Peanut CRSP 2012 Final Report for Project NMS 172

1. Final Summary

a. Brief statement of overall goal

The demand for Valencia peanut in Uganda is growing at a greater pace. However, the producers are still growing the age-old peanut varieties, Red beauty and Acholi white, because of their superior confectionery traits over other market types. The major drawback about these cultivars is their low yield potential and susceptibility to groundnut rosette disease (GRD) and late leaf spot (LLS), the two devastating diseases with a potential to cause substantial losses to peanut production and peanut quality. The development and release of Valencia types with GRD and LLS resistance will help peanut farmers raise production of the specialty peanut (Valencia type), which will result into more farm-income for sustainable livelihood. Efforts are underway to combine GRD and LLS resistance into the improved genetic background with Valencia characteristics. We have so far made about 400 selections from six crosses for GRD resistance and about 225 selections from nine crosses for LLS resistance. The advanced breeding lines of Valencia market types, developed at New Mexico State University, are in advanced stage of evaluation prior to their inclusion in "National Performance Trial" for release in Uganda. Seed increase of the promising lines is underway to provide enough seed stocks once either of these lines is notified for release.

The NMS-172 project had the six specific objectives:

1: Evaluate accessions for agronomic and seed quality traits, resistance to pod rot and tolerance to drought

2: Study population structure and diversity of US Valencia core collection accessions using SSRs and high throughput assay?

3: Study variation in transcript abundance among drought tolerant and susceptible lines using oligonucleotide microarrays

4: Evaluate Valencia core collection accessions for groundnut rosette disease and late leaf spot

5: Evaluate Valencia variety Red Beauty with fungicide Abound at two locations to access its economic impact on yield and disease.

6: To support and train two graduate students from Makerere University in Plant Breeding and Agronomy

b. Significant Technical Achievements-Host Country (Uganda) and USA

Uganda:

• Few advanced breeding lines (Valencia types) identified for inclusion in National Performance Trials prior to their release in Uganda, and efforts are on to produce sufficient seeds of these selected lines for on-farm trials and demonstration to popularize amongst the peanut farmers.
• Uganda-specific peanut breeding populations generated to select for resistance to GRD and LLS into improved genetic background adapted to Ugandan growing conditions.
• Few GRD and LLS resistant germplasm identified for use in peanut breeding.
• Three high nitrogen fixing Valencia peanut germplasm identified for use in peanut breeding.

USA:

• A high oleic Valencia peanut variety, NuMex-01, adapted to New Mexico and western Texas, has been identified for commercial cultivation.
• Collaboration between ICRISAT and NMSU resulted in development of several breeding populations combining resistance to drought, early maturity and cold tolerance, which will be shortly available to NMSU for evaluation in New Mexico and western Texas.
• A pot and field screening technique developed for evaluating resistance to pod rot complex of diseases in peanut.

c. Significant Issues/Challenges

• Lack of trained technical personal on peanut research and development in Uganda
•Limited budget had significant constraint to achieving project objectives
• Frequent movement of personal to the project sites for conducting trials and evaluating materials in Uganda

d. Capacity development, i.e. laboratory, field, equipment-Host Country, US

We were able to purchase a pickup truck for the host country - Uganda by sharing the cost with UGA 136. This has been a great help to the host country partners undertake several on-site breeding trials for both UGA 136 and NMS 172.

e. Human Capacity/training to be listed in a table that includes:

Name	Gender	Country	Degree	Completion Date	University	Funding source
Rachel Nalugo	F	Uganda	Master	May 2013	Makerere University	NMS-172
Wambi Wilber	M	Uganda	Master	May 2013	Makerere University	NMS-172
Julius Kwesiga	M	Uganda	Master	May 2013	Makerere University	NMS-172
Mulindwa Joseph	M	Uganda	Master	May 2013	Makerere University	NMS-172
Supatra Mahakose e	F	Thailand	Master	August 2013	Khon Kaen University	NMS-172

f. Publications

Peer reviewed

1. Rowland, D., **N. Puppala**, J. Beasley, Jr., M. Burow, D. Gorbet, D. Jordan, H. Melouk, C. Simpson, J. Bostick and J. Ferrell. **2012**. Variation in carbon isotope ratio and its relation to other traits in peanut breeding lines and cultivars from U.S. trials. J. Plant Breed. Crop Sci. 4(9), 144-155.

2. Singkham, N., Sanun Jogloy, Bhalang Suriharn, Thawan Kesmala, Prasan Swatsitang, Prasit Jaisil, **Naveen Puppala** and Aran Patanothai. **2012**. Types of gene effects governing the inheritance of oleic and linoleic acids in peanut (*Arachis hypogaea* L.). Afr. J. Biotechnol. 11(67), 13147-13152.

3. Belamkar, V. M.G. Selvaraj, J.L. Ayers, P.R. Payton, **N. Puppala** and M.D. Burow. **2011.** A first insight into population structure and linkage disequilibrium in the US peanut minicore collection. Genetica. 139:411-429.

4. Kottapalli, P. H.D. Upadhyaya, K.R. Kottapalli, P. Payton, S.L. Dwivedi, K.O. David, S. Sanogo and **N. Puppala***. **2011**. Population structure and diversity in Valencia peanut germplasm collection. Crop Science. 51(3): 903-1392.

5. Puangbut, D., Jogloy, S., Kesmala, T., Vorasoot, N., Akkasaeng, C., Patanothai, A., **Puppala, N. 2011**. Heritability of early season drought resistance traits and

genotypic correlation of early season drought resistance and agronomic traits in peanut. SABRAO Journal of Breeding and Genetics, 43(2): 165-187.

6. Selvaraj, M. G., Burow, G., Burke, J. J., Belamkar, V., **Puppala, N**., Burow, M. D. **2011**. Heat stress screening of peanut (Arachis hypogaea L.) seedlings for acquired thermotolerance. Plant Growth Regulator, 65, 83-91.

7. Cho, Y., Kodjoe, E., **Puppala, N**., Wood, A. J. **2011**. Reduced trigonelline accumulation due to rhizobial activity improves grain yield in peanut (Arachis hypogae L.). *Acta Agriculture Scandinavica, 61*(5): 395-403.

8. Singkham, S., S. Jogloy, T. Kesmala, P. Swatsitang, P. Jaisil and **N. Puppala**. Genotypic Variability and Genotype by Environment Interactions in Oil and Fatty Acids in High, Intermediate and Low Oleic Acid Peanut Genotypes. **2010**. J. Agric. Food Chem. 58:6257-6263.

9. Singkham, S., S. Jogloy, T. Kesmala, P. Swatsitang, P. Jaisil, **N. Puppala** and A. Patanothai. Estimation of heritability by parent-offspring regression for high-oleic acid in peanut. **2010**. Asian J. of Plant Sci. 9(6):358-363.

10. Paxton Payton, Kameswara Rao Kottapalli, Diane Rowland, Wilson Faircloth, Baozhu Guo, Mark Burow, **Naveen Puppala**, Maria Gallo. **2009.** Gene expression profiling in peanut using high density oligonucleotide microarrays. *BMC Genomics* **10**: 265.

11. Kameswara R. Kottapalli, Randeep Rakwal, Junko Shibato, Gloria Burow, David Tissue, John Burke, **Naveen Puppala**, Mark Burow, Paxton Payton. **2009**. Physiology and proteomics of the water-deficit stress response in three contrasting peanut genotypes. Plant Cell and Environment 32: 380-407.

In print

12. Ligeon, C., C. Jolly, N. Bencheva, S. Delikostadinov and N. Puppala. 2013. Production Efficiency and Risks in Limited Resource Farming: The Case of Bulgarian Peanut Industry. JDAE.

13. Sanogo, S and **N. Puppala**.**2012**. Microorganisms Associated with Valencia Peanut Affected by Pod Rot in New Mexico. Peanut Sci. 40**.**

<u>Submitted to the Journal</u>

14. Burow, M.D., M. R. Baring, **N. Puppala**, C. E. Simpson, J. L. Ayers, J. Cason, A. M. Schubert[†], A. Muitia, and Y. López. **2013**. Registration of "Schubert" Spanish variety. J. Plant Reg.

15. Thuo, M., Bell, A, Bravo-Ureta, B. E., Okello, D. K., Okoko, N., Kidula, N., Deom, C. and Puppala, N. **2013a**. Effects of Social Network Factors on Information Acquisition and Adoption of Improved Groundnut Varieties: The Case of Uganda and Kenya. *Agriculture and Human Values*: Revise and resubmit.

16. Thuo, M., Bell, A, Bravo-Ureta, B. E., Okello, D. K., Okoko, N., Kidula, N., Deom, C. and Puppala, N. **2013b**. Social Network Structures among Groundnut Farmers. *Journal of Agricultural Education and Extension*.

17. Okello, D.K., Deom, C.M., Monyo, E., Puppala, N., Bravo-Ureta, B. and Oloka, H.K. "Reaction of Elite Germplasm Lines to Groundnut Rosette and Late Leaf Spot Diseases in Uganda." *Health Plant Progress (2013)*: Under Review.

Poster/abstract presentation during the workshops/conferences

1. Burow, M.D., J. L. Ayers, A. Muitia, A. M. Schubert, Y. Lopez, C. E. Simpson, **N. Puppala**, and M.R. Baring. **2012**. Development of High-Yielding, High-Oleic Valencia Peanut. American Peanut Research and Education Society, APRES, Raleigh, North Carolina, July 10-12. (abstr.)

2. Jogloy, S. N. Vorasoot, S. Mahakosee, T. Moee and **N. Puppala**. **2012**. Genetic diversity of Valencia Peanut Genotypes for Traits Associated with Nitrogen Fixation. American Peanut Research and Education Society, APRES, Raleigh, North Carolina, July 10-12. (abstr.)

3. Kandala, C.V.K., and **N. Puppala**. **2012**. Near Infrared Reflectance Spectroscopic Method to Determine Moisture Content and Fatty Acid Composition in In-Shell Peanuts. American Peanut Research and Education Society, APRES, Raleigh, North Carolina, July 10-12. (abstr.)

4. Mulindwa, J., Kaaya, A. N., **Puppala, N**., Okello, D. K., Deom, C.M., Bravo-Ureta, B. **2011**. "Development of a stable vitamin-A Rich Nutrient Peanut Butter for School age Children". Peanut CRSP Strategic Research Conference, Peanut CRSP, Malta, Europe. December 2011.

5. Kwesiga, J., Ssebuliba, J. M.,**Puppala, N**., Okello, D. K., Deom, C.M., Bravo-Ureta, B. **2011**. "Effect of Rhiozobium Inoculation on Growth and Yield of Peanut (Arachis hypogaea L.) Culivars in Uganda". Peanut CRSP Strategic Research Conference, Peanut CRSP, Malta, Europe. December 2011.

6. Okello, D. K., Deom, C.M., **Puppala, N**., Bravo-Ureta, B. **2011**. "Evaluating ICRISAT Breeding Material for Groundnut Rosette and Late Leaf spot Diseases in Uganda". Peanut CRSP Strategic Research Conference, Peanut CRSP, Malta, Europe. December 2011.

7. Nalugo, G. R., Ssebuliba, J. M., **Puppala, N**., Okello, D. K., Deom, C.M., Bravo-Ureta, B. **2011**. "Introgression of Groundnut Rosette Virus Resistance into Valencia Peanut Varieties using Conventional Breeding". Peanut CRSP Strategic Research Conference, Peanut CRSP, Malta, Europe. December 2011.

8. Wambi, W., Tukamuhabwa, P., **Puppala, N**., Okello, D. K., Deom, C.M., Bravo-Ureta, B. **2011.** "Introgression of Late Leaf Spot Resistant Genes in Valencia Peanut". Peanut CRSP Strategic Research Conference, Peanut CRSP, Malta, Europe. December 2011.

9. Smythe, B. G., Sanogo, S. **Puppala, N**., Thomas, S., Steiner, R. L., **2011**. American Phytopathological Society (APS) Annual Meeting, APS, Hawaii, "Screening Valencia Core Collection for Resistance to Sclerotinia sclerotiorum" August, Hawaii. August (abstr.)

10. Burow, M., Ayers, J., Mutia, A., Schubert, M., Lopez, Y. Simpson, C. **Puppala, N. 2011**. Development of High-Yielding, High-Oleic, Early Maturing Spanish. American Peanut Research and Education Society, APRES, San Antonio, Texas July 13-15. (abstr.)

11. Chopra, R., Swaroop, S., Burow, G., Xin, Z., Gregory, S. M., Farmer, A., May, G., Simpson, C., **Puppala, N. 2011.** Chamberlin, K., Wilkins, T.A., Burow, M.D. Next Generation Transcriptome Sequencing of the High Oleic Peanut. American Peanut Research and Education Society, APRES, San Antonio, Texas July 13-15. (abstr.)

12. **Puppala, N**., and Nuti, R. **2011.** Valencia Peanut Yield to Digging Dates and Irrigation Rates. American Peanut Research and Education Society, APRES, San Antonio, Texas July 13-15. (abstr.)

13. Kalule, D.O., M. Deom, B.E. Bravo-Ureta, P. Paxton, K.R. Kottapalli, P. Kottapalli, S. Sanogo and **N. Puppala**. 2009. Screening for Rossette Resistance in Valencia Mini Core Collection. American Peanut Research and Education Society. Raleigh, North Carolina, July 14-16. (abstr.)

14. Kottapalli, P., H.D. Upadhyaya, R. Varshney, K.R. Kottapalli, P. Payton, **N. Puppala**. 2009. Molecular characterization and assessment of genetic diversity in Valencia mini core using SSR markers. American Peanut Research and Education Society. Raleigh, North Carolina, July 14-16. (abstr.)

15. **Puppala, N**., R. Nuti, R. Sorensen. 2009. Planting Pattern Studies in Valencia Peanuts. American Peanut Research and Education Society. Raleigh, North Carolina, July 14-16. (abstr.)

16. Sanogo, S., and **N. Puppala.** 2009. Yield and Quality of Valencia Peanut as Affected by Application of Biorational and Chemical Fungicides. American

Peanut Research and Education Society. Raleigh, North Carolina, July 14-16. (abstr.)

17. Singkham, N., S. Jogloy, P. Jaisil, and **N. Puppala**. 2009. Combining ability for Oleic Acid in Peanut. 2009. American Peanut Research and Education Society. Raleigh, North Carolina, July 14-16. (abstr.)

2. Final Interpretation

a. Importance of Technical Achievements-

i. Host Country

The two-years funding support from the project enabled four graduate students from Uganda and one from Thailand complete their master's degree in Agriculture. Technical collaboration and exchange of germplasm between NMSU and NaSARRI have strengthened peanut (Valencia types) variety development program in Uganda. Twelve peer-reviewed research articles have been published in reputed journals, while several posters/abstracts were presented in workshops/conferences to highlight our work to peanut researchers/development agencies engaged in peanut research and development.

ii. USA

The funding from the NMS-172 project was partially used to strengthen peanut breeding at New Mexico State University (NMSU), which will shortly release its first high oleic peanut Variety, NuMex-01, Valencia market type, adapted to New Mexico and Western Texas. In multi-year evaluation trials, NuMex-01 produced an average pod yield of 4265 kg ha^{-1}. The average pod yield of the control (Valencia-A) was 3448 kg ha^{-1}. Its oil quality as determined by oleic (O)/linoleic (L) ratio is far superior (O/L ratio: 18 to 25) to Valencia A (O/L ratio: 1 to 2).

b. Importance of physical and human capacity development-

i. Uganda

The four MS students from Makerere University, Uganda have been exposed to various issues related to peanut improvement (breeding, genetics, peanut quality, and host plant resistance), which will help them to undertake peanut research and development in Uganda.

ii. USA

NMSU awarded a short-term consultancy contract to an international expert, and hiring of temporary post docs whose presence at NMSU during the project period has helped Naveen Puppala (the peanut breeder) strengthen peanut research on variety development at NMSU.

c. Heritage left from workshops and short-term training-

i. Uganda

We wanted to conduct a workshop for technicians to help with breeding techniques but we were not able to complete this aspect of short-term training. We also wanted to train the field officers who do on farm trials collecting data but due to restriction in funding we were unable to complete this short-term workshop.

ii. USA

We wanted to train the co-PI's in molecular breeding by inviting them to USA but due to fund restrictions we decided to postpone it to next phase if this project continues.

d. Heritage left in publications

There are several publications that will be completed in 2013. Some of those that are in preparation are listed below:

1. Okello, D.K. C. M. Deom*, **N. Puppala**, E. Monyo and B.E. Bravo-Ureta. **2013**. Registration of "Serenut 5R" Groundnut. J. Plant Reg.

2. Okello, D.K. C. M. Deom*, **N. Puppala**, E. Monyo and B.E. Bravo-Ureta. **2013**. Registration of "Serenut 6T" Groundnut. J. Plant Reg.

3. **Puppala, N**., and S.P. Tallury. Registration of high oleic Valencia peanut "NuMex-01". **2013**. J. Plant Reg.

Master Theses:

1. Nalugo Rachael Grace. 2013. Introgression of Rosette Virus Resistant Genes into Exotic Valencia Varieties. August 2013.

2. Wambi Wilber. 2013. Inheritance of Late Leaf Spot (*Phaeoisariopsis personata*) Resistance in Valencia Groundnut. August 2013.

3. Kwesiga Julius. 2013. Effects of Rhizobium Inoculation on Growth and Yield of Elite Groundnut (*Arachis hypogaea* L.) Cultivars in Uganda. August 2013.

4. Mulindwa Joseph. 2013. Production, Acceptability and Stability of Pro-vitamin A enhanced Peanut Butter. August 2013.

5. Supatra Mahakosee. 2013. Genotypic Diversity of Traits Related to Nitrogen Fixation in Valencia Peanut Germplasm. August 2013.

3. Final Summary of Accomplishments by Objectives

1: Evaluate accessions for agronomic/seed quality traits, resistance to pod rot and tolerance to drought

A set of Valencia accessions, including those from US Valencia core and global core collections, were evaluated for agronomic traits, and identified three high nitrogen fixing germplasm, i.e., PI 475921, PI 536307 and Vemana, which may be used to introgress high nitrogen fixing trait into improved genetic background. The objective of our drought study was to identify and screen for drought tolerant lines among Valencia core collection. For any breeding program to be successful we need to identify germplasm lines that are tolerant to drought and at the same time yield high. Recently a Valencia core was developed from the USDA collection using 26 morphological descriptors. In this study we grew 80 PI's from the Valencia core collection developed by NMSU at Brownfield, Texas under full irrigation (673 mm) and limited irrigation (419 mm). We identified few PI's (315612, 493630, 493325, 493810, 493624, 493415, 497642 and 493461) that performed better under limited irrigation conditions compared to the check Valencia- C. The pod rot screening could not be completed due to limitation in funding.

2: Study the genetic structure of accessions using SSRs and high throughput assay

Using SSRs and high throughput assay, the Valencia peanut accessions from different geographical regions were characterized for population structure and diversity, which differentiated germplasm into different clusters, indicating the presence of genetic diversity amongst Valencia germplasm included in this study. This is the first extensive molecular study of Valencia peanuts. The genetic diversity detected in this study may be utilized for selection of parents for breeding Valencia cultivars with economically desirable traits.

3: Study variation in transcript abundance among drought tolerant and susceptible lines using oligonucleotide microarrays

We have developed a high-density oligonucleotide microarray for peanut using 49,205 publicly available ESTs and tested the utility of this array for expression profiling in a variety of peanut tissues. To identify putatively tissue-specific genes and demonstrate the utility of this array for expression profiling in a variety of peanut tissues, we compared transcript levels in pod, peg, leaf, stem, and root tissues. Results from this experiment showed 108 putatively pod-specific/abundant genes, as well as transcripts whose expression was low or undetected in pod compared to peg, leaf, stem, or root. The transcripts significantly over-represented in pod include genes responsible for seed storage proteins and desiccation (e.g., late-embryogenesis abundant proteins, aquaporin's, legumin B), oil production, and cellular defense. Additionally, almost half of the pod abundant genes represent unknown genes allowing for the possibility of associating putative function to these previously uncharacterized genes. The peanut oligonucleotide

array represents the majority of publicly available peanut ESTs and can be used as a tool for expression profiling studies in diverse tissues.

4: Screening of Valencia core collection for Rossette and Leaf Spot

The Valencia core collection accessions were evaluated for resistance to GRD and LLS for two seasons, and the results summarized below.

1. None of the 77 Valencia core accessions were found resistant to LLS.

2. One hundred and twelve Valencia accessions were screened for resistance to GRD for two seasons, and identified a number of PI's that were resistant to GRD; 493566 (best performing line), 390432, 502023, 493688, 493810, 493666, 475913, 406718 and 493340, which may be used in breeding to develop commercial Valencia cultivars with GRD resistance.

5: Evaluating Valencia variety Red Beauty with fungicide Abound at two locations and its economic impact on yield and disease.

We could not conduct this study due to limitation in help from the farm crew. As rains were delayed during 2010 all the farm crew has to concentrate on the breeding studies to plant the material.

6: To support and train two graduate students from Makerere University in Plant Breeding and Agronomy

The project funded four students from the Makerere University, Uganda and one student from Khon Kaen University of, Thailand to complete their MS program, as detailed below.

1. **Ms. Rachael Nalugo**, a graduate student from Makerere University, Uganda, made crosses involving Valencia - C and NuMex-M3 (a peanut breeding line from New Mexico State University, USA) with rosette resistant lines, Serenut 6T and Serenut 2, and a local variety from Mali. F1's were back crossed with parental lines. This material is currently in F_2 generation with variable plant populations: Valencia-C x Serenut 6R (10 plants); Valencia-C x Serenut -2 (15 plants); Valencia-C X Mali-1 (14 plants); NuMex-M3 x Serenut-6 (14 plants); NuMex-M3 x Serenut-2 (10 plants); NuMex-3 x Mali-1 (9 plants in F_1).

2. **Mr. Wambi Wilber,** a graduate student from Makerere University, Uganda, made crosses involving Valencia-C, Red beauty and NuMex-M3 with leaf spot resistant lines, ICGV 03590, ICGSM 02501 and 91707. The F_1's were generated in season 1 and back crossed with parents in season 2.

3. **Mr. Julius Kwesiga,** a graduate student from Makerere University, Uganda, has taken up a field and greenhouse study for testing commercial rhizobium inoculants in comparison to locally available strain to test its efficacy in raising the peanut production. Preliminary evaluation revealed that commercial rhizobium inoculants Vault and Lift gave higher pod yield compared to Histick and MUK. Further, data analysis is in progress and plans are made to test one more season before concluding the possible benefit of applying rhizobium inoculants to raise peanut productivity in Uganda.
4. **Mr. Mulindwa Joseph,** a graduate student from Makerere University, Uganda tested peanut butter fortified with orange-fleshed sweet potato (OFSP) and found that it has high values of pro vitamin A, which can reduce Vitamin- A deficiency in school age children for enhanced academic performance.
5. **Ms. Supatra Mahakosee,** a graduate student from Khon Kaen University has evaluated the US Valencia core collection together with ICIRSAT Valencia collection for agronomic traits and identified three accessions, PI 475921, PI 536307 and Vemana for high nitrogen fixation, which may be used in peanut breeding to select segregants with high nitrogen-fixation ability.