*	*	*	*				
Obj.6 Goal 2- Temporal and spatial population dynamics of GLM in UG.	*	*	*	*	*	*		
Obj.6 Goal 3-Identification of Natural enemies of GLM in Uganda.	*	*	*	*	*	*		

Obj.6 Goal 4- Survey of natural enemies of GLM in neighboring Countries.					*	*	*	*
Obj.6 Goal 5- Augmentative biological control.					*	*	*	*
Obj.6 Goal 6- Determine need for classical biological control.							*	*
ICRISAT								
Obj.1A Goal To complete and release new varieties of groundnuts resistant to GRD, ELS, RUST with either local or new genetic backgrounds.								
Task 1. Undertake advanced regional trials in MA, MZ and ZA	*	*	*	*	*	*		
Task 2. Evaluate mini-core for resistance at ICRISAT MA.	*	*	*	*	*	*	*	*
Obj.1C Goal-To develop eco-adapted varieties with high levels of essential fatty acids (oleic acid), micro-nutrients (Zn) as value added to the rich protein and energy base contributing to nutrition and income security outcomes.								
Task 1. Improving popular materials for essential fatty acids.	*	*	*	*	*	*	*	*
Task 2. Improving popular materials for micro-nutrients Zn.	*	*	*	*	*	*	*	*
Obj.2 Goal- Exploiting advances in genomics and bioinformatics for breeding.		*	*	*	*	*	*	*
Obj.5 Goal- To determine improve capability of participating NARS in medium to long term to generate and disseminate new groundnut innovations as well as in the short term disseminate new released varieties and their management.								
Task 1. Knowledge management.	*	*	*	*	*	*	*	*
Task 2. Graduate and partner training.	*	*	*	*	*	*	*	*
Task 3. Infrastructure improvement.	*	*						

Gender Research Strategy

In many developing countries, especially in SSA, women predominantly grow and manage groundnuts. As varieties enter advanced stages of development, farmers are used in the trials established by the breeders. Since the large majority of groundnut farming is perform by women, then women have an enormous input into deciding during the advanced trials which varieties will eventually be adopted. This is even more apparent based on the large representation by women in local farmer organizations. Therefore, increased groundnut production resulting from the production and quality enhancements proposed will have a direct and positive bearing on the overall economic, financial, and nutritional well- being on all impacted, women, men and children.

Environmental Considerations

No pesticides will be tested or studied in the projects.

Outcomes and Impacts

Outcomes

New Technologies developed over the granting period (released or in advance stages prior to release):

1. New Spanish and Virginia varieties identified with GRD resistance and/or early or late leaf spot resistance.
2. GRD resistance/early or late leaf spot resistance Spanish and Virginia varieties previously released and adopted improved with high oleic content.
3. Improved GRD/late leaf spot resistant lines previously released.
4. GRD/leaf miner resistant line released.
5. Improved landraces and preferred local varieties with GRD resistance.
6. Valencia varieties developed with GRD resistance (none existed presently) and leaf spot resistance.
7. Improved Valencia varieties with resistance to podrot resistance.
8. Valencia varieties with high oleic content.
9. New drought tolerant and drought avoidance Valencia, Spanish and Virginia varieties.
10. New rust resistant Spanish and Virginia varieties.
11. New Spanish varieties identified with high oleic content, high oil content, improved edible seed qualities.
12. Identify varieties with micronutrient dense traits.
13. Development and improvement of leaf miner resistant variety.

Developed genomic tools for breeding:

1. Drought stress markers developed.
2. SNP based map developed of the peanut A genome.
3. SNP based chip/array developed for desirable traits.

Transgenic Technology:

Transgenic lines developed (glasshouse tested) with resistance to GRD.

Technology adoption survey:

Data available and published on impact of new technologies released in UG over the last 10 years.

Capacity building:

1. Knowledge passed on through education and training for peanut improvement, maintenance and storage.
2. Host country infrastructure developed to facilitate peanut improvement.

Management of Groundnut Leaf Miner:
Development of groundnut leaf miner pest management scheme to lessen impact of the pest.

Impacts

1. Development of improved and/or new varieties capable of increasing production yields in current growing environments, primarily through the introduction and improvement of resistance to biotic and abiotic stresses.
2. Adoption of the improved and new technologies through outreach activities to educate farmers on the benefits of the improved and new technologies.
3. Development of genomic tools to increase the efficiency of new and improved technology development.
4. Provide an educated core of scientists and technicians with the knowledge to continue improving varieties and the infrastructure to make it possible.