BILL & MELINDA GATES foundation

Progress Narrative

Use this form to provide updates to your foundation program officer regarding progress made toward achieving your project's stated outputs and outcomes.
The Progress Narrative must be submitted in Word, as PDFs will not be accepted.

General Information

Investment Title	Tropical Legumes III - Improving Livelihoods for Smallholder Farmers: Enhanced Grain Legume Productivity and Production in Sub-Saharan Africa and South Asia		
Grantee/Vendor	International Crops Research Institute for the Semi-Arid Tropics		
Primary Contact	Rajeev Varshney	**Investment Start Date**	April 23, 2015
Feedback Contact[1]	Rajeev Varshney	**Investment End Date**	April 30, 2019
Feedback Email[1]	r.k.varshney@cgiar.org	**Reporting Period Start Date**	May 1, 2017
Program Officer	Jeffrey Ehlers	**Reporting Period End Date**	April 30, 2018
Program Coordinator	Emily Zuberi	**Reporting Due Date**	June 15, 2018
Investment Total	$25,026,495.00	**Opportunity/Contract ID**	OPP1114827
Scheduled Payment Amount (If applicable)	$ $4,336,395		

[1] Feedback Contact/Email: The full name and email of the contact whom foundation staff queries for various surveys.

Submission Information

By submitting this report, I declare that I am authorized to certify, on behalf of the grantee or vendor identified on page 1, that I have examined the following statements and related attachments, and that to the best of my knowledge, they are true, correct and complete. I hereby also confirm that the grantee or vendor identified on page 1 has complied with all of the terms and conditions of the Grant Agreement or Contract for Services, as applicable, including but not limited to the clauses contained therein regarding Use of Funds, Anti-Terrorism, Subgrants and Subcontracts, and Regulated Activities.

Date Submitted	[June 20, 2018]	**Submitted by Contact Name**	Rajeev Varshney
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Progress and Results

1. Progress Details

Provide information regarding the current period's progress toward achieving the investment outputs and outcomes as well as the work planned or anticipated for the next period. In addition, submit the Results Tracker with actual results as requested.

EXECUTIVE SUMMARY

During year three, the project has made significant improvements towards achieving its proposed targets. Impact for Change studies were conducted in all Tier 1 countries and crops - Nigeria (groundnut and cowpea), Tanzania (common bean and groundnut), and Ethiopia (common bean and chickpea). Significant adoption figures were presented in draft reports and presentations at the Annual Review and Planning Meeting in Kampala, Uganda (April 3-6, 2018). An interesting example of this pertains to common bean in Southern Tanzania, where variety Uyole 96 had been dominating more than 60% of production; by 2016, it had been replaced by Njano Uyole that is appreciated for its agronomy, consumption, processing and marketing attributes such as better yield, pest/disease resistance, ease of shelling, storability, market price, color and cookability.

The technological progress in form of varietal change, improved agronomic practices have combined to provide positive growth trends in bean productivity in Ethiopia; yield grew from 1.0 ton/ha in 2008 to about 1.7 ton /ha in 2016. After controlling for cofounding factors, the adoption of improved common bean varieties has increased the average yield of beans by 336kg/ha. National adoption rate of improved varieties in Ethiopia is about 37% of the bean growers, which translates to about 1.5 million households. Mexican 142 that was controlling over 50% of white canning bean market class and Red Wolita that was controlling about 70% red cooking bean type at the time of baseline studies in 2009 have totally replaced by new varieties promoted under the project.

Improved groundnut varieties in Nigeria registered an overall adoption rate of 44% (60% for females and 42% for males) by farmers. When the project started in 2007, old varieties released between 1960s and early 1990s such as Samnut 1 to Samnut 20, were still dominant. The project promoted the adoption of Samnut 21, Samnut 22 and Samnut 23 released in 2000 before the release of newer varieties, Samnut 24 (2011), Samnut 25 (2013) and Samnut 26 (2013) which have replaced these old varieties, with Samnut 24 controlling about 25% of groundnut production currently. Project interventions and associated enabling factors including strategic partnerships led to a significant yield increase of 222.44 kg/ha (391 kg/ha for females and 200.5 kg/ha for males) and associated income increase of $135/ha ($168/ha for females and $93/ha for males).

In cowpea in Nigeria, old varieties such as Sampea 7, released in 1985, have almost been completely replaced by newer varieties such as Sampea 8 released in 2005 and promoted under the project since 2007. Better still, Sampea 8 was quickly replaced by Sampea-11 released in 2009, which in turn is currently seeing a swift replacement by Kwankwaso which is yet to be officially released.

The latest data on chickpea varietal adoption at the national level in Ethiopia is awaiting analysis. However, an earlier study conducted in three intervention districts showed up to 80% adoption levels of new varieties although the national average is estimated to be less than 30%. Together with integrated crop management practices, chickpea productivity increased from 1.27 kg/ha in 2007 to 1.97 kg/ha in 2016; and total production rose from 253,871 tons (t) on about 200,066 ha to 444,146 t on about 225,608 ha in 2016. The change in production is about 75% over 2007 base figures, mainly accounted for by gain in productivity (55%) rather than area (13%).

In Tanzania, adoption of improved groundnut varieties is estimated at 19% nationally before correction through DNA fingerprinting data. However, the seed systems work through about 400 farmer research groups linked to seed companies as contract seed producers, together with training and adoption of integrated crop management practices have contributed to increased groundnut productivity from 724 kg/ha in 2008 to about 1010 kg/ha in 2015 and total production from 340,770 t on about 470,670 ha to 1,635,335 t on about 1,619,500 ha in 2015. The change in production is about 480% over 2008 base figures, and both gains in area (244%) and productivity (39%) have contributed to these remarkable increases. The varieties that were reigning before 2007 include Nyota (1.5t/ha), Johari (1t/ha), Sawia (1.5t/ha) and Pendo (1.5t/ha). While Pendo is still dominant and is currently being replaced by rosette resistant Nachgwea (1-1.5kg/ha) and Mangaka (1.5-1.8t/ha), the other varieties have been largely been replaced.

In Mali, the ruling varieties before 2007 were very old with some dated back in 1928. New varieties of <10 years old were promoted by the project. Fleur 11 and ICGV 86124 are currently replacing the old ones because of their high fodder yield, their short duration in an area with rainfall shortage where most farmers prefer early maturing varieties with high pod and haulm yield for livestock.

DNA fingerprinting work to support adoption data is underway in collaboration with Intertek and DArT Pvt Ltd in Australia for chickpea, groundnut and cowpea and at CIAT headquarters in Columbia for common bean. The two ICRISAT gender scientists redeployed to the project in ESA and WCA have supported the national programs to run focused group discussions and surveys around gender yield gaps which reported no significant yield gaps. Recommendations from such studies have also been used to reorganize and strengthen seed systems approaches including multi-stakeholder platforms (MSPs) as well as design product profiles that respond to different stakeholders in the market.

The project employed the former TL III Project Coordinator as a project advisor to fast-track the NARS Breeding Program Assessment Tool (BPAT) self-assessment status and recommendations for Program Improvement Plans around enhancing genetic gain. All the 15 National Agricultural Research Systems (NARS) partner crop breeding programs have in varying degrees embraced approaches that enhance breeding efficiency and accelerate genetic gains, such as the use of BMS for field planning, data gathering and management; digital data collection tools; increasing the number of crosses, cycles per year, and test locations besides redesigning breeding and hybridization methods to include early generation screening. The programs also documented product profiles guiding their crop improvement programs and these are highlighted under each program's report. The detailed reports of the project advisor are hyperlinked under the Project Coordination section of this report. Fourteen training workshops were conducted for a total of 120 national breeders and technicians to improve their capacity to optimize their breeding efficiency.

A total of 17 new farmer-preferred varieties were released across the four legumes (3 groundnut, 5 cowpea, and 9 common bean) and 50 lines were submitted for Distinctness, Uniformity and Stability (DUS) tests. A total of 110 lines were entered into national performance testing (NPT) for a possible future release. A total of 1492 new breeding lines were developed by the NARS and CGIAR center for maintaining the pipeline full. A total of 585 farmer participatory varietal selection (FPVS) trials were conducted involving

11,744 farmers, with more than 50% representation of women (5026 men; 6718 women), a significant improvement from year 2 and well above the target of 30%. In total, 41 new MSPs were established/strengthened at national and/or regional levels and the capacities of 9083 platform members in seed production techniques, good agronomic practices, post-harvest handling, seed marketing and group dynamics across legumes, were enhanced.

A total of 201.8 t of breeder, 2,816t of basic, and 36,124t of certified/quality declared (QDS)/ truthfully labelled seeds (TLS) was produced. Of the certified/QDS/TLS produced, 9.6% (beyond the targeted 5%) was distributed in small packs to enhance wider and affordable access to seed of improved legume varieties, especially by resource-poor women famers. A total of 1562 seed enterprises (seed companies, farmer organizations, farmers groups, public seed enterprises, and individual seed entrepreneurs) were engaged in seed production/marketing across legume crops in the target countries. The project also developed a digital seed Seed roadmap and catalogue: http://seedsystems.icrisat.org as well as a digital planning, monitoring, evaluation, accountability and learning framework: http://measure.icrisat.org.

A number of avenues were used to disseminate technical and policy information on available technologies and inputs to target audiences, such as the TL III website (213,096 visits from 175+ countries), quarterly TL III bulletins, articles in ICRISAT Happenings (25), abstracts (18), at the 7th International Food Legumes Research Conference, and a training manual on "Seed Business Management in the Context of Smallholder Farmers". The TL III social media platforms are Facebook (885 followers), Twitter (579 followers), Slideshare (94 presentations with 13,716+ views), and Flickr (646 photos). As a result, knowledge has been disseminated to a large number of people including 2,151,837 people with 267,370 impressions through Twitter and 1,884,467 people virtually over Facebook.

1. INTRODUCTION

TL III is a visionary project that aims to improve the lives of smallholder farmers in the target region through enhanced grain legume productivity and production. It operates under three pillars: (1) Developing improved varieties; (2) Improving breeding program capacity; and (3) Seed delivery and gender as a crosscutting theme. The activities included under pillar 1 are: (i) Trait discovery pipeline; (ii) Breeding pipeline; (iii) Testing for release; and (iv) Best bet varieties. Pillar 2 lays emphasis on developing the capacity of partner breeding programs by incorporating modern breeding technologies. Pillar 3 seeks to ensure timely delivery of improved cultivars to smallholder farmers through efficient seed systems via: (i) establishment of multi-stakeholder platforms (MSPs); (ii) seed production and delivery; (iii) innovative and targeted seed marketing; (iv) popularizing new varieties; and (v) strengthening impact-oriented seed systems. This report is organized by crop breeding program into the following sections: (i) Development and release of farmer-preferred legume crop varieties; (ii) Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers; and (iii) Strengthening legume breeding capacities of partner NARS and CGIAR centers (ICRISAT, IITA and CIAT), mainly in Africa.

2. Groundnut crop improvement

2.1 Groundnut crop improvement in Mali

2.1.1 Development and release of farmer-preferred groundnut varieties

- In collaboration with other projects, whole-genome resequencing (WGRS)-based approach referred to as 'QTL-seq', was deployed and 25 candidate genes were identified controlling resistance to rust and late leaf spot (LLS) (Plant Biotechnology Journal 2017, 15:927–941; Biotechnology Reports 2017, 15:132–137; Plant Biotechnology Journal 2018: doi: 10.1111/pbi.12930). This study helped in developing a 10-SNP panel for early generation screening through HTPG project for three traits (high oleic acid, rust and LLS) in groundnut.
- TL III project in collaboration with other ongoing projects developed a high-density SNP array 'Axiom_Arachis' with 58 K highly informative genome-wide SNPs which will accelerate the process of high resolution trait genetics and molecular breeding in cultivated groundnut (Scientific Reports 2017, 7:40577, DOI: 10.1038/srep40577; Journal of Experimental Botany 2018, doi:10.1093/jxb/ery088). We have deployed this SNP array for genotyping >3000 lines including bi-parental population (TAG 24 × ICGV 86031) for mapping drought tolerance related traits, multiparent advanced generation intercross (MAGIC) population for aflatoxin resistance and training population for initiating genomic selection breeding in groundnut.
- With partial support from TL III project, genome-wide discovery and deployment of insertions and deletions markers provided greater insights on species, genomes, and sections relationships in the genus Arachis (Frontiers in Plant Science 2017, 8:2064, doi: 10.3389/fpls.2017.02064).
- In collaboration with TL III and other projects, molecular breeding lines (19 lines) for high oleic acid and foliar fungal diseases developed in collaboration with NARS partners are in the final year of testing for distribution to NARS partners.
- Two groundnut varieties (ICGV 94379 resistant to aflatoxin and ICGV 86124 susceptible to aflatoxin) were assessed for aflatoxin levels using phenotyping platforms established in 2016 at IER, with the support of TL III project. The two lines will be used as parental lines to develop aflatoxin mapping populations.
- Besides the technicians trained in aflatoxin quantification at ICRISAT-Mali (2 in 2015 and 3 in 2016), 30 extension technicians were trained in 2017 conducting on-farm trials and demonstrations for field aflatoxin control.
- ICRISAT-Mali has irrigation facility for drought phenotyping/off-season nurseries and it uses artificial inoculation for aflatoxin phenotyping. IER has also installed a 2 ha irrigation facility as the research center is far from the ICRISAT site.
- In 2016, IER sent 11 varieties (Diakandape, Kaarta-tiga, ICGV 86124, ICGV 01276, ICGV 00064, ICGV 99029, ICGV 96802, JL 24, Fleur 11, ICIAR19BT and 55-437) to ICRISAT-Kenya for genotyping; this was successfully completed for 9 varieties (Kaarta-

tiga, ICGV 86124, ICGV 01276, ICGV 00064, ICGV 99029, ICGV 96802, Fleur 11, ICIAR19BT and 55-437) in 2017. Backcrossing populations (BC_3) described below in the breeding pipeline will be sent to ICRISAT-Kenya for genotyping in 2018.

- At ICRISAT-Mali, populations were developed in 2015 involving 5 females (Fleur 11, ICGV 00064, ICGV 01276, ICGV 03179, JL 24) and 5 males (ICGS 44, ICGV 86015, ICGV 86024, ICGV 86124, ICGV 99241) parents. By the end of 2017, a total of 20 F_5 populations had been advanced and will be genotyped together with the parents to assess them for marker polymorphism. Inbred lines from polymorphic parents will be phenotyped for drought QTL analysis.
- In 2017, ICRISAT-Mali sent a total of 42 groundnut breeding lines used for population development to ICRISAT-Kenya for molecular polymorphism studies using 10 SNP panel. The lines were found to have low variability, and none have the high oleic allele suggesting the need to diversify the breeding gene pool.
- IER is working on two breeding pipelines for: (1) Short-duration and climate resilient varieties with resistance to foliar fungal and virus diseases for oil, food and dual purposes and (2) medium-duration (MD) varieties with resistance to foliar fungal and soil borne diseases for oil, food and confectionery, and dual purposes.
- For short duration (SD), ICRISAT-Mali developed 50 new F_1 populations with moderate leaf disease resistance using 10 female (ICGV 00064, ICGV 01276, ICGV 99029, ICG 7878, ICGV 89767, ICGV 00068, ICGV 00005, ICGV89104, ICGV 02271, ICGV 99241) and 5 male (ICGV 91114, ICGV 07356, ICGV 00350, 55-437, Mossitiga) parents in 2016 at Samanko; currently at stage F_3.
- ICRISAT-Mali made another 20 new crosses using 5 female (12 CS-042, ICGV 01276, ICGV 00064, ICGV 08837, 12CS-116) and 4 male (Samnut 25, QH243C, Samnut 26, JL 24) parents in year 3 (2017) resulting in F_1s that are currently being advanced to F_2.
- ICRISAT-Mali evaluated 50 F_4 populations developed from 10 female (ICGV-IS 14858, ICGV-IS 14876, ICGV-IS 14877, ICGV-IS 14880, ICGV-IS 14897, ICGV-IS 14943, ICGV-IS 14964, ICGV-IS 14965, ICGV-IS 141076, ICGV-IS 14849) and 5 male (ICGV 99240, ICGV 00068, ICGV 00064, ICGV 01276, ICG 7878) parents in 2015 in 2017 and advanced to F_5 which are currently in the field during off-season. Single plants will be selected for evaluation in an observation nursery during the 2018 main rainy season.
- ICRISAT-Mali evaluated eighty single plant F_5 SD lines developed from QH234C x Nama cross as part of a PhD research on ELS in 2017 and 11 were selected for further evaluation.
- ICRISAT-Mali made fifty new crosses for SD + aflatoxin using 10 female (ICGV-IS 14858, ICGV-IS 14849, ICGV-IS 14876, ICGV-IS 14877, ICGV-IS 14897, ICGV-IS 14880, ICGV-IS 14943, ICGV-IS 14964, ICGV-IS 14965, ICGV-IS 141076) and 5 male (ICGV 00068, ICGV 99240, ICGV 01276, ICGV 00064, ICG 7878) parents and were advanced to F_2 in year 3.
- ICRISAT-Mali made another twenty new crosses using 5 female (55-437, J 11, ICGV 94379, ICGV-IS 14855, ICGV-IS 14880) and 4 male (ICIAR 19BT, ICGV 92302, ICGV 91278, ICGV 91317) parents in 2017, where F_1 are currently in the field during the off-season.
- At ICRISAT-Mali 15 F_5 populations for SD + aflatoxin developed from 5 female (Fleur 11, 55-437, ICGV 86124, ICIAR 19BT, ICGV 86015) and 3 male (ICGV 94379, ICGV 91317, ICGV 91324) parents in 2013 under TL II were evaluated at F_5 where 118 single plants were selected for seed multiplication during the 2018 off-season. These lines will be evaluated in the observation nursery during the 2018 main season.
- At ICRISAT-Mali 132 lines (Table 2.1.1) with a combination of traits (SD, drought and resistance to foliar diseases) were selected from an observation nursery containing 1,175 lines. The 132 lines will be evaluated in preliminary yield trial.
- For drought tolerance screening, 50 new F_1 populations were developed using 10 female (ICGV 99240, ICGV 99241, ICGV 99240, ICGV 02271, ICGV 07356, ICGV-IS 13850, ICGV-IS 13967, ICGV-IS 13979, ICGV-IS 13950, ICGV-IS 13833) and 5 male (ICGV 86124, ICGV03179, ICGV 86015, JL 24, Fleur 11) parents in 2016 and another 20 new crosses were made using 5 female (ICGV 86124, ICGV 91114, ICGV 86015, ICGV-IS 13863, ICGV-IS 13937) and 4 male (ICGV-IS 13833, ICGV-IS 13979, ICGV-IS 13834, ICGV-IS 13950) parents in 2017; F_1s have been planted for advancement to F_2.
- For traits combining drought and aflatoxin tolerance, 50 F_4 populations developed from 10 female (ICGV-IS 14964, ICGV-IS 14965, ICGV-IS 141076, ICGV-IS 14876, ICGV-IS 14877, ICGV-IS 14943, ICGV-IS 14849, ICGV-IS 14858, ICGV-IS 14880, ICGV-IS 14897) and 5 male (ICGV 00064, ICGV 00068, ICGV 01276, ICGV 99240, ICG 7878) parents in 2015 were evaluated at ICRISAT-Mali and advanced to F_5 which are currently planted during the 2018 off-season.
- IER made 6 crosses for SD using Fleur 11 as female parent and 3 male (55-437, Diakandape, ICGV 00064) parents, and the 6 populations are at F_4. In 2016, 21 crosses were made for SD and combination of traits involving 7 female (ICGV 86124, ICGV 86015, ICGV 02271, Diakandape, Fleur 11, ICGV 00064, ICGV 00068) and 7 male (Fleur 11, JL 24, ICIAR19BT, ICGV 01276, ICGV 02271, ICGV 86015, ICG 7878) parents, and these populations are currently at F_4. In year 3, 7 crosses were made for drought and confectionery with 7 lines (ICGV 07356, ICGV 91114, ICGV 00350, ICGV 09194, ICGV 08134, ICGV 08056, ICGV 09191) used as females and ICGV 86024 as male. Two of the crosses failed and a total of 28 F_1 seeds have been harvested from the remaining 5 crosses and will be confirmed in the main season.
- For PC 2, 50 F_1 MD populations were developed during the 2016 main rainy season using 10 female (ICGV 97087, ICGV 97094, ICGV 98088, ICGV 98089, ICGV 98100, ICGV 88434, ICGV-IS 96801, ICGV-IS 96826, ICGV-IS 96891, ICGV 01276) and 5 male (ICGV 86024, ICGV 97188, ICGV 99240, ICGV 02271, ICGV 99241) parents at ICRISAT-Mali.
- ICRISAT-Mali made another 20 new MD crosses using 5 female (ICG 7878, ICGV 07210, ICGV 98088, ICGV 98089, ICGV 98100) and 4 male (Samnut 22, Samnut 23, ICGV 97087, Nama) parents in year 3; F_1 have been planted during 2018 off-season. The 50 F_3 and 20 F_2 will be planted for advancement during the 2018 main rainy season while additional crosses will also be made.
- In addition, ICRISAT-Mali selected 98 lines with a combination of traits (MD, drought and resistance to foliar diseases) from an observation nursery containing 1,175 lines. These 98 lines will be evaluated in a preliminary yield trial during the 2018 main season and some are also being shared with Burkina Faso, Ghana, Mali and Nigeria breeding programs.
- ICRISAT-Mali started working on confectionery lines with 6 new populations developed using 2 female (Fleur 11, 47-10) and 3 male (ICGV-IS 08854, ICGV-IS 08834, ICGV 09195) parents in 2017 and the F_1 populations are currently in the field (off-season) and the F_2 will be planted during the main rainy season of 2018.
- Sixteen advanced confectionery lines (ICGV 09196, Fleur 11, ICGV 08056, ICGV 09194, ICGV 09195, ICGV 09191, ICGV 09221, ICGV 08134, ICGV 08081, ICGV IS-08834, ICGV 09207, ICGV 08054, ICGV 08088, ICGV 08086, ICGV 08110, and ICGV 09208)

were evaluated at ICRISAT-Mali in a preliminary yield trial in 2017 and enough seed was obtained for multi-location trials during the 2018 main season.

- IER established a hybridization block in 2015 using 3 medium-duration varieties tolerant to ELS (ICGV 01276, ICGV 99029, ICG 7878) collected from ICRISAT-Mali and 3 farmer-preferred varieties (JL 24, Fleur 11, ICIAR 19BT) where a total of 282 F_1 were harvested. Hybridity confirmation test was done in the 2017 rainy season, and backcrossing performed using confirmed F_1s to generate BC_1 populations using 3 farmer preferred varieties (JL 24, Fleur 11, ICIAR 19BT) as recurrent parents. A total of 1405 BC_1s were harvested for 9 BC_1 populations.
- During 2016 and 2017 rainy seasons, IER developed 8 BC_2 populations with a total of 59 BC_2 and 8 BC_3 with a total of 274 BC_3, respectively, harvested (Table 2.1.2). In 2017, IER developed 2 MD populations using ICGV 01276 as female and 2 male (ICGV 99029, ICG 7878) parents which are currently at F_2. IER also developed 23 new MD populations using 3 female (Fleur 11, ICGV 86124, ICG 7878) and 8 male (Serenut 8R, Serenut 9T, Serenut 10R, Serenut 11T, Serenut 12R, Serenut 14R, DOK 1R, DOK 1T) parents. The male parents were obtained from the Uganda groundnut breeding program. Three crosses failed and the remaining 20 F_1 populations will be planted in the 2018 main rainy season for hybridity confirmation and advancement.
- In 2016, ICRISAT-Mali organized a Regional Variety Trial (RVT 1) with 16 varieties (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834, ICGV 86024, ICGV 86015, ICGV 93305, ICGV 93328, ICGV 91317, ICGV 91315, ICGV 94379 and local check) for Burkina Faso (2 locations), Ghana (6 locations), Mali (6 locations – 1 location at ICRISAT Mali) and Nigeria (5 locations). ICRISAT-Mali also conducted four sets of preliminary variety trials, containing 122 breeding lines (Table 2.1.3). Select 34 lines (Table 2.1.4) and 2 checks were evaluated in other regional variety trials (RVT 2) during 2017 in partnership with NARS (5 locations in Ghana, Mali and Nigeria). Besides, a total of 132 unique advanced lines (Table 2.1.5) were provided to NARS including Nigeria (34), Mali (56), Gambia (63), DR Congo (68), Ethiopia (63), Ghana (34), Niger (34) and Senegal (34).
- In 2016, IER conducted RVT 1 with the 16 entries at five locations and repeated the same regional trial successfully in 2017 in the same locations. The combined analysis of RVT 1 in the 2016 across locations revealed 5 lines to be promising (ICGV-IS 13834, ICGV-IS 13830, ICGV-IS 13806, ICGV-IS 13824, ICGV-IS 13827). One of these lines (ICGV-IS 13830) has already been included in the DUS test.
- In 2017, IER conducted a second regional trial (RVT 2) with 34 entries plus 2 checks in four locations. Combined analysis will be done on this data to identify best performing lines. The trial will be repeated to confirm best performing lines that will go for on-farm evaluation.
- IER evaluated 9 SD lines (ICGV-IS 13094, ICGV-IS 13085, ICGV-IS 13054, ICGV-IS 13079, ICGV-IS 13111, ICGV-IS 113106, ICGV-IS 13055, ICGV 00064 and check Fleur 11) in 2016 and 3 promising lines (ICGV-IS 13085, ICGV-IS 13054, ICGV-IS 13079) were selected.
- IER evaluated another 9 drought and ELS tolerant varieties (ICGV-IS 13809, ICGV-IS 13871, ICGV-IS 13830, ICGV-IS 13972, ICGV-IS 13866, ICGV-IS 13912, ICGV-IS 13825, ICGV-IS 13863 and check 55-437) and 3 promising lines (ICGV-IS 13871, ICGV-IS 13830, ICGV-IS 13825) were identified.
- Besides, IER evaluated 81 ELS and drought tolerant lines from ICRISAT-Mali in a preliminary trial in 2015, from which 30 promising lines (ICGV -IS 13802; ICGV-IS 13950, ICGV-IS 13884, ICGV-IS 13876, ICGV-IS 13881, ICGV-IS 13910, ICGV-IS 13817, ICGV-IS 13871, ICGV-IS 13822, ICGV-IS 13865, ICGV-IS 13967, ICGV-IS 13813, ICGV 86124, ICGV-IS 13850, ICGV-IS 13821, ICGV-IS 13847, ICGV-IS 13864, ICGV-IS 13967, ICGV-IS 13848, ICGV-IS 13830, ICGV-IS 13870, ICGV-IS 13828, ICGV-IS 13979, ICGV-IS 13930, ICGV-IS 13846, ICGV-IS 13833, ICGV-IS 13927, ICGV-IS 13867, ICGV-IS 13855, ICGV-IS 13962) were selected for advanced trials during the 2016 rainy season. Twelve best lines (ICGV-IS 13871, ICGV-IS 13967, ICGV-IS 13979, ICGV-IS 13821, ICGV-IS 13864, ICGV-IS 13802, ICGV-IS 13910, ICGV-IS 13876, ICGV-IS 13830, ICGV-IS 13828, ICGV-IS 13833, ICGV-IS 13867) were selected from the advanced trial and evaluated in multilocation trials in 2017 at two locations. Six varieties (ICGV-IS 13967, ICGV-IS 13876, ICGV-IS 13833, ICGV-IS 13821, ICGV-IS 13802, ICGV-IS 13910) performed better than the check (Waliyar Tiga) and the best variety (ICGV-IS 13821) was proposed for DUS in 2018.
- IER conducted another multilocation trial consisting of 16 high yielding genotypes (ICGV-IS 14880, ICGV-IS 14877, ICGV-IS 141088, ICGV 01258, ICGV 07241, ICGV-IS 14876, ICG 1415, ICGV 99240, ICGV-IS 14961, ICGV-IS 14928, ICGV-IS 14876, ICGV-IS 14857, ICGV-IS 141084, ICGV 86124, ICG 5195, ICG 14630) with drought, aflatoxin, foliar disease and short duration at three locations. Seven varieties (ICGV-IS 14876, ICG 14630, ICGV-IS 141084, ICG 5195, ICGV-IS 14877, ICGV 07241) performed better than the check (ICGV 86124). Three best performing varieties (ICGV-IS 14877, ICGV-IS 14876, ICGV 07241) have been selected for DUS test in 2018.
- Sixty FPVS trials with 7 entries (ICGV 03196, ICGV 00350, ICGV 03131, ICGV 86015, ICGV 03181, ICGV 02271 and local check) were conducted by IER in five regions in 2016. Two promising lines (ICGV 03181, ICGV 00350) were preferred by farmers because of their pod yield potential, pod size and haulm yield and were included for DUS test in 2017.
- Another 60 FPVS trials with 11 entries (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834, ICGV 93305, ICGV 93328, ICGV 94379) were conducted by IER in four regions in 2017, from which farmers preferred 4 lines (ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13825 and ICGV-IS 13806) because of the good germination rate, high pod and haulm yield.
- In 2017, DUS test was conducted on 10 varieties (the 6 varieties selected from multilocation evaluation in 2016, the 2 preferred by farmers from FPVS results and 2 varieties (Mwenje and Nyanda) provided by Syngenta Foundation) in five locations. Based on 2017, many varieties were confirmed superior over the best checks (ICGV 86124 and Fleur 11)
  - In Samé, ICGV-IS 13085 with 2.9 t/ha against Fleur 11 with 1.9 t/ha and ICGV 86124 with 1.5 t/ha
  - In Ntarla, ICGV-IS 13871 with 2.1 t/ha against Fleur 11 with 1.8 and ICGV 86124 with 1.7 t/ha;
  - In Kita, ICGV-IS 13830: 1.1 t/ha against Fleur 11 with 0.34 t/ha and ICGV 86124 with 0.3 t/ha;
  - In Cinzana, ICGV-IS 13079 with 1.8 t/ha against Fleur 11 with 0.8 t/ha and ICGV 86124 with 0.8 t/ha.

The DUS test will be repeated in 2018 to meet the requirement of the national variety release committee. IER registered 3 varieties (ICIAR 19BT, J11, ICGV 92099) from TL II trials in the national and ECOWAS regional variety catalogue in Year 2.

2.1.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- The total groundnut seed produced by the project was 3,070 t, accounting for 67% of the project target of 4569 t (Table 2.1.6). This is further broken down into 78% of breeder seed, 21% of foundation seed, and 73% of certified/QDS seed (Table 2.1.6). Details of different seed classes produced by variety over the years are given in Table 2.1.7; Table 2.1.8 and Table 2.1.9.
- Two trainings were conducted for 2852 members (1726 male and 1126 female) of four MSPs established (2 each in 2016 and 2017). Besides, 32 actors (25 extension agents, 4 research staff, 3 members of MSPs) were trained in groundnut seed value chain.
- Forty tons of groundnut seed produced were marketed in small packs of 1, 2 and 5 kgs, mainly by Faso Kaba, Comptoir 2000 SA and SOPROSA seeds companies besides being distribution by CBO, MSPs and some individual seed producers.
- Three private seed companies, 40 farmer organizations, 5 public seed companies and 30 individual entrepreneurs were involved in groundnut seed production and marketing.
- Fifty demonstration trials were conducted in four regions using three varieties (Fleur 11, ICGV 86124, and local check (47-10)) with innovative practices such as ridge planting. Twenty field days were conducted and attended by 2980 (2247 female and 733 male) farmers, up from 2781 (2071 female and 710 male) in 2016. Farmers preferred improved varieties than the local checks because of the yield potential and drought tolerance.
- Eight radio/TV programs were done and 5 agri-seed fair/show/exhibitions were conducted and attended by 476 people (346 female and 130 male), up from 300 participants (200 female and 100 male) in 2016. A total of 2643 promotional materials composed of a production guide, posters, flyers on aflatoxin management and varieties production guides were distributed to farmers, traders and policy makers during the events, up from 400 in 2016.
- A study was conducted to analyze groundnut productivity gaps and adoption rates between male and female farmers and between project beneficiary and non-beneficiary farmers. The survey data was analyzed, and the report is being compiled.

2.1.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The ICRISAT-WCA program went through an external BPAT assessment in 2015 for its Nigeria (Kano) and Mali (Bamako) operations. Although the activities in Nigeria were just starting at that time, the ICRISAT-Mali program has been operating for many years. It was recommended that the scale and efficiency of the breeding program be enhanced. The following progress has been made:
  - A total of 80-200 populations are being developed per year compared to 15-35 populations before the BPAT assessment and the program has moved from Pedigree to Single Seed Descent (SSD) method;
  - Both off-season (irrigation) and main season are being used to speed up generation advancement and reduce the breeding cycle with 2-3 generations per year as currently managed;
  - The number of advanced lines in observation nurseries ranges from 800 to 1200, compared to 100 to 500 lines earlier;
  - The number of advanced lines in preliminary variety trials (PVT) has increased to at least 100 per season compared to 10-49 lines;
  - The number of advanced lines in multilocation trials/regional trials has increased to 16-36 compared to 10-20 lines, and the number of locations has increased to at least five locations per country;
  - The program has fully digitized trial management and data collection using handheld tablets, barcoding facilities and BMS; (vii) Germplasm and breeding data for 2014 to 2017 was migrated to BMS Cloud;
  - The program acquired field and laboratory equipment such as the NIRS machine, seed counter, plot thresher and seed moisture tester which will help mechanize breeding operations and increase accuracy;
  - The program is providing 120-300 advanced breeding lines per year to NARS breeding programs;
  - The program is receiving support on data management and genotyping services from Abhishek Rathore and Damaris Odeny, respectively;
  - The program has a very good aflatoxin laboratory;
  - As highlighted in the country reports, the program is also backstopping NARS programs by training their technicians and breeders through short training on breeding techniques (crossing, trial management, data analysis, etc.) and data collection and management (digital data collection using handheld devices, BMS), and through post graduate studies.
  - However, progress is yet to be made in improving seed storage and preparation facilities, human resources (there is only 1 scientific officer and 1 technician), and allied disciplines (there is no physiologist, pathologist, nutritionist and biometrician). The on-station trial site has a variability problem and there is a plan to improve field levelling. Limited funding has been the main challenge in the program improvement process, including hiring additional staff and improving facilities.

- The Mali groundnut program at IER which went through a BPAT self-assessment in February 2017, has been addressing the following areas of improvement identified in the self-assessment:
  - Defined two product concepts in 2017, as described above – SD & MD (Mali Groundnut product concept Nov 2017;
  - For both product concept 1 (i.e. SD) and product concept 2 (i.e. MD), the program has been evaluating advanced lines from ICRISAT for various traits and developing new populations since 2015, when the program was able to make 15 crosses; this increased to 21 in 2016 and 30 crosses in 2017 (Table 2.1.10 and Table 2.1.11), with a plan to increase to 40 crosses in 2018 and a shift to the SSD method. The traits addressed are ELS, drought tolerance and confectionary, rosette disease, aflatoxin tolerance, short and medium duration maturity.
  - Currently, 25 F_1 populations, 27 segregating populations at F_4 generation under pedigree method, 8 BC_3 populations for ELS and medium duration, and 2 populations at F_2 to follow the SSD method at F_3 are available. The program will focus on the SSD method in 2018 for better genetic gain targeting farmer preferred traits (Table 2.1.12).
  - With TL III support, a 2 ha irrigation facility was established in 2015 which has been used for managing nurseries (2 to 3 generations per year) and for breeder and foundation seeds production. The program expects to extend the irrigated area up to 7 ha in 2018;
  - The program has set up an aflatoxin phenotyping platform;

- A cold storage was made functional with support of TL III in 2016;
- The program was strengthened with two technicians in 2017;
- The program started using BMS and data collection using handheld devices in 2016;
- An assistant breeder and a technician were trained on BMS and handheld device use by ICRISAT in 2016 and three technicians were trained by ICRISAT in electronic data collection in 2017;
- In 2017, BMS and handheld devices were fully utilized to capture trial data and pedigree management;
- The program started entering the previous year's data into the BMS local system, with 1 trial data from 2015, 5 trials' data in 2016 and 7 trials' data in 2017;
- However, this data is yet to be migrated to BMS Cloud version, which is planned in 2018. All the breeding trials data for 2017 will be entered into the BMS and shared with ICRISAT-Mali. The crossing block should be supported with a small glasshouse to increase hybridization efficiency through the optimization of success rate.

2.2 Groundnut crop improvement in Ghana

2.2.1 Development and release of farmer-preferred groundnut varieties

- Hybridity-confirmed F_1s from 12 crosses made in 2016 which are currently at F_2 (Table 2.2.1) will be advanced twice in 2018 to F_4 via single seed descent and with irrigation facility. At the F_4 stage, the population will be genotyped using the 58K 'Axiom_Arachis' genome-wide SNP array developed by ICRISAT. The target traits here are earliness, foliar disease resistance, confectionery use, aflatoxin tolerance and stay-green properties.
- The first drought screening at the project's modernized irrigation facility was conducted in 2017 involving 50 genotypes (Table 2.2.1), of which 40 were from ICRISAT-Mali and 10 from local crosses. Ten promising genotypes (12 CS-004, 12 CS-042, ICGV 91114, CN-94C, ICGV 01276, ICGV 89767, ICGV 91317, SARGV 008, SARGV 010, and SARGV 018) were identified and were included in multilocation trials. Currently, F_1, F_2 and F_3 nurseries arising from the 2016 and 2017 crosses have been established within the facility.
- Twelve populations (Table 2.2.2) to detect QTLs associated with ELS and LLS disease as well as stay-green property were developed in 2016. The hybrids obtained from these crosses were confirmed using DNA markers and were grown in an F_1 nursery during year 3 (2017). By the end of 2017, the generated F_1s had been planted under irrigation to generate F_2s which will be advanced to F_4 by the end of 2018 and then genotyped using the 58K 'Axiom_Arachis' SNP array.
- In 2017, seven new crosses were made (Table 2.2.3) involving released varieties in Ghana and advanced lines obtained from ICRISAT-Mali in 2015 that were tolerant to foliar diseases (Table 2.2.4) and targeting SD and tolerance to ELS and LLS and 6 out of the 7 produced successful F_1 seeds which are currently being grown under irrigation in the drought screening facility. This is in addition to the 4 crosses made using the same materials in 2016 (Table 2.2.4), where hybridity of successful crosses was confirmed using SSR markers and an F_1 nursery was set up during 2017.
- For SD + aflatoxin resistance, 4 crosses were made and hybridity of successful crosses was confirmed using SSR markers with the F_1 nursery being set up during 2017. Two out of the 4 crosses produced successful F_2 seeds which are currently being evaluated under irrigation using the drought screening facility. A total of 15 SD + aflatoxin-resistant advanced breeding lines (Table 2.2.5) obtained from ICRISAT-Mali and a local check were evaluated in multilocation trials in 2016 and the trial repeated in 2017
- Another set of 4 new crosses targeting SD + aflatoxin resistance were conducted in year 3 and all the four crosses produced successful F_1 seeds (Table 2.2.6) which are currently growing under irrigation in the drought screening facility.
- The hybridity of successful year 2 crosses targeting drought tolerance, early maturity and resistance to ELS and LLS was confirmed using SSR markers, and the F_1 nursery was set up during 2017. Successful F_2 seeds are currently being evaluated under irrigation using the drought screening facility. Four new crosses targeting the same traits were made, all producing successful F_1 seeds (Table 2.2.7) which are currently being grown under irrigation in the drought screening facility.
- SARI received 12 high oleate lines (Table 2.2.2) and 7 drought tolerant lines (Table 2.2.8) from ICRISAT-India in 2017. A preliminary observational trial suggests that some lines could be promising and the trial will be repeated under irrigation in 2018 followed by multilocation adaptability trials in the Guinea and Sudan Savannah agroecologies.
- One F_3 MD population comprising 132 genotypes (Table 2.2.9) was imported from Texas Tech A&M University to establish an F_3 nursery.
- A cross of genotype ICGV 15044 as the female parent and NKATIESARI as the male parent was made during year 3. A total of 12 F_1 hybrid seeds were obtained and they have been planted under irrigation.
- In 2015, a regional variety trial (RVT 1) with 15 lines (Table 2.2.10) was received from ICRISAT and grown in an observation nursery to multiply seeds for multilocation testing. In 2016, the RVT 1 was conducted and repeated in 2017. Five genotypes (ICGC-IS 13834, ICGV-IS 13830, ICGV-IS 13912, ICGV 94379, ICGV 86015) have been selected for on-farm evaluation. Another set of 34 introduced germplasm RVT 2 (Table 2.2.11) selected for high yields, earliness and tolerance to foliar diseases was evaluated in 2017. Four genotypes (ICGV 01276, ICGV 00005, ICGV 00064, 12 CS-042) were selected for on-farm evaluation.
- A multilocation trial to identify aflatoxin tolerant lines adapted to the Guinea and Sudan Savannah agroecology of Ghana was conducted with 10 advanced breeding lines (Table 2.2.12) obtained from ICRISAT-Mali and a local check in 2016 and repeated in 2017. Four genotypes (ICGV 91324, ICGV 93305, ICGV 91278, ICGV 94379) were selected for on-farm evaluation.
- Fifteen advanced breeding lines + 1 local check (Table 2.2.13) with drought tolerance were obtained from ICRISAT-Mali and tested in 2016 and repeated in 2017. Four genotypes (ICGV 99240, ICGV 99247, ICGV 03056, ICGV 99241) were selected for on-farm evaluation.

- A total of 44 FPVS were carried out in year 2 using mother-baby trials with 20 genotypes (Table 2.2.14) received from ICRISAT-Mali as part of 124 short duration + aflatoxin resistance types (Table 2.2.15) and repeated in year 3 with 40 farmers, each growing 2 genotypes in the baby trials under their management.
- A total of 94 farmers participated in these FPVS (63 female and 31 male). After a preliminary evaluation, 30 genotypes (Table 2.2.16) were selected, out of which 20 were selected for the FPVS trials based on their yield and reaction to foliar diseases. The inputs of farmers and their preferences were noted during field days organized at each of the sites (*http://www.icrisat.org/farmers-select-promising-aflatoxin-tolerant-lines-during-a-field-day-at-silbelle-ghana/).*
- Five genotypes (ICGV-IS 08837; ICGV 13071, ICGV 91279, ICGV 13015, ICGV 13106) selected by farmers during these FPVS were entered into the varietal release pipeline and will be profiled for nutritional quality in 2018 to comply with all formal requirements for varietal release.
- In addition, the following lines were selected from the multilocation trials and will be entered into the varietal release pipeline starting with on-farm evaluation: ICGV 99240, ICGV 99247, ICGV 03056, ICGV 99241, ICGV 91324, ICGV 93305, ICGV 91278, ICGV 94379, ICGV 01276, ICGV 00005, ICGV 00064, 12 CS-042, ICGC-IS 13834, ICGV-IS 13830, ICGV-IS 13912, ICGV 94379 and ICGV 86015.
- Nutritional profiling of 6 genotypes (ICGV-IS 08837, GAF 1665, GAF 1723, Chinese, Nkatiesari, Kpanielli) has been completed and 3 genotypes (ICGV-IS 08837, GAF 1665, GAF 1723) have been proposed for release.

2.2.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- A total of 10.6 t of breeder seed was produced in 2017, up from 5.8 t in 2016 and 2.2 t in 2015 (Table 2.2.17). A total of 29.5 t of foundation seed was produced in 2017, up from 13.2 t in 2016 and 2 t in 2015. Finally, 131.9 t of certified/QDS/TLS was produced in 2017, up from 36.7 t in 2016 and 36.5 in 2016. Details of the seed production by variety in 2017 are shown in Table 2.2.18.
- Results from focus group discussions (FGDs) recommended the establishment of MSPs to support seed delivery (Ghana FGDs Report). Five MSPs have since been established and a total of 6 trainings have been organized for MSP members, of which 2 were attended by 217 MSP members (92 female and 125 male) in 2017.
- At least 4 t of the seed produced was sold in small packs (1, 2, and 5 kgs). A total of 9 organizations (seed companies, farmer organizations, public seed enterprises) and individual entrepreneurs were engaged in seed marketing of groundnut in Ghana. Individual entrepreneurs accounted for more than 30% of the total seed marketed followed by farmer organizations/groups (40%) and seed companies 30%.
- SARI used different promotional avenues such as demonstrations, farmer field days, distribution of technology factsheets (guides, flyers, leaflets, posters, brochures, and manuals), radio/TV programs and agri/seed fairs/shows/exhibitions (Table 2.2.19). Sixty four demonstration trials were conducted in 2017 with 1621 farmers (947 female and 674 male) attending. A total of 134 field days were conducted (up from 125 in 2016 and 80 in 2015) with 5038 farmers (2503 female and 2535 male). Three agri-seed fairs were organized for the first time and attended by 1,000 farmers (700 female and 300 male) (Table 2.2.20)
- Further, CSIR-SARI set up exhibition stands at events such as the Sixth Annual Northern Ghana Pre-Season Planning and Networking Forum (Tamale, 14th April 2017), CORAF/WECARD West Africa Seed Program Learning Event (Accra, 13th – 14th June 2017) and the Ninth National Food and Agricultural Show (Tamale, 26th - 30th September 2017), demonstrating new and improved varieties to more than 10,000 people comprising farmers, researchers, traders, entrepreneurs, students, development workers in the agriculture sector, among others. Over 2,000 information leaflets (on varieties, agronomy, plant protection, post-harvest) were developed and distributed at these events (http://tropicallegumes.icrisat.org/brochures-flyers/).
- An intensive desk review of Ghana's agricultural policy was conducted in 2016 with the focus on two broad thematic areas: constraints in agricultural sector and gender mainstreaming (Ghana extensive desk review report). A total of 200 groundnut producing farm households were interviewed and a gender productivity gap analysis of groundnut production among smallholder farmers was conducted (Ghana gender productivity gap report). Several strategies to reduce the gender yield gap were developed by stakeholders at a brainstorming workshop organized following the gender yield gap analysis (Ghana Groundnut Yield Gap Strategies).

2.2.3 Strengthening legume breeding capacities of partner NARS and CGIAR centers (ICRISAT, IITA and CIAT) African hub stations - Ghana

- The Ghana Groundnut Improvement Program has defined and is implementing two product concepts (Ghana groundnut product concept new 2017-1: (1) Short-duration and climate resilient varieties with resistance to foliar fungal and virus diseases for oil, food and dual purposes, and (2) Medium-duration varieties with resistance to foliar fungal and soil borne diseases for oil, food and confectionery, and dual purposes.
- Further, to improve the groundnut breeding program in Ghana, an irrigation facility was installed on 2.25 ha that will not only enable drought tolerance screening but also allow more than one generation per year. In 2017, a motorized bore hole was installed to supply water to the facility.
- Other strategies already implemented include: increasing the number of testing sites from three to six; integrating other disciplines (protection, soil fertility, seed systems); initiating an in-house crossing program where the number of crosses was increased from 12 in 2016 to 16 in 2017 (the Crossing Manager component in BMS is used to manage the crossing program); reducing the breeding cycle by making use of SSD and doing two generations in a year with the assistance of the drought screening irrigation facility; using a more advanced experimental design and mixed model analysis to reduce errors associated with experiments (field experiments are designed using the Field Trial Manager in the BMS and the resulting data are curated in the same system); and digitizing data collection using handheld android-based tablets and barcoding devices recently supplied by ICRISAT.

- All crosses, nurseries and field trials are designed using the BMS suite and the resulting data are all documented in the same BMS. Android-based tablets running the FieldLab application are used for digital data collection. A barcode printer and handheld barcode reader were acquired in 2017 to aid in digital data collection. By the end of 2017, the BMS database had 36 field trials, 5 nurseries and 29 germplasm lists. This is an improvement over the 28 field trials, 1 nursery and 17 germplasm lists in 2016.
- Two technical staff were trained in the use of BMS and digital data capture using tablet computers running the FieldLab application, data cleaning, processing and analysis at Bamako by ICRISAT in 2017 as a follow up to the training conducted for 11 technicians in 2016.

2.3 Groundnut crop improvement in Nigeria

2.3.1 Developing superior high yielding, stress tolerant farmer-preferred groundnut varieties

- ICRISAT-Nigeria initiated 10 crosses involving ICG 5891, ICG 12991, ICG 1703, ICGV 00064 and ICGV 91324 as female parents and CS 16 (rust and LLS resistance) and ICGV 15001 (high Oleic acid) as pollen parents in 2016 and F_1s were identified and advanced to F_2 in 2017.
- The F_1s from 15 crosses for SD + aflatoxin tolerance made in 2015 between 3 low aflatoxin accumulating varieties (ICGV 91317, ICGV 91324, ICGV 91328) and 5 IAR-released varieties (Samnut 22, Samnut 23, Samnut 24, Samnut 25, and Samnut 26) were advanced to F_3 in 2017.
- At ICRISAT-Nigeria, 50 new crosses made in Year 1 (Table 2.3.1) and 64 crosses made in Year 2 (Table 2.3.2), plus 42 crosses developed in 2014 during TL II and absorbed into TL III are currently at F4, F3 and F2 stages, respectively, with an objective to develop high yielding, multiple biotic and abiotic stress tolerant breeding lines.
- In 2017, a total of 45 crosses were made targeting aflatoxin resistance, foliar disease resistance, high pod and haulm yields. These crosses involved the 7 aflatoxin-resistant lines (ICG 1415, ICG35 84, ICG 6888, ICGV-IS 96909, ICG 13603, ICG 6703, ICGV-IS 94379) which were crossed with 6 Nigerian improved varieties (Samnut 21, Samnut 22, Samnut 23, Samnut 24, Samnut 25 and Samnut 26).
- The 72 mutant populations generated in 2014 by IAR under TL II through fast neutrons mutagenesis were advanced sequentially to M_5 by 2017 and will be phenotyped on-station in 2018.
- A total of 144 advanced lines (Table 2.3.3) were evaluated/phenotyped for yield and other traits in preliminary yield trials: (1) Drought and foliar disease-resistant lines – 40 entries; (2) Elite breeding lines – 28 entries; (3) Short-duration lines – 40 entries; 4. Confectionary lines – 36 entries.
- In 2016, RVT 1 with 16 entries organized by ICRISAT Mali was conducted at 5 locations. In 2017, RVT 2 with 34 entries (Table 2.3.4) from ICRISAT-Mali, Samnut 22 and Samnut 24 as local check varieties was conducted at five locations to determine the adaptability of entries to different agro-ecological zones.
- Selections were made from 144 elite lines (20 drought and foliar disease resistant) received from ICRISAT-Bamako in 2014 (Table 2.3.3) and those acquired from ICRISAT-Kano in 2015 (45 SD and 25 MD lines with multiple stress resistance and 107 groundnut rosette disease-resistant lines) were constituted into four sets of multilocation trials (MLT).
- The three superior groundnut breeding lines identified from the FPVS of 2016 (ICGV-IS 07999 - short duration, ICGV 01276 and ICGV-IS 08540 - medium duration) were nominated to the National Variety Release Committee in 2017. The lines proposed for release have nutritional status comparable to existing varieties (Table 2.3.5).

2.3.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- A total of 7,954.3t of improved groundnut seeds have been produced in the last 3 years, of which 25.4t is breeder seed, 86.4t is foundation and 7,842.5t is certified/QDS seed. (Table 2.3.6). Detailed seed production by variety is shown in Table 2.3.7; Table 2.3.8 and Table 2.3.9.
- In the last three years, a total of seven MSPs have been formed (3 in 2015 and 4 in 2016). Three trainings were conducted in 2017 for 7014 stakeholders (1596 female and 5418 male), up from 1 in year 2 with 34 trainees (30 female and 4 male) covering groundnut seed production, management of foliar diseases, and measures to reduce aflatoxin contamination in groundnuts and groundnut products.
- Twenty extension staff of NARS and seed companies were trained in seed certification and quality control. Also, 25 staff of NARs partners were trained in operation and maintenance of groundnut threshers.
- In 2017, 346 demonstration trials, 8 field days, 239 mentions in both print and electronic media and 24 agri-seed fairs/shows/exhibitions were conducted in partnership with the USAID - Groundnut Up-scaling Project, all of which were an improvement over years 1 and 2 (Table 2.3.10; Table 2.3.11)
- An adoption and impact assessment survey was carried out in 2017 with a sample size of 1470 households, and 1459 seeds were collected from the surveyed households for DNA fingerprinting. The survey report can be accessed at (Nigeria Groundnut Survey Report). The survey revealed that about 39% of the farmers had adopted improved groundnut varieties (56% female and 38% male). The main reason for non-adoption was the lack of improved seed (about 27% cases mentioned this reason). Participating in a demonstration and being in a TL III village increased the probability of adopting improved groundnut varieties by about 15% and 14%, respectively.
- The average groundnut yield for female farmers was 549 kg/ha compared to 724 kg/ha for male farmers. The 175 kg/ha gap was significant at 1%. Details on the results can be found in Nigeria Groundnut Survey Report.

2.3.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- In 2015, 1 groundnut breeder from the Nigerian groundnut program attended a short training in Nairobi, Kenya on BMS and MLE. In 2016, 1 breeder and 1 technical support staff were supported to attend a training on electronic data capturing in Kano, Nigeria.

Two breeding technicians from IAR attended a training on Electronic Data Capturing for NARS breeding technicians which was organized by ICRISAT in Bamako, Mali in 2017.

- In 2016, the program acquired handheld tablets for digitized data collection, transfer and storage for subsequent analysis. All trials conducted on-station in 2017 were designed using BMS and electronic field books were generated for data collection. Five trials that were conducted in 2017 were uploaded onto the BMS.
- These capacity building initiatives have improved phenotyping and evaluation data collection efficiency. In 2017, institutional support was extended to collaborators in agricultural development projects with handheld tools (6 tablets) for enhanced data capturing. Besides, the program acquired a barcode printer, scanner, and printing labels through the support of ICRISAT-Mali.
- The program defined 4 product concepts (Nigeria Groundnut Product concept 2017-1): (1) Early maturing, high yielding varieties with resistance to GRD, ELS & LLS; (2) Medium maturing dual purpose varieties with resistance to GRD, ELS and LLS; (3) Medium-duration dual purpose, large seeded confectionery varieties with resistance to GRD, ELS, and LLS; and (4) Medium-duration dual purpose, high oil content industrial varieties with resistance to GRD, ELS, and LLS.
- The program has reported making 45 new crosses during the 2017/18 off-season, up from the 15 reported in 2016. The program has been relying on breeding lines provided by ICRISAT-WCA breeding program and germplasm collections from the ICRISAT gene bank.

2.4 Groundnut crop improvement in Burkina Faso

2.4.1 Developing superior high yielding stress tolerant farmer-preferred groundnut varieties

- In 2017, a total of 8 lines (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834 and ICGV-IS 13912) were screened for drought tolerance. This trial will be repeated in 2018.
- Phenotyping for aflatoxin was based on artificial inoculation of *Aspergillus flavus* and *Aspergillus parasiticus* spores. The program evaluated 10 lines (ICGV 91328, ICGV 91315, ICGV 91284, ICGV 92302, ICGV 91278, ICGV 91317, ICGV 91324, ICGV 93305, ICGV 94379 and ICGV 91279) received from ICRISAT-Mali for aflatoxin and selected 5 (ICGV 93305, ICGV 91317, ICGV 91328, ICGV 03323 and ICGV 91283) which were further evaluated for yield and foliar diseases reaction.
- The program also assessed aflatoxin levels in 16 lines (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834, ICGV 86024, ICGV 86015, ICGV 93305, ICGV 91328, ICGV 91317, ICGV 91315, ICGV 94379 and Kiema) included in the Regional Variety Trial and selected 4 varieties (ICGV 91317, ICGV 91328, ICGV 93305 and ICGV 94379) which have very low (0-4.5 ppb) aflatoxin content.
- The program made 30 new reciprocal crosses in 2017: for SD lines with resistance to foliar diseases, the parents were 3 males (ICIAR 19BT, KIEMA and FLEUR 11) and 5 females (ICGV 01276, ICGV 86015, QH 243C, SH 470P and CN 94C); for SD lines tolerant to aflatoxins, the male parents were ICIAR 19BT, KIEMA and FLEUR 11 and the female parents were ICGV 91324, ICGV 93305, ICGV 91317, ICGV 94379, ICGV-IS 13824 and ICGV 92302; for drought tolerance, the male parents were SH 470P, QH 243C and FLEUR 11 and the female parents were ICGV 99240, ICGV 99241, ICGV 99247, ICGV 02271 and ICGV 07356; for MD lines with foliar disease resistance, the parents were ICGV 97087, ICGV 97094, ICGV 98088, ICGV 98089 and ICGV 98100 with 3 varieties resistant to foliar diseases (ICGV 01276, ICGV 86015, FRDF7-44).
- A regional variety trial from ICRISAT-Mali with 16 varieties (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834, ICGV 86024, ICGV 86015, ICGV 93305, ICGV 91328, ICGV 91317, ICGV 91315, ICGV 94379 and Kiema) was evaluated in two locations in 2016 and repeated in 2017 in six locations.
- Eight varieties (ICGV 86015, ICGV 86024, ICGV-IS 13806, ICGV-IS 13824, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834 and ICGV-IS 13912) consistently outperformed the best check, Kiema in the two years. Four of these (ICGV 93305 tolerant to aflatoxins; ICGV-IS 13806; ICGV-IS 13830; ICGV-IS 13912 short duration and drought tolerant) have been recommended for release. The four lines proposed for release have been nutritionally profiled at institutes of the National Scientific and Technology Research Centre (IRSAT).
- ICIAR 19BT (Samnut 24) and ICGV 86015 have been released in Nigeria and Mali, respectively, and are registered in the regional catalogue; therefore INERA can't propose them for release with the new regional regulation but it can promote them for dissemination in Burkina Faso.
- In 2016, the program conducted three sets of multilocation trials: (i) 7 best aflatoxin-tolerant varieties (ICGV 93305, ICGV 91328, ICGV 91317, ICGV 03323, ICGV 92302, ICGV 94379 and ICGV 91315); (ii) 9 best ELS- and LLS-resistant varieties (ICGV 86015, ICGV 86024, ICGV 01276, ICGV-IS 13984, ICGV-IS 13015, ICGV-IS 13085, ICGV-IS 13111, ICGV-IS 13042 and ICGV-IS 13991) (iii) 10 best drought-tolerant + short-duration varieties (ICGV-IS 13806, ICGV-IS 13809, ICGV-IS 13912, ICGV-IS 13824, ICGV-IS 13825, ICGV-IS 13827, ICGV-IS 13830, ICGV-IS 13834, ICIAR 19BT and Kiema).
- Nine promising varieties from these trials (ICGV 91317, ICGV 91328, ICGV 93305, Kiema, ICGV 86015, ICIAR 19BT, ICGV 13806, ICGV 13825 and ICGV 13912) were selected for National Performance Trials (NPT) in 2017.

2.4.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- By the end of year 3 (2017), the project had produced a total of 8,664.4t of groundnut seed in Burkina Faso; this represents about 101% of the target by the end of the project (Table 2.4.1). Of this, 14.7t is breeder seed, 705.7t foundation and 7,944.0t certified seed.
- Going by these trends, the project is projected to bypass all its seed production targets by the end of year 4. For details on the amount of seed produced by variety over time, see Table 2.4.2, Table 2.4.3, Table 2.4.4.
- In 2017, a total of 2 MSPs were established in addition to the 3 in 2016. A total of 2,482 new members joined the MSPs (1425 individual farmers, 120 seeds producers, 3 representatives of seed companies, 12 NGO staff, 885 members of farmers groups, 5 media, and 32 extension service agents) and were trained, and old members re-trained in 2017.
- In 2016, 5,800 small seed packs of groundnut seed (4800 of 1 kg and 1000 of 5 kg) was distributed to smallholder farmers. In 2017, a total of 25,000 small seed packs were sold (15,000 of 1 kg, 1000 of 5 kg and 200 of 25 kg).

- In 2017, the program conducted 92 FPVS trials with ICGV 93305, ICIAR 9BT, SH 470P and QH 243C involving 6,000 farmers (4680 female and 1320 male), which was a significant increase from 12 FPVS trials conducted in 2016 with 1850 farmers (1240 female and 610 male).
- The nine varieties under NPT (ICGV 91317, ICGV 91328, ICGV 93305, ICIAR 19BT, ICGV 86015, Kiema, SH 470P, QH 243C and Fleur 11) were also evaluated under FPVS in 2017.
- Farmers' preference criteria accounting for gender differences were assessed. In the Northern Centre region, the varieties selected were ICGV 93305, ICGV-IS 13912 and ICIAR 19BT. In the Eastern Centre region, farmers preferred ICGV 91328, ICGV 86015 and ICGV 94379 while in the Western Centre region, Kiema, ICGV 86015 and ICGV 93305 were the preferred varieties.
- The program conducted 94 demonstration trials with four varieties (SH 470P, QH 243C, ICIAR 19BT and ICGV 93305) during 2017, up from 60 in 2016 and 10 in 2015. A total of 92 field days were hosted on these demonstration trials, up from 8 in 2016 and none in 2015 with 1800 farmers attending (1440 female and 360 male), up from 1500 farmers in 2016 (1200 female and 300 male).
- A total of 950 flyers detailing groundnut seed production and management information were distributed to farmers during FPVS, demonstrations, field days and agri-fairs/shows in 2017, up from 750 in 2016.
- Six radio and TV programs and four print media items were aired in 2017 compared to 5 in 2016. On the other hand, project activities/technologies were published in the print media 4 times in 2017 compared to 3 times in 2016. Agri-fairs/shows were also conducted to popularize project technologies. A total of eight seed fairs were conducted in year 3 compared to three in 2016 and none in 2015.
- An analysis of the social dynamics of adoption of improved groundnut and cowpea varieties by women producers (Burkina Faso Gender Review Report) was conducted. The study recommended that women be given equitable access to land for production, input endowment for off-season cultivation, and capacity building for improved theory and practice of legume production.
- Also, specific to Burkina Faso, FGDs were conducted in year 2 on gender yield gap and the analysis completed in 2017 (Burkina Faso Focus group discussion report). The literature review on "Analysis of the social dynamics" together with focus group discussion shows that adoption of improved varieties and associated good agronomic practices such as land preparation, seed dressing, use of fertilizers in micro-dosing, line planting, proper spacing and planting density have shown positive impacts on improved yields, household food security, poverty reduction, reduced financial dependence of women, improved social cohesion and improved overall livelihoods for adopters. However, adoption is limited by poor access to improved varieties and associated production technologies.
- During year 3 of the project, a survey on adoption of improved groundnut and cowpea varieties was conducted using tablets for data collection in five regions (Mohoun's Buckle, Eastern Centre, Northern Centre, Western Centre and North). About 200 farmers were sampled per region resulting in 1006 farmers being interviewed (6 extra farmers were interviewed).

2.4.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The program acquired 10 tablets and is currently using them for data collection. The senior groundnut breeder attended a training on BMS in Nairobi organized by ICRISAT in 2016. Two research technicians were trained on BMS and digital data collection organized at Bamako, Mali during 2017.
- Currently, nine trials and nurseries are on BMS (advanced trials: 60 varieties for yield and rosette resistance, 44 varieties for drought and early maturity, 20 varieties for drought and foliar diseases, 8 varieties for drought tolerance, 120 varieties for foliar diseases and drought tolerance, 16 varieties for multi traits; international trials of 2016 and 2017, 4 nurseries of crosses; and multilocation trials of 2016 and 2017).
- In response to the BPAT, the program also developed 3 product profiles (Burkina Faso Groundnut product concepts new 2017): (1) Extra-early groundnut varieties tolerant to drought; (2) Early groundnut varieties tolerant to ELS & drought; and (3) Medium groundnut varieties tolerant to LLS, ELS and rosette.

2.5 Groundnut crop improvement in Tanzania

2.5.1 Developing superior high yielding stress tolerant farmer-preferred groundnut varieties

- Ten lines (ICGX-SM 08028/6/P2-8, ICGX-SM 08028/6/P9-5, ICGX-SM 08028/6/P9-7, ICGX-SM 08028/6/P11-9, ICGX-SM 08028/6/P13-3, ICGX-SM 08028/6/P10-3, ICGX-SM 08028/6/P4-7, ICGX-SM 08028/6/P4-5, ICGX-SM 08028/6/P6-10 and ICGX-SM 08028/6/P6-2) selected from 145 good x good F_9 lines evaluated in 2016 were planted and 6 lines (ICGX-SM 08028/6/P2-8, ICGX-SM 08028/6/P9-5, ICGX-SM 08028/6/P9-7, ICGX-SM 08028/6/P11-9, ICGX-SM 08028/6/P13-3 and ICGX-SM 08028/6/P10-3) were selected for Preliminary Groundnut Variety Trial. The aim is to come up with improved varieties of Pendo 98 (ICGMS-33) with resistance to rosette disease.
- Drought Groundnut Preliminary Variety was set up at Makutopora in 2017 with 2 lines that performed well in both water stress and non-water stress conditions (NARI 1413 and ICGV-SM 06637), under non-stress conditions (ICGV-SM 05650 and NARI 1403) and under water stress (ICGV-SM 03530 and NARI 1416) during the 2016 off-season trial with irrigation treatments in 3 replications using 50 advanced breeding lines (Table 2.5.1). The trial is being repeated under Advanced Groundnut Variety Trial in drier parts of the country in Makutopora-Dodoma and Naliendele-Mtwara.
- Similarly, at ICRISAT Malawi, five hundred and sixty (560) populations now at F4 generation were phenotyped for drought at Ngabu research station and further selection and advancements is under way. The materials were derived from 10 new populations which had been developed earlier.
- As a part of a PhD student's degree program, 120 lines in year 4 (Table 2.5.2) were planted at ARI-Naliendele and at Chambezi, Bagamoyo in 2017. Both phenotypic and genotypic data will be generated during the study with a focus on providing consolidated genetic information on rust resistance genetics.

- Following the identification of sources of resistance to groundnut rosette Disease (GRD), a mapping population (400) was developed by ICRISAT-Malawi and send to ICRISAT-Kenya for genotyping. High throughput phenotyping for GRD resistance for the same population will be done this coming year in the glass house.
- In 2015, a set of 20 genotypes was evaluated and 5 SD lines (ICG 12991, ICGV-SM 01514, ICGV-SM 05570, ICGV-SM and ICGV-SM 05657) with moderate level of resistance to ELS, LLS and rust were identified. In 2016, these 5 SD lines were crossed with three popular varieties to develop SD breeding lines with moderate levels of resistance to rust, LLS and ELS. In 2017, more crosses were made with two of these lines (ICG 12991 and ICGV-SM 01514) as male parents and crossed with three, varieties (Nachingwea 2009: ICGV-SM 01711, Masasi 2009: ICGV-SM 01721; and Nachi 2015: ICGV-SM 90704), that are medium duration and rosette resistant.
- At ICRISAT Malawi, a total of 53 genotypes from the medium duration category selected from previous evaluation of 72 entries were evaluated further for reaction to foliar diseases i.e. groundnut rosette diseases and leaf spots at Chitedze Agricultural Research Station.
- New medium duration population with groundnut rosette disease resistance background was developed that comprised of 35 crossing combinations and the F1 were planted in glass house at Chitedze Research Station for further advancement.
- Six lines (ICGV-SM 03519, ICGV-SM 06525, ICGV-SM 03520, ICGV-SM 06637, ICGV 00331, and ICGV-SM 03710) were advanced for yield trial with the aim of developing short-duration varieties with high yield, rosette and foliar disease resistance. A total of 12 crosses (Table 2.5.3) were made in 2016 and are currently at F_2 stage to be further advanced through SSD selection.
- Ten lines were evaluated in low altitude and moisture stress sites to determine their drought resistance in 2015 and 7 drought-tolerant lines were identified (ICGV 00331, ICGV-SM 99568, ICG 14788, ICGV-SM 08528, ICGV-SM 08533, ICGV 00331 and ICGV-SM 99568). In 2016, 12 crosses of the 7 lines were made with 3 adapted popular varieties (Nachi 15: ICGV-SM 90704;, Masasi 2009: ICGV-SM 01721; and Mnanje 2009: ICGV-SM 83708) to develop drought-tolerant breeding lines that were at F_2 by the end of 2017. Three cycles of advancement of these materials are planned, whereby the F_2 plants will be selected and advanced to F_3-F_4 through SSD selection.
- In 2017, two sources of drought tolerant lines (ICGV 00331 and ICGV-SM 99568) from ICRISAT-Malawi were used as male parents to introgress the trait into Nachi 15, Masasi 2009 and Mnanje 2009 varieties which are large seeded, high yielding, rosette and foliar disease resistant.
- Ten MD lines were identified and crossed with 3 adapted popular varieties to develop MD varieties with high levels of rust and LLS resistance in 2015. In 2016, 18 reciprocal crosses were made using 3 MD lines (ICGV-SM 08503, ICGV-SM 08501 and ICGV-SM 08584) with high levels of rosette and foliar disease resistance from ICRISAT-Malawi and 3 released SD varieties (Mangaka 2009, Pendo 98 and Naliendele 2009) at ARI-Naliendele to improve dormancy in the SD lines that germinate at maturity. Though popular, they are susceptible to groundnut rosette disease. The crosses are currently at F_2 and will be advanced to F_3-F_4 through three cycles of SSD.
- Two sets of rust resistance populations each comprising of 36 genotypes were evaluated by ICRISAT-Malawi and these have been advanced to the preliminary yield trial at Chitala
- Six MD lines selected for rosette resistance (ICGX-SM 08028/6/P2-8, ICGX-SM 08028/6/P9-5, ICGX-SM 08028/6/P9-7, ICGX-SM 08028/6/P11-9, ICGX-SM 08028/6/P13-3 and ICGX-SM 08028/6/P10-3) from 145 good x good lines (Table 2.5.4) from ICRISAT-Malawi, are currently in PYT.
- Another set 503 F_3 lines (Table 2.5.5) were received from ICRISAT-Malawi in 2016, advanced to F_4 in 2017 and 21 lines (Table 2.5.6) selected for drought phenotyping during off-season under irrigation in 2018.
- Thirty Elite Rust Resistant Groundnut Variety Trial (Table 2.5.7), 30 lines for Advanced Rust Resistant Trial (Table 2.5.8), 30 lines for Regional Elite Groundnut (Virginia Bunch) Trial (Table 2.5.9), 30 lines and Regional Elite Valencia groundnut variety 20 lines (Table 2.5.10) for Regional Elite Groundnut Variety Trial – (Valencia) were received from ICRISAT-Malawi.
- Ten lines (ICGV-SM 01514, ICGV-SM 05611, ICGV-SM 06518, ICGV-SM 06711, ICGV-SM 06737, ICGV-SM 07509, ICGV-SM 07599, ICGV-SM 08503, Mnanje 2009 and Pendo) advanced from 2016 PYT were evaluated in 5 multilocation trial sites and three best lines (ICGV-SM 08503, ICGV-SM 08584 and ICGV-SM 05570) were selected for further testing in 2018.
- At ICRISAT Malawi, data from previous multi-location evaluations was analyzed and key mega environments namely (Nachingwea in Tanzania, Chitedze in Malawi and Nakabago in Uganda) identified. Desirable (ICGV-SM-07520) and ideal (ICGV-SM-01514) genotypes respectively were identified which would act as checks in trial evaluation.
- Ninety FPVS trials were conducted using 6 groundnut genotypes (ICGV-SM 01514, ICGV-SM 07509, ICGV-SM 08503, ICGV-SM 07599, Mangaka 09, Mnanje 2009, and Local) in 15 districts and 6 villages per district with the participation of 2412 (1438 female and 974 male) farmers, up from 2001 (1112 female and 889 male) in 2016 and 1505 (954 female and 551 male) in 2015; three lines (ICGV-SM 07599, ICGV-SM 08503 and ICGV-SM 01514) were selected on the basis of pod yield, pod size, pod filling, high yield, disease (rosette and foliar diseases) resistance, bold kernel size, high flour content, ease of shelling, and early maturity and were released as TANZANUT 2016 (ICGV-SM 01514), MTWARANUT-2016 (ICGV-SM 07599) and Naliendele 2016 (ICGV-SM 08503).
- Nutrient profiling of six varieties (Masasi 2009, Narinut 2015, Kuchele 2015, Naliendele 2016, Tanzanut-2016 and Mtwaranut 2016) is underway. This will be in addition to the six varieties (Mangaka 2009, Mnanje 2009, Naliendele 2009, Nachi 2015, Nachingwea 2009 and Pendo 98) profiled at TFDA laboratories in 2016.
- At CRISAT-Malawi, a new population targeting nutrient content enhancement (zinc, iron, oil content) was developed, whereby a total of 70 crossing combinations were made. The F1 generation was planted in the glasshouse offseason as a strategy to ensure two cycles are accomplished per year.

2.5.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- ICRISAT-Malawi shared a total of 10 kg of nuclear seed with Tanzania program (ICGV-SM 90704 =5 kg; ICGV-SM 99557=5 kg) for subsequent breeder seed production.
- Since 2015, a total of 10 MSPs have been formed, 5 in 2017 (Table 2.5.11) and 4277 MSP members were trained in 2017 (2106 female and 2171 male).
- Fifty two trainers including 23 research officers (18 male and 5 female) from ARI-Naliendele, 5 seed company representatives (5 male) from ASA, Beula, Suba-Agro, Temnar and Meru-Agro and 24 extension agents (22 male and 2 female) were trained on Gender Learning, Mainstreaming and Analysis in seed systems and Improved groundnut seeds production demand creation.
- In terms of seed production, the project has produced a total of 8236 t of seed since 2015 (Table 2.5.12), of which 30 t of breeder, 413 t of foundation and 3897 t of certified/QDS were produced in 2017 (Table 2.5.12). Detailed seed production by variety is given in Table 2.5.13, Table 2.5.14 and Table 2.5.15.
- A total of 323.9 t of QDS produced were sold in small 1-5 kg packs (Table 2.5.16) during seed fairs and agricultural shows, whereas 477.3 t were sold in 25 kg packs and 869.6 t were sold in different packages between 50-100 kg. Of this, 634 small seed packs were distributed to smallholder farmers in 2017 (421 female and 213 male), 319 in 2016 (203 female and 116 male) and 217 in 2015 (120 female and 97 male).
- The groundnut program works with Agricultural Seed Agency (ASA) as a public seed company, 1 national farmer Association (DASPA), 4 private seed companies (Suba-Agro, Temnar, Meru-Agro and Beulal), 4 NGOs (CARE international through WWF, One-acre fund, RECODA and Aga Khan Foundation) and more than 400 Farmers Research Groups and 107 individual entrepreneurs (63 female and 44 male) throughout the country.
- A total of 150 demonstration trials were conducted in 2017, up from 100 each in 2016 and 2015, with 5693 (2739 female and 2954 male) farmers attending in 2017, up from 3937 (1826 female and 2111 male) in 2016 and 2778 (1217 female and 1561 male) in 2015.
- Eleven field days were conducted in 2017 compared to 10 in 2016 and 5 in 2015. The 2017 field days (Table 2.5.17) were attended by about 2009 farmers (977 female and 1032 male). Five agri-seed fairs/shows/exhibitions were held in 2017 compared to 1 each in 2015 and 2016. The total number of farmers who participated in year 3 in agri-seed fair/show/exhibitions was 6796 (2652 female and 4144 male). A total of 23 media mentions were made in 2017, up from 17 in 2016 and 10 in 2015 (Table 2.5.18).
- A total of 2122 copies of promotional materials (2000 leaflets and 122 production guides) containing information on different groundnut technologies were distributed to farmers and other stakeholders during field days, seed fairs, demo plot visits and agricultural show (nane nane) during 2017. This was an increase from the 1500 that were distributed in 2016 and 1000 in 2015.
- Four success stories of FRGs were documented and aired through AZAMTV, ITV, CHANNEL 10, Star TV and TBC. These lessons were shared with 171 policy makers (69 ward councilors - 12 female and 57 male) from Tunduru district who visited ARI-Naliendele and 100 employees (24 female and 76 male) of Central Bank of Tanzania including the Bank's Governor. The lessons were also shared with the Minister and Deputy Minister for Agriculture who visited ARI-Naliendele at different times.
- Preparation for the adoption and impact survey started in 2015 and the survey instrument was developed in 2016. The survey was conducted in 2017 with a sample size of about 1200 households, and 808 groundnut seed samples were collected for DNA fingerprinting analysis. A detailed econometric analysis of the data is underway but descriptive statistics show that about 19% of the groundnut growing households had adopted improved groundnut varieties with an adoption intensity (% groundnut area under improved varieties) of 20%. These preliminary results also show that there was no significant difference in yield between male (0.42 t/ha) and female (0.336 t/ha) adopters, meaning that given equal opportunities, there would not be gender yield gaps.

2.5.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The program conducted a self-assessment using BPAT to identify priority areas for improvement. Physical infrastructure and human capacity were some of the priority areas. NARI scientists and technicians were trained in collecting and evaluating phenotypic data using handheld electronic devices, trial planning and data handling using BMS. The following trial data were populated in BMS: Preliminary Groundnut Variety Trial, Advanced Groundnut Variety Trial, NPT, PVS and medium, short duration and drought tolerant crosses.
- From the BPAT self-assessment reports, 2 product concepts (Tanzania Groundnut Product concept Dec 2017) were developed during 2017: (1) Short-duration and climate resilient varieties with resistance to foliar fungal and virus diseases for oil, food and dual purposes; and (2) Medium-duration varieties with resistance to foliar fungal and soil borne diseases for oil, food and confectionery, and dual purposes.
- The program has an operational irrigation system currently being used for advancing 2 generations per year but requires more drippers, sprinklers and pipes. It also has a seed storage which requires regular maintenance, rehabilitation and expansion of working areas.
- The program requires a laboratory with facilities such as a leaf area meter and for nutritional, oil test and aflatoxin analyses, among others.
- Beside these, the program plans to acquire or make improvements in the following areas in 2018: (i) seed storage status and possible improvement - currently NARI uses a fridge to store seeds, but in the long run, a cold room is needed; (ii) hot air blower to quickly dry groundnut seeds during the rainy season; (iii) accurate seed inventory information and (iv) use of a greenhouse for controlled crossing and disease screening. The TL III project bought eight groundnut labor saving technologies (4 groundnut planters and 4 ox ploughs) from Senegal for possible use and fabrication in the project areas.

2.6 Groundnut crop improvement in Uganda

2.6.1 Development and release of farmer-preferred groundnut varieties

- Eighteen drought- and aflatoxin-tolerant lines sourced from NaSARRI Serere evaluated in 5 NPTs for drought tolerance, groundnut rosette disease and LLS in year 2 were replanted at 6 NPT sites.
- Twenty lines from ICRISAT regional trial set and ten NaSARRI lines were also screened in the laboratory for aflatoxin tolerance at ICRISAT-Malawi.
- Four previously evaluated NaSARRI lines and 6 candidate lines were screened in the laboratory for aflatoxin tolerance and used as parental material to develop QTL mapping populations which will be evaluated for LLS in two LLS hotspot sites in 2018.
- Short-duration advanced lines with high oil and big seeded confectionery traits from 4 crosses (Gwerinut x S.2 red (4 test lines); Gwerinut x S.2 tan (4 test lines); S.3 x Erudu red (4 test lines) and Acholi white x Igola/S6T) were evaluated for yield, GRD and LLS during year 3.
- At ICRISAT-Malawi, three sets of short duration materials with high oil content, confectionery and drought tolerance backgrounds which are at F4 stage were phenotyped as a further advancement initiative. These included Spanish (480), Valencia (1500) and Virginia (1120).
- At ICRISAT Malawi, a total of 25 progeny entries for confectionery trait which had been derived from medium seeded released varieties as females (e.g. CG7) and confectionary landrace Chalimbana as the male were evaluated in advanced yield trial at Chitedze and Chitedze Research Stations for reaction to foliar diseases (groundnut rosette disease and earl leaf spot) and true expression of seed size respectively.
- Lines selected from Gwerinut x S.2 red (SGV 0060, SGV 0050, SGV 0062 and SGV 0049); Gwerinut x Serenut 2 tan (SGV 0083, SGV 0082, SGV 0072 and SGV 0076); Serenut 3 x Erudu red (SGV-ER 10010, SGV-ER 10004, SGV-ER 10002 and SGV-ER 10003); Acholi white x Igola/S6T advanced crosses underwent NPT in year 3. SGV-ER 10010 passed NPT/DUS tests and is being bulked for release in 2018.
- Forty two advanced SD lines received from ICRISAT-Malawi: Rosette resistant and SD (7), rosette resistant and confectionery (5), rosette resistant (5), early leaf spot resistant and confectionery traits (10), SD (5) and confectionery traits (10) were also evaluated and will be replanted on-station in 2018.
- Two sets of medium-duration advanced populations with high levels of LLS resistance and GRD resistance and other stresses were also evaluated in repeat NPT. The first set contained 9 lines from ICGV 89751 x Serenut 1 cross evaluated for GRD and LLS with Serenut 1 used as check. Lines SGV 0029, SGV 0019, SGV 0023, and SGV 0002 will undergo final NPT in year 4 and possible DUS in 2018. The second set contains 9 lines from ICGV 91707 x Serenut 1 cross evaluated for GRD and LLS with Serenut 1 used as check. Lines SGV 07003, SGV 07002, SGV 07008, and SGV 07005 will undergo final NPT in 2018 and possible DUS in 2018.
- The program obtained 8 MD maturing lines from ICRISAT-Malawi which were space planted for initial characterization and seed production. The lines will be evaluated on-station and at two hotspots for GRD and LLS, during 2018.
- Thirteen advanced confectionery lines (7T x 11T, 10R x 9T, 990400, S11T x 7T, S3R x ICGV-SM 89751, AW x 88711, SGV 04001, Tatu x 99024, S1 x 89751, S2 x VC74, (S2 x S1R) x VC01, Egoromoit x VC195, and SGV 12004) developed by NaSARRI breeding program with LLS (s), GRD (1-3), 100-seed weight (60-102 g), seed coats plain tan, red and stripped tan, with stay green, erect and easy to shell traits were multiplied. They will be in NPT in 2018.
- Another confectionery pipeline with 26 F_3 segregating populations was advanced amidst selection for 100-seed weight (>60 g), GRD, LLS, erectness, ease of shelling, stay green and seed coat (tan and red). Besides, a total of 26 ICRISAT confectionery lines, i.e. confectionery (10), rosette resistant and confectionery (5), ELS resistance and confectionery (11) (Table 2.6.1) were introduced and will be hybridized in 2018 with at least 10 of NaSARRI crosses.
- NPT was conducted for 7 SD lines (ICGV-SM 99568, DOK 1 RED, DOK 1 TAN, Erudu Red, ICGV-SM 01515, ICGV-SM 95731 and ICGV-SM 99555) (Table 2.6.2) from multiple crosses (plus 3 checks Serenut 2 Tan, Serenut 3 Red and Serenut 4 Tan). The 7 lines underwent final evaluation in 2017 B season. Three candidate lines (SGV-ER 10010, DOK 1T and DOK 1R) passed the first DUS in 2016 and were taken to the final DUS test in year 3. Two lines (DOK 1T and DOK 1R) passed the final DUS and NPT; have enough bulked nuclear seeds (1.0 t) and are scheduled for release in 2018.
- In addition to the farmers who mapped out for FPVS in year 2, more farmers were identified bringing the total to 236 (135 female and 101 male) hosting FPVS in 2017 (Table 2.6.3). At least 21 pre-releases (DOK 1R, DOK 1T, SGV 10010-ER, SGV 990400, SGV 0023, SGV 0060, SGV 0050, SGV 0062, SGV 0049, SGV 0083, SGV 0082, SGV 0072, SGV 0076, SGV 10004-ER, SGV-ER 10002, SGV 10003-ER, SGV 0801, SGV 0802, SGV 0803, SGV 0804 and SGV 0805) were evaluated alongside landraces such as Kabonge, Redbeauty, Erudurudu, Egoromoit, Igola, Agrikaca, Ebaya, Gugutur and Ongwara.
- Preferred lines were the DOKs, SGV 10010-ER, SGV 990400, SGV 0023 and SGV 0804. Farmers' preference criteria included extra early maturity, drought tolerance, GRD and LLS resistance, sweetness, high yield, red seed color, erect growth habit, easy to harvest, easy to shell, stay green, high number of pods per plant, leafminer tolerance and high oil.
- Red varieties are preferred in central, southern and western Uganda whereas Tan are consumed widely in the east and northern parts. When grown for commercial purpose, red varieties command a premium price and are preferred. The FPVS materials for 2017 will be replanted in 2018.
- Four superior lines from each of the four crosses (91707 x Serenut 1R; 89751 x Serenut 1R; Serenut 3 x Erudu red and Gwerinut x Serenut 2) were selected giving a total of 15 lines for NPT and DUS tests 2018.

2.6.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- A total of 5,940.8 t of seed has been produced in the past 3 years, including seed breeder (<1%), foundation seed (3%) and certified/QDS/TLS (97%) (Table 2.6.4). The target breeder (9 t), foundation (267 t) and certified (4000 t) seed production for the 4 years has been surpassed. In the current year, 5.1 t of breeder, 91.8 t of foundation and 548.8 t of certified/QDS was produced. Details of seed produced by variety are shown in Table 2.6.5; Table 2.6.6 and Table 2.6.7.
- Three MSPs in the seed value chain have been formed since project inception. Two of these MSPs were formed in 2015 and another was established in 2016.
- A total of 2,254 members of 3 MSPs formed in years 1 and 2 and 60 trainers were trained during 2017 on seed multiplication, marketing, seed business planning, and post-harvest handling.
- The program is working with Integrated Seed Sector Development (ISSD) to test, demonstrate, carry cost-benefit/business viability of small packs under various marketing opportunities, and promote the use of small seed packs. A total of 116 small seed packs (of 21 kg each; total 2436 kgs) were produced and marketed to smallholder farmers during 2017. On average, Ugandan farmers plant groundnut in 0.5- 1.0 acre of land and the smallest seed pack possible for this is a 21 kg pack.
- A total of 197 (116 female and 81 male) demonstration trials were conducted, up from 132 (82 female and 50 male) in 2016 and 56 (36 female and 20 males) in 2015. A total of 126 field days were conducted on these demo trials attended by 1761 farmers (782 female and 979 male), up from 20 field days in year 2 and none in 2015.
- There were 15 media mentions of the project in 2017 (9 electronic and 6 print) compared to 14 in 2016 (7 electronic and 7 print) and 10 in 2015 (10 electronic).
- Six agri-seed fairs/shows/exhibitions/field days have been conducted since the beginning of the project in Uganda (two per year), during which 17,900 dissemination materials (books, brochures and factsheets) were distributed in 2017, up from 6,000 in 2016 and none in 2015 (Table 2.6.8).
- A household survey was conducted involving 258 smallholder farmers and 18 FGDs to document legume production and productivity yield gaps between male and females. Descriptive and econometric data analysis indicates that there exists a significant yield gap between male and female groundnut farmers. Men were found to be producing more than women farmers in all seasons. In order to reduce the identified gender yield gap, the study strongly recommends paying greater attention to proper seed selection, which is the major influencing factor for the gender yield gap and access to extension services. The detailed report is here (Uganda Objective 1 Groundnut Survey Report).

2.6.3 Strengthening legume breeding capacities of partner NARS and CGIAR centers (ICRISAT, IITA and CIAT) African hub stations – Uganda and ICRISAT Malawi

The BPAT self-assessment in 2016 highlighted a relatively well-organized program with weaknesses in breeding organization, infrastructure, irrigation, laboratory services, product support, and performance management. Improvements done in response to observations include installation of irrigation facilities, leveraging on partnerships to obtain laboratory services, strengthening product support and performance management evaluations.

- All on-station field data collection is tablet based. From 2018 onwards, the national program will be using barcodes for seed labeling and packaging. The number of germplasm, nurseries and trials uploaded in the BMS are as indicated in Table 2.6.9.
- So far, 50 trials have been conducted and data uploaded onto BMS. Two refresher courses on BMS have been conducted in which a total of 22 trainees attended (5 female and 17 male).
- Recently, NaSARRI completed installing a 10-acre irrigation facility functional with 20,000 litre reservoirs which will help in conducting drought phenotyping studies, for faster generational advance for segregating populations as well as early seed increase for the Early Generation seeds (nuclear, breeder, and foundation).
- The detailed Uganda groundnut product concepts are here Uganda Groundnut product concepts 2017.
- The ICRISAT-Malawi program went through external BPAT assessment in 2017 for its operations, and a number of recommendations were made for implementation towards enhancing the efficiency of the breeding program. The progress made so far includes:

.3 A total of 200 and above crosses are being developed per year compared to 100-150 crosses before the BPAT assessment and the program continue to use Single Seed Descent (SSD) method. The female parents are farmer preferred varieties released in the Region while the male parents are accessions and or improved material.

.4 At ICRISAT Malawi, the breeding program has defined four product concepts (Short duration (Spanish; Valencia), Medium duration-Virginia and Long duration-Virginia) that are being used to guide breeding operations. The current pipeline consists of 700 lines at various stages (Product Concept Notes for ESA Groundnut Breeding Program_ICRISAT Malawi).

.5 Adaptation of both offseason (irrigation at Ngabu; Bunda University farms and glass house at Chitedze Research Station) and main season are being used to speed up generation advancement and reduce breeding cycle with 2-3 generations per year

.6 The program has fully digitized trial management and data collection using handheld tablets, barcoding facilities and BMS; and data for 20176 has been migrated to BMS

.7 The breeding program at ICRISAT-MALAWI has trained NARs partners staff on the use of BMS through short training on breeding techniques (including crossing, trial management, data analysis etc.) and data collection and management (including digital data collection using handheld devices, BMS), and through postgraduate studies.

.8 The program has procured and installed high throughput phenotyping equipment such as Gas Chromatographer for nutrient content (Oleic acid) analysis); and we have engaged a service provider to supply NMR analyzer for oil analysis and the equipment has already been optimized.

.9 A seed testing laboratory has been installed for seed handling and procurement of more seed handling equipment is under way

3.1 Cowpea crop improvement in Nigeria

3.1.1 Developing superior high yielding stress tolerant farmer-preferred cowpea varieties

- A total of 160 MARS derived lines obtained from IITA in 2015 and 10 checks (standard and local) that were Striga resistant and susceptible; drought tolerant and susceptible, large and small seeded, low and high P tolerant, were evaluated for Striga resistance, terminal drought and seed size. The trials were planted out in 2016 and 2017 and the MARS lines performed better than the standard checks for Striga emergence, Striga count, seedling vigor, survival rate, stay green and grain yield (Table 3.1.1). The 2016 and 2017 data will be used to select promising lines for multilocation trials and introgression using SSD to incorporate drought and Striga resistance genes in 2018.
- Five most contrasting parental lines (drought susceptible and tolerant) identified in 2016 were hybridized to generate 70 individual F_2 seeds derived from three successful sets of crosses (Oho x IT99K-499-35, Oho x IT90K-277-2 and Borno local x IT97K-499-38). The 70 F_2 individual seeds were screened for drought under stress condition. More than 90% of the plants in this evaluation died and new sets of parents from MARS lines will be used in 2018.
- The program received a total of 18 cowpea elite lines from IITA in 2016 and two checks (standard and local) and evaluated these materials in 2016 and 2017 for resistance to aphids, thrips, pod borer, and pod sucking bugs. The trial results for 2017 are shown in Table 3.1.2.
- A total of 300 F_8:10 MAGIC RILs populations and their 8 parents were evaluated for agro-physiological performance under well-watered and post-flowering water stress conditions in 2016. The 300 F_2 seeds along with their respective parents were planted in the screen house for early generation selection of bacterial blight resistance lines in 2017. Disease severity was visually scored and 58 resistant lines from F_2 and 38 from Backcross derived lines were selected.
- Four crosses were made in 2017 between lines with drought tolerance, early maturity and medium seed size from donor parents (IT00K-1263, IT97K-573-1-1 and IT99K-499-35) and elite lines and varieties as follows: Oho x IT00K-1263; Danrima x IT00K-1263; IAR-176B x IT97K-573-1-1 and IAR-1696 x IT99K-499-35.
- Five drought tolerant lines (228-7-QTL, 235-1-QTL, 244-3-QTL, 245-6-QTL and 43-6-QTL) were identified from MARS lines and will be used in 2018 to generate more segregating populations with other elite lines as well.
- A total of 160 MARS derived lines and 10 checks were screened for their response to low and high soil phosphorus. Most of the MARS lines responded positively to P fertilization (Table 3.1.3). Adaptive lines to low soil P will be used as donor parents for crossing with indigenous varieties.
- A total 300 F_2 lines (Table 3.1.4) and 120 BC_1F_1 (Table 3.1.5) were generated from four sets of crosses (Sampea 11 x Sampea 17; Sampea 7 x Danrima; Sampea 1 x Oho and Sampea 12 x Mai bakar kona) for cowpea Bacterial blight (CoBB) and 480 individual seeds of F_2 for Striga were generated in 2017 and planted in Zaria on-station (February 2018) for advancement to F_4.
- In 2015, three trials were conducted (Table 3.1.6): (1) Selections from cowpea landrace, Kanannado, where Kanannado-49 had the highest grain yield; (2) medium maturing Striga-resistant lines, where IRS-09-1106-4 was Striga free and (3) late maturing lines, where IAR-07-1058 produced the highest grain yield.
- In 2016, 5 sets of cowpea AYTs (Table 3.1.6 and Table 3.1.7) were conducted at four locations (Bakura, Samaru, Minjibir and Makurdi). These sets included: (i) 24 medium-duration entries; (ii) 18 short-duration entries; (iii) 16 grain quality and fodder yield entries; (iv) 22 Striga resistance entries; and (v) 22 medium-maturing and leaf spot resistance entries.
- In 2017, three sets of AYT and two sets of NPT (short and medium duration) were conducted (Table 3.1.6 and Table 3.1.7). The AYT trials were conducted in three locations: Samaru, Minjibir and Bakura. The first AYT had 20 lines (late maturing with consumer preferred traits), the second had 14 advanced lines of medium maturing with Striga resistance and two checks (see Table 3.1.8 for the results) and the third had early maturing with leaf spot and aphid resistance.
- Seven best performing lines were identified and selected by farmers based on their tolerance to drought, large grain size, and high grain and fodder yields compared with the two checks (Table 3.1.9). Two medium maturing and Striga resistance lines (IRS-09-1037-2, 1889 kg/ha and IRS-09-1134-5, 1855.8 kg/ha) were identified on the basis of high yield above the standard check (IT97K-499-35, 1151.2 kg/ha) (Table 3.1.10). The identified lines were planted under irrigation in 2017 to increase seed for multilocation trials during 2018.
- Nutrient analysis was started in 2016 and finalized in 2017. Samples from 5 candidate varieties (IT08K-150-24, IT08K-150-12, IT07K-297-13, IT07K-274-2-9 and IAR-1050) were submitted to the Product Development Research Program of IAR and Multiuser laboratory, ABU, Zaria for nutritional profiling in 2016. The results finalized in 2017 showed that all the varieties have low phytic acid ranging from 0.009 to 0.05%, high protein content ranging from 23 to 26%, high grain iron (5.89 to 8.23mg/kg) and magnesium (13.51 to 15.32mg/kg) contents.
- Four candidate varieties (IT07K-297-13, IT08K-150-12, IT08K-150-12 and IT07K-274-2-9) were demonstrated in three states: Kano, Katsina, Kebbi and Jigawa, under farmers' management conditions in two sets of on-farm trials conducted in 2017 using recently released variety IT07K-292-10 (SAMPEA-16) as the standard check and the farmers variety as the local check.
- Across locations, IT08K-150-12 outyielded the standard check and the local check. Both IT07K-297-13 and IT08K-150-12 will be submitted for registration and release in 2018.
- Eleven FPVS were conducted on the three AYTs (early, medium and late maturing trials) and one of the NPTs (medium duration) with 150 farmers (102 male and 48 female) in three locations (Zaria, Bakura and Minjibir).
- Twenty different lines were selected across the three locations from 2 AYTs and one NPT. Seven lines were selected from Advance 1 (Table 3.1.3); 5 lines from Advance 2 (Table 3.1.11), and 6 lines from medium-duration trial (one of the NPTs) as shown in Table 3.1.12. Lines selected from the AYT and NPT will be tested in NPT while the promising lines identified from NPT will be evaluated on-farm in 2018.
- Five varieties (IT07K-292-10, IT04K-333-2, IT08K-150-24, IT08K-150-12 and IAR-1050) were evaluated in FPVS trials in 50 communities across 24 Local Government Areas (LGAs) in 4 States (Kano, Jigawa, Katsina, and Sokoto) and attended by 1010 farmers (802 male and 208 female) in 2016.

3.1.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- Thirty five MSPs have been established/ strengthened to link actors in the cowpea value chain since 2015 (6 in 2017, 9 in 2016 and 20 in 2015). A total of 2069 MSP members were trained (335 female and 1734 male) in 2017 in addition to 2211 in 2016 (510 female and 1701 male) and 5727 in 2015 (1449 female and 4278 male).
- A total of 4150.4 t of cowpea seed has been produced representing about 49% of the targeted seed production (Table 3.1.13). This comprises 81% (6.4 t) of the breeder, 66% (354 t) of the foundation and 47% (3790 t) of the certified/QDS seed targets of the project. Details on production of improved cowpea seed in Nigeria by variety are shown in Table 3.1.14; Table 3.1.15; Table 3.1.16.
- All certified seed produced was sold, with over 30% of it sold in small packs (1, 2, 5 and 9 kgs), exceeding the 20% target (Table 3.1.17). Certified Seed (CS) is largely produced by the private sector and farmer groups. Individual seed producers are engaged in Quality Seed (QS) production, of which over 80% are certified by the seed regulatory agency.
- A total of 248 demonstrations have been carried out by the project in the last 3 years and 96 of them were in 2017 (18 female hosts and 78 male hosts), 142 in 2016 (52 female and 90 male) and 10 in 2015 (2 female and 8 male).
- Five field days were held since project inception, two of them in 2017 and three in 2016. The total number of farmers who participated in the 2 field days held in 2017 was 486 (102 female and 384 male) while 759 attended the 3 field days held in 2016 (247 female and 512 male).
- Six agri-seed fairs/shows/exhibitions have so far been organized, 1 in 2017, 4 in 2016 and 1 in 2016. The total number of farmers who attended the 2017 agri-seed fair/show/exhibitions were 208 (56 female and 152 male), while 821 (252 female and 579 male) attended in 2016 and 162 (46 female and 126 male) attended in 2015.
- There were 21 media mentions on the project since 2015, of which 8 were in 2017, 12 in 2016 and 1 in 2015. A total of 27,400 technology information leaflets/guides have been distributed since 2015, of which 4000 were in 2017, 3400 in 2016 and 2000 in 2015.
- Adoption and impact assessment surveys were conducted with a sample size of 1520 households from 10 different states; the preliminary results are in the report Nigeria Cowpea Adoption and Impact Assessment.

3.1.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- Fifteen extension staff of Agricultural Development Programs including 3 seed companies have been trained in seed certification and quality control. In 2017, three trainings to develop the capacity of research staff were conducted and 2 IAR cowpea breeders attended a training in IITA on the application of BMS. Twenty three staff and students (15 IAR technical staff and 8 post graduate students) were trained in data collection using handheld devices. Another 2 IAR cowpea technical staff attended a regional training on data management and curation (data upload) using the online version of BMS at ICRISAT-Mali.
- Two additional tablets were procured and delivered to two trainees in 2017, thus extending electronic data capture to two multilocation sites (Bakura and Minjibir). Therefore, by the end of 2017, the cowpea breeding team (scientists and technicians) of IAR were using IBP tools in germplasm management, trial design, data collection and analyses.
- About 1112 (70%) of Nigerian cowpea accessions (commercially released varieties, germplasm including landraces, breeding lines, lines from IET and PYT) were organized and an inventory was created using BMS software.
- The number of breeding populations has significantly increased from a maximum of 10 populations (600 individual seeds) in 2015 to 20 populations (1300 -1600 individual seeds) in 2016 and rose to a maximum of 30 populations (2800 to 3200 individual seeds) in 2017. This is in addition to the increasing number of germplasm (160 MARS lines in 2016 and more than 200 lines (RILS and GWAS) in 2017, received from IITA and UCR over the years. Handling such populations is becoming more difficult in labelling and phenotyping particularly for drought related traits. In view of this we ordered some equipment such as PhenoApps, Barcode printer, barcode scanner, GreenSeeker etc.) that will increase efficiency and precision in handling large populations.
- The number of plots in our yield trials has also exponentially increased from 1,368 plots (from 5 AYT) in 2015 to 2,148 plots (in year 2 (2016) and 3,168 plots (from 8 trials) in year 3 (2017).
- The number of locations for AYT has increased from two agro-ecologies: Northern Guinea Savannah (NGS) and Sudan Savannah (SS) in 2015 to 4 agro-ecologies: NGS, SS, Sudano-Sahelian transition zone (SST) and Southern Guinea Savanna (Makurdi) in 2016 and 2017 respectively. We are currently planning to add another location (Mokwa) also in the Southern Guinea Savanna (a hot spot for striga and other tropical diseases) in 2018.

- Local data base for 10 years (2007 -2017) of all AYT and NPT trials was created and started uploading into central data base (TL III). We started adopting BMS for generation of electronic field book and electronic data capture with on-station trials only in 2016 with: 3-AYT (60 entries), 2-NPT (42 entries), Phenotyping for drought (170 entries), Striga (70 entries) and Generation advancement. We later extended these trials to two of our sub-stations (Bakura and Minjibir) in 2017 (9-AYT, 4-NPT and generation advance) and planning to extend to Mokwa in 2018. In addition to SAS software, we are also utilizing Breeding View for both single site and Multi-site analyses.

- The program developed 6 product concepts (Nigeria cowpea product concept Nov 2017): (1) Medium white seed, for domestic markets with drought and disease tolerance (5% export; 95% domestic); (2) medium brown seed, with drought and disease tolerance (10% export; 90% domestic); (3) large white seed with low P, drought and disease tolerance (15% export; 85% domestic); (4) medium brown seed with drought and disease tolerance for domestic markets; (5) large white seed with Striga and drought tolerance for domestic markets and (6) large brown seed with insects, disease tolerance and low P tolerance (10% export; 90% domestic).

3.2 Cowpea crop improvement in Ghana

3.2.1 Developing superior high yielding stress tolerant farmer-preferred cowpea varieties

- In 2015, 4 elite lines (SARVx-09-001, SARVx-09-002 SARVx-09-003 and SARVx-09-004) for aphids and Striga resistance were in advanced and multilocation trials that have been validated through 2016 and 2017 and the lines have been proposed for a possible release in 2018.
- Twenty advanced breeding lines (Padi-tuya x Songotra, Padi-tuya x IT86D-610, Padi-tuya x IT99K-1122, Padi-tuya x Sanzei, Songotra x Padi-tuya, Songotra x Sarc-57-2, Songotra x IT86D-610, Songotra x IT99K-1122, Songotra x Sanzei, Sarc-57-2 x Padi-tuya, Sarc-57-2 x Songotra, Sarc-57-2 x IT86D-610, Sarc-57-2 x IT99K-1122, Sarc-57-2 x Sanzei, IT86D-610 x Padi-tuya, IT86D-610 x Songotra, IT86D-610 x Sarc-57-2 Padi-tuya x Sarc-57-2, IT86D-610 x IT99K-1122 and IT86d-610 x Sanzei) were evaluated for drought tolerance, early maturity and thrips resistance in 2016. Genotyping of these lines was done at UCR to accelerate the selection of required recombinant lines and selected lines were advanced to F_2 generation in 2017.
- Thirty seven advanced breeding lines from IITA were evaluated for extra early maturity, grain quality and thrips resistance (Figure 3.2.1, Figure 3.2.2 & Figure 3.2.3).
- Twenty five crosses targeting single and multiple traits were conducted (Table 3.2.1; Table 3.2.2) in 2017. The F_1s were advanced to F_2 during the off-season under drip irrigation to shorten the cultivar development period.
- Sixteen drought-tolerant lines (IT89KD-288, IT86D-610, IT97K-390-2, IT97K-819-118, IT97K-1069-6, IT98K-128-3, IT98K-166-4, IT98K-311-8-2, IT98K-412-13, IT98K-491-4, IT98K-628, IT99K- 7-21-2-2, IT99K-216-24-2, IT99K- 529-2, IT99K-1122 and IT00K-1263), 12 early-maturing and 12 dual purpose cowpea lines received from IITA in 2012 (during TL II) were screened for 2 seasons in 2012 and 2013 under different environmental conditions using participatory approach by establishing PVS trials in 5 sites of the Northern Region of Ghana. Out of these, 10 good performing lines (IT89KD-288, IT86D-610, IT97K-390-2, IT97K-819-118, IT98K-628, IT99K-7-21-2-2, IT99K-216-24-2, IT99K- 529-2, IT99K-1122 and IT00K-1263) were selected among existing elite lines to constitute entries of advanced yield trials and on-farm trials in 2015, 2016 and 2017 cropping seasons (Figure 3.2.4). The drought-tolerant line IT86D-610, aphid-resistant line SARVX 09-004 and extra-early maturing line IT99K-303-1 outperformed the check variety (*Songotra*) and were selected as candidate lines proposed for release in 2018.
- In 2017, the 10 good drought-tolerant lines were re-evaluated in “mother and baby trial” with the 10 lines in mother trials while the “baby trials” consisted of 4 top drought-tolerant lines (IT99K-1122, IT89D-610, IT99K-529-2 and ITKD-288) plus local landrace checks under the farmers’ management.
- The three best performing lines in 2015, 2016, 2017 were IT86D-610, IT99K- 1122 and SARVX 09-004. IT99K-1122 was the 2nd best yielding, with small and brown seed, a trait not preferred by the Ghanaian consumer.
- In 2016, IT99K-1122 was therefore crossed with Padi-tuya which is bold creamy/white seeded. The F_1s from this crossing were again crossed with *Songotra* in 2017 to incorporate Striga resistance and seed quality.
- Another advanced yield trial for early maturity was conducted with SARI-3-15-1, SARI-2-3-4, SARI-1-3-90, SARI-6-2-9, SARI-5-5-5, SARI-1-50-81, SARI-6-2-6, SARI-3-11-100, IT10K-837-1 and SONGOTRA. Another advanced yield trial for dual purpose cowpea (high grain and biomass yields) was conducted with IT08K-150-24, IT07K-291-92, IT08K-125-100, IT07K-304-100, IT07K-394-44, IT06K-137-1, Padi--tuya, IT10K-817-7, IT97K-390-2, IT08K126-19 and IT07K-303-1.
- IT07K-303-1 was the best performing dual purpose line across the locations with high grain yield, fodder, large grain size (>22g/100 seed) and white seed coat which will be evaluated on-farm in 2018. There was no marked yield difference among the early maturing lines in the two years’ evaluation (Figure 3.2.5).
- On-farm participatory evaluation was carried out on five good performing drought-tolerant, early-maturing and dual purpose lines plus farmer variety. In all the categories, six lines (SARI-3-11-100, SARI 6-2-6, SARV– 09 - 004, IT86D-610, IT10K-837-1 and IT07K-303-1) were selected through on-farm PVS and will be proposed for release in 2018.

3.2.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- A total of 4 MSPs have been established in Ghana since project inception, 2 in 2015 and 2 in 2016. Seven trainings were conducted for MSP members in 2017, up from 4 in 2016 and 1 in 2015 with 2861 (1625 female and 1236 male) stakeholders in 2017, up from 1796 (883 female and 913 male) in 2016 and 3045 (1005 female and 2040 male) in 2015.
- A total of 2,496.6t of cowpea seed has been produced in Ghana, of which 6.8t is breeder seed, about 147.9foundation and 2,341.9 certified seed (Table 3.2.3). The of breeder produced so far represents about 85%, the 167.1 t of foundation seed representing 78% and the 2361.4 t of certified representing about 74% of the project’s 4-year target. The detailed seed production by class, variety and year are as presented in Table 3.2.4 and Table 3.2.5. In partnership with USAID-COSP and MoFA, registered seed companies, FBOs, individual seed producers, MSP members and nucleus farmers were engaged in the production of various categories of cowpea seed in 2017, expanding the focus from FBOs and individual farmers in 2016 and 2015.
- A total of 68 cowpea demonstration trials were conducted (30 female hosts and 38 male hosts) in addition to the 50 in 2016 (19 female and 31 males) and 70 in 2015 (14 female and 56 male). A total of 114 field days were held in these demo trials, up from 73 in 2016 and 3 in 2015 with 1,200 (700 female and 500 male) stakeholders attending, up from 700 (320 female and 380 male) in 2016 and 200 (50 female and 150 male) in 2015.
- A total of 2400 farmers visited the demos that were established in 2017 (1100 female and 1300 male) compared to 1700 in 2016 (800 female and 900 male) and 500 in 2015 (30 female and 470 male). Beside the demos, a total of 12 field days were conducted in 2017, up from 10 in 2016 and none on 2015. The participants in the 12 field days during 2017 were 1200 (700 female and 500 male) compared to 700 in 2016 (250 female and 450 male) and 200 in 2015 (35 female and 165 male).

- The cowpea varieties in 2017 field days were Wang Kae, Kirkhouse Benga 1, Padi-tuya, Songotra, Zaayura and Apagbaala. In 2016, they were Padituya, Songotra, Zaayura and Apagbaala and in 2015 they were Padi-tuya, Zaayura and Apagbaala.
- The project was covered thrice in the media in 2017 compared to 5 in 2016 and 1 in 2015. One agri-seed fair/show/exhibition was held each in years 3 and 2. The total number of people who attended the agri-seed fair/show/exhibition in year 3 was 1820 (1040 female and 780 male) while 900 attended (350 female and 550 male) in 2016.
- A total of 4150 small seed packs were distributed to 4150 (2000 female and 2150 male) smallholder cowpea farmers in Ghana (Table 3.2.6; Table 3.2.7).
- Data on FGDs around gender yield gaps was collected in Ghana in 2017. Following Moser resource control and access analysis, the access and control profile of both genders over farmland, labor, farm income, extension services and farmer-based organizations were evaluated. The study found men to have more access to farmland (77%) than women (23%).
- Both genders were found to have equal access to farm income, extension services as well as membership to farmer-based organizations. It was however found that men were more willing to be members of FBOs. Seventy percent of respondents believed that yields from male cowpea farmers were higher than that from their female counterparts.
- From the FGDs, it is recommended that local authorities including community chiefs be engaged in improving women's access to fertile lands for cowpea production. Men should also be encouraged to see women's rights in terms of access to local resources. Technical training should also be organized at the community level to improve community members' understanding of gender issues.

3.2.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- Sixteen stakeholders (agricultural extension agents and technicians) attended a training on electronic data collection and capture (2 female and 14 male). Data on all the trials were taken and stored in the electronic field books. BMS continued to be applied in all breeding activities since it was introduced in 2015. Two more tablets were procured to add to the earlier one.
- Two technical staff from the program attended a regional training on data management and curation (data upload) using the online version of BMS in ICRISAT-Mali during 2017.
- The program developed 6 product concepts (Ghana Cowpea Product Concept NEW 2017): (1) Extra-early maturing cowpea varieties with resistance to major insect pest and diseases; (2) early maturing cowpea varieties with resistance to Striga *gesnerioides;* (3) early maturing cowpea varieties with tolerance to drought and resistance to major pest and diseases; (4) dual purpose, medium maturing cowpea varieties with resistance to thrips and Striga and (5) large white grain cowpea varieties with resistance to *Aphis craccivora* and tolerance to other field pests.

3.3 Cowpea crop improvement in Mali

3.3.1 Developing superior high yielding stress tolerant farmer-preferred cowpea varieties

- A backcross progeny from a cross made during TL II between Amary Sho and M'Barawa recurrent parents and the resistance parent IT97K-299-35 (male parent) was advanced in 2015 and 2016 and new crosses were initiated (Table 3.3.1) in 2017 among lines with desired traits (IT99K-573-1-1, Striga resistant; Korobalen, high yield, Sanoudaounlen and Hawaba local lines, highly susceptible to Striga and Cinzana Telimani, brown color with good nutritional quality).
- The resultant F_1, F_2, F_3 and F_5 were screened for Striga resistance in the field under natural infestation. A total 200 F_2, 150 F_3 families and 80 F_5 lines derived from 34 sets of crosses for Striga resistance were generated in 2017 (Table 3.3.2).
- Three sets of preliminary yield trials were conducted for: (1) 16 lines derived from single plant selections from Jiguiya, a popular variety resistant to Striga; (2) 16 entries from single plant selections for Striga resistance derived from hybridization between CZ06-3-1, CZ06-1-12, CZ06-4-16 and CZ06-2-17 as recurrent parents and Jiguiya as donor parent) and (3) 16 entries of medium maturing lines resistant to Striga, each from single plant selections of CZ06-3-1, CZ06-1-12, CZ06-4-16 and CZ06-2-17 as recurrent parents and Jiguiya as donor parent. Ten 10 promising lines will be selected from each trial to be conducted in advanced yield trial (AYT) in 2018.
- Twelve advanced yield trials were also conducted in 2017 with: (1) 25 entries of early maturing lines derived from Jiguiya resistant to Striga and 2 local lines Amary Sho (KT1) and M'Barawa (KT2), popular local varieties with good yield and tolerant to insects but susceptible to Striga; (2) 15 entries from single plant selections for medium maturing lines resistant to Striga; (3) 10 entries each of early maturing lines resistant to striga derived from single plant selections from Jiguiya resistant to striga and the two local lines Amary Sho (KT1) and M'Barawa (KT2) evaluated in 3 trials; (4) 10 entries each from medium maturing single plant selections from Jiguiya resistant to Striga and two local lines Amary Sho and M'Barawa evaluated in 3 trials and (5) 10 lines each of late maturing lines derived from single plant selection from Jiguiya resistant to Striga and two local lines Amary Sho and M'Barawa. A total of 5 promising lines will be selected from each trial to be included in two National Performance Trials.
- Three multilocation tests for release were conducted: (1) Acar 1 derived from a cross between Wuyo (local line, large, white seed and susceptible to Striga) and Korobalen (improved line resistant to Striga with good yield); (2) Simbo derived from a cross between Tobi (local line tolerant to insect, but susceptible to Striga) and Korobalen and (3) CZ06-1-12 and CZ06-4-16 and CZ06-1-05 derived from the cross between IT81D-994 (improved line with high grain and fodder yields) and Korobalen.
- Two early promising lines Acar 1 and Simbo and two medium promising lines CZ06-1-12 and CZ06-4-16 were selected by farmers from an NPT. Three FPVS were conducted in 2017, two on AYTs (early, medium maturing trials) and one on NPTs (early and medium duration), with 89 participants (53 female and 36 male).
- From these tests, 5 lines (3 early maturing lines Acar 1, Simbo and CZ06-1-05 and 2 medium maturing lines CZ06-1-12 and CZ06-4-16) all resistant to Striga with good grain and folder yields were released and registered in ECOWAS catalogue in 2017.

3.3.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- In the last 3 years, 5 MSPs have been established in Mali (2 in 2015 and 3 in 2016). In 2017, a total of 11 trainings involving 337 participants/members of the MSPs were conducted (66 female and 271 male) up from 9 trainings involving 333 MSP members in 2016 (103 female and 328 male) and 7 trainings in 2015 with 208 MSP members (27 female and 181 male).
- A total of 1,560.8 t of cowpea seed has been produced in Mali since the project inception representing about 46% of the 4-year target (Table 3.3.3). About 67% of the targeted breeder seed, 33% of foundation seed and 46% of certified seed has been produced. The total amount of seed produced by variety, year and class are shown in Table 3.3.4; Table 3.3.5 and Table 3.3.6.
- In 2015, 20 demonstrations were conducted by 5 women and 10 men in 20 villages in Ségou and Mopti regions with 4 lines each for early (Acar 1, CZ06-2-17, CZ06-1-05 and, Djiguiya) and medium maturity (CZ06-4-16, CZ06-1-12, Korobalen and Wilibali). In year 2, a total of 160 demos were conducted by 20 women and 30 men. In 2017, 150 demos were conducted by 25 women and 35 men with the same varieties.
- Twelve field days were successfully conducted in 2017, up from 9 in 2016 and 3 in 2015. A total of 528 (210 female and 318 male) attended the 2017 field days, compared to 152 in 2016 (25 female and 127 male) and 71 in 2015 (26 female and 45 male).
- A total of 24 radio programs promoting cowpea technologies in Mali were aired in 2015 compared to 17 in 2016 and 1 in 2015. Five agri-seed fairs/shows/exhibitions with a total attendance of 485 farmers (235 female and 150 male) were conducted in 2017, up from 2 and with 300 farmers (200 female and 100 male) in 2017.
- A total of 39,169 small seed packs of cowpea were sold to smallholder farmers in Mali as indicated in Table 3.3.7 .

3.3.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The number of crosses increased significantly from 5-10 per cycle for only one cycle and two generations advancement to 10-20 sets of crosses per cycle for up to 2 cycles per year in 2016; the number for 2017 was 20-30 sets of crosses per cycle for 3 cycles. The progress was due to refurbishing two screen houses, which provided more space.
- The program has 5 well-defined product concepts (Mali Cowpea Product Concepts 2017 Dec): (1) Large white cowpea for export market with drought and Striga resistance (5% export; 95% domestic); (2) large red cowpea with drought and Striga resistance (5% export; 95% domestic); (3) medium white cowpea for export market with drought and Striga resistance (5% export; 95% domestic); (4) medium red cowpea for export market with drought and Striga resistance (5% export; 95% domestic) and (5) small white cowpea for export market with drought and Striga resistance.

3.4 Cowpea crop improvement in Burkina Faso

3.4.1 Developing superior high yielding stress tolerant farmer-preferred cowpea varieties

- In 2015, Feed the Future Innovation Lab for Climate Resilient Cowpea project led by the University of California, Riverside (UCR) which involves INERA, SARI and IITA facilitated the application of a new tool called “60k iSelect Bead Assay” for cowpea genotyping.
- BC_1F_1 crosses between IT81D-994 and 4 released varieties (Komcallé, Yisyandé, Niizwe and Melakh) were generated in 2015 and about 300 leaf samples each were sent to UCR in 2016 and 2017 for genotyping for SNP markers for alectra, Striga, pod sucking bugs and thrips resistance.
- A set of 300 F_8:10 RILs (F_8:10) MAGIC lines derived from crosses between 8 different parents (SuVita 2 from Burkina Faso, CB27 from UCR and the remaining IT93K-503-1, IT89KD-288, IT84S-2049 and IT82E-18 from IITA) through MAS was tested in 2016 for drought and Striga and data collected used in Marker-trait-association mapping and QTL identification for aphids, Striga and bacterial blight resistance. The set was used for drought tolerance and Striga resistance trials. Other traits like disease scores and date to maturity were recorded in these trials. Two planting dates method was used to evaluate the MAGIC lines for drought tolerance using two replications per planting date. The results from the first trial on MAGIC are shown in Figure 3.4.1.
- Markers for drought tolerance, Striga resistance and seed size used in MARS were developed through crosses between Gorom local and IT97K-499-35 and between Gorom local and IT99K-573-2-1 and recycled twice between offsprings to obtain C_2 populations that were screened under drought to select best lines and then apply FPVS to retain farmer preferred lines. The farmer preferred lines were then screened for drought.
- The elite lines (C2-18-2, C2-46-4, C2-57-1, C2-99-2 and C2-9-1) from these populations were retained for seed increase for on-farm trials in 2017. SSD has also been initiated on MARS lines to fix different traits in the population. The best lines will be selected in 2018.
- Crosses were also made in 2017 for brown blotch disease resistance study involving KN-1, Donsin local and Moussa Local as resistant parents and Tiligré as susceptible parent. F_1 and F_2s are under screening in screen house for genetic study and marker discovery. The distribution of resistant and susceptible phenotypes and the Chi-square results applied to the Tiligré x KN-1 population revealed that resistance to *C. capsici* strain Ccap-SA in KN-1 was controlled by a single QTL. This resistant QTL is related to the resistant parent, KN-1 and has been identified at 35 days after infestation (DAI). The plant material used in this study consisted mainly of F_2 and F_3 populations derived from the cross between KV x 775-33-2G (Tiligré), susceptible to brown blotch and KN-1 variety. The KN-1 cowpea variety identified as resistant to the three *Colletotrichum capsici* strains (C.cap-FA, C.cap-SA and C.cap-PO) was used as a source of resistance. The fungal material consisted essentially of the monospore isolate C.cap-SA, the most pathogenic strain used as inoculation material. The SNP work was done in the University of Virginia between 2016 and 2017. A total of 11,813 codominant SNP markers covering 1019.3 cM of the total cowpea genome were identified in this. In order to identify the QTL related to brown blotch resistance, an association test between 11,813 SNP markers and phenotyping data of 63 F_2 individuals was performed.

- Three (3) drought-tolerant crosses were made involving KN-1, Donsin (local), and Moussa (local) as resistant parents and Tiligré as susceptible to Brown blotch disease. The resultant F_1 and F_2 brown blotch lines were genotyped at the University of Virginia for marker discovery. The BC_3F_1 population was made toward the end of 2017.
- A flower thrips resistance trial was set up to identify sources of resistance with nine entries from the germplasm (Nafi, Komcallé, Tiligré, KV x 165-14-1, KV x 780-1, KV x 780-2, KV x 780-3, KV x 780-4, KV x 780-6, KV x 61-1, KV x 745-11P, Moussa local, Donsin local, Pobé local, KN -1, Sanzi, TVU 1509, TVX 3236, KV x 404-8-1, NS Farako-Ba, and NS1). The best lines were TV x 3236 and KV x 780-1. A total of 10 combination of crosses were made with these lines for further genetic studies on thrips resistance and F_1 and F_2 populations are available.
- Aphid resistance screening was done with 10 cowpea lines (B301, KV x 295-2-124-99, SARC1-91-1, SARC1-57-2, IT97K-556-6, NS1, N°2300, NS-Farako-Ba, CB27 and KN-1 plus one resistant (IT97K-556-6) and one susceptible (KN-1) check) originating from different countries that were infested with aphids collected from three zones of Burkina Faso. Line IT97K-556-6 was found to be the most resistant while N ° 2300 is the most susceptible to all the three strains of aphids. Promising lines like IT97K-556-6, SARC1-91-1, KV x 295-2-124-99 and KN-1 have been identified for crosses to improve cowpea for aphid resistance (Figure 3.4.2).
- Ten cowpea lines (Local, Moussa, KV x 30-309-6G, IT82D-849, Nafi, Tiligré, Komcallé-P5, IT98K-205-8, IT81D-994 and B301) were screened for Alectra resistance from the screenhouse. Genotypes B301, IT81D-994 and IT98K-205-8 were resistant.
- Six lines developed using MABC with their three parents (IT97K-499-35 and IT93K-503-1 as donors and Moussa local as recurrent parent) and checks making a total of 15 lines (Table 3.4.1) were evaluated under advanced yield trials, with significant genotype by environment (GXE) interactions for all the parameters, indicating that the genotypes performed differently across the locations.
- A study was conducted to determine cowpea breeding progress in terms of grain size. A total of 30 cowpea genotypes comprising 6 newly released varieties, 21 old varieties and breeding lines, and 3 landraces were used (Table 3.4.2).
- The 300 inbred lines of the MAGIC populations and their parents were evaluated for their reaction to drought. The best 20 lines based on grain yield were selected (Table 3.4.3). Further FPVS conducted on MAGIC derived lines helped select 38 lines (Table 3.4.4). This selection will be combined with the selection from the analysis to retain 64 lines to advance to the next generation of FVPS.
- Seven lines were selected (MAGIC089, MAGIC246, MAGIC180, MAGIC066, MAGIC230, MAGIC220 and MAGIC036) from the MAGIC population for physiological trial on water stress during 2017. Data analysis is underway and a further screenhouse trial is scheduled for 2018.
- Five lines comprising 4 lines (KV x 780-1, KV x 780-3, KV x 780-4, KV x 780-6, Moussa Local) in the pipeline for release and local line (Moussa local) were screened under five different treatments for P application. The objective of the experiment was to evaluate the responses of these 5 cowpea varieties to five levels of P (0, 7.5, 15, 22.5 and 30 g P_2O_5/ha) with N and K applied at recommended rates. KV x 780-4, KV x 780-6 and Moussa Local (with 1008.1 kg/ha; 969 kg/ha and 701 kg/ha at 0 kg/ha of P applied respectively) were more responsive to low P than KV x 780-3 and KV x 780-4 (with 650 and 1008 kg/ha at 0 kg/ha of P applied respectively).
- Four pre-release varieties were evaluated in 2 sets for yield adaptability, 25 breeding lines evaluated in 2 sets for Striga resistance and 12 MARS C_2 populations were evaluated in 2016. Five FPVS sessions were held at 5 locations and 5 lines were identified from 25 entries. The main criteria for selection were stay green after pod maturity, earliness, pod length, pod load, grain size and color. Eight pipeline varieties were nutrient profiled in 2016 at the University of Ouagadougou's biochemistry lab. Nutritional profiling and digestibility of the fodder lines were done in 2017 at Kamboinsé.
- In 2017, 6 lines (KV x 780-1, KV x 780-3, KV x 780-4, KV x 780-6, POPA44 and P35PL3) were evaluated on farm and proposed for release. Other lines -- KV x 781-1, KV x 781-2 and KV x 781-3 -- developed for resistance to Striga race Kp from crosses between Tiligré and IT93K-693-2 and KV x 782-1 derived from a cross between Nafi and IT93K-693-2 were evaluated on farm in 2017. Four FPVS trials were conducted with varieties shown in Table 3.4.5 with 33 participants (26 producers, 5 casual laborers and 2 INERA researchers).

3.4.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- One MSP was established in 2017 to add to the 3 established in 2016 and 9 trainings conducted in 2017 to add to the 3 conducted in 2016 to build the capacities of MSP members. The total number of MSP members trained were 558 (357 male and 201 female) in 2016 and 888 (272 females and 616 male) in 2017. The fourth platform installed in year 3 is mainly made of women from YiYE Association with more than 3000 members. This platform conducted 25 demonstration tests, planted 10 ha of certified seed and 5 ha of contracted foundation seed.
- In the last 3 years, a total of 1,562.1 t of improved cowpea seed was produced, representing about 30% of the total project seed production target, comprising of 12.8 t (160%) of breeder, 196.2 t (61%) of foundation and 1,353.1
- t (28%) of certified/QDS (Table 3.4.6). Details on the amount of seed produced by variety is shown in Table 3.4.7, Table 3.4.8 and Table 3.4.9. A total of 160 demonstration trials (70 female hosts and 90 male hosts) were conducted in 2017, up from 133 (88 male and 45 female) in 2016 and 75 (50 male and 25 female) in 2015. Seven field days were conducted in 2017, attended by 2974 farmers (1233 female and 1741 male), up from 9 in 2016 attended by 420 farmers (220 female and 200 male) and none in 2015.
- In 2017, the project found 14 media mentions (2 TV, 6 radio and 6 print) in addition to the 15 in 2016 (1 TV program, 8 radio programs, and 6 in print media) and none in 2015. A total of 5000 leaflets highlighting improved cowpea technologies were translated into 3 local languages, printed and distributed to farmers during field days and agri-seed fairs/shows/exhibitions.

- All cowpea seed was sold in small packs of 3 kg (0.25 ha), 6 kg (0.5 ha), 12 kg and 15 kg (1 ha). NAFASO seed enterprise sold more than 30 tons of cowpea seed in small packets of 3 kgs and 6 kgs.
- The program involved 40- 50% of women in FPVS, processing, training, field days, agri shows, and studies conducted by the gender team. The last study conducted by the Gender team showed a 35% adoption of improved varieties by men and 61.6% by women.

3.4.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The use of handheld electronic data collection gadgets (tablets), BMS and installation/expansion of irrigation facilities have been supported by the project.
- Fifteen technicians were trained during 2017 on BMS and 10 tablets were provided. However, there is still need for more training on the IBP tools such as MBDT, OptiMAS and ISMU used to facilitate MABC and MARS. Fifteen scientists and technicians were trained in the use of handheld devices to collect data and about 7 of them are using the gadgets.
- BMS is used as a tool for trial design, data analysis and sharing for greater scale and efficiency in the Burkina Faso cowpea program. Tablets are used to capture data. The barcoding system has not started but we will share the barcode printer recently acquired by the groundnut program. With the support of IITA/Monsanto project, we are planning to acquire PhenoApps and label printers to increase precision.
- For each trait at least 10 crosses are made to improve the chance of obtaining better results. In the past, only 2- 5 crosses were made per trait per year. SSR markers are being used routinely to reduce population size to be taken to the field, mainly for Striga resistance.
- More screenhouses have been built as well as three irrigation sites and growth chamber to speed up population advancement procedures. As a result, up to three generations are obtained. SSD has been implemented recently. Two main sites are used for crosses and population advancement.
- The program has defined product concepts as described in the link Burkina Faso Cowpea Product Concept NEW 2017 - - -fish

4.1 Common bean crop improvement in Uganda

4.1.1 Developing superior high yielding stress tolerant farmer-preferred Common bean varieties

- Phenotyping protocols for screening for bean stem maggot (BSM) and bruchid resistance were developed in 2015 and 2016 and validated in a trial that comprised 7 lines including 5 sources of resistance to BSM lines (Sinon, BFS 14, G21212, GLPX92 and KFRR26) and 2 susceptible commercial checks (Cal 96 and NABE 4). Using this protocol, two released variety's NABE 2 and NABE 16 were identified to be moderately resistant to BSM.
- The program undertook three molecular breeding programs.
- The first comprised of an F_2 populations developed to combine resistances for Pythium, anthracnose, drought and BSM being established in Namulonge, Uganda screenhouse. This population will be genotyped using a set selected markers established at the Intertek SNP platform to aid selection.

  ii) In the second program; a total of 168 lines bred for resistance to different diseases (Pythium, anthracnose, angular leaf spot (ALS), bean stem maggot (BSM) and bean common mosaic virus (BCMV)) were genotyped using 16 SNP markers associated with various traits including; ALSChr08_CT_57798588, ANT_Co-1_ss715645251; ANT_Co-3_ss715640025; ANT_Co-u_ss715648452 for anthracnose resistance, Bc-3b; bc3; BCMV_I_00453_M1 for BCMV/BCMNV resistance; Chr07pos971353_1; MAS_ALS4b; Phg1new_TC_51617802 for ALS resistance; SAP6_801; SU91_g91004686 for common bacterial blight disease (CBB) resistance; YDHA1_1_H28_7a_2/2_20959857; YDHA8_1_H441_2/4a_58431641 for yield; and IntRegAPA3 for bruchid resistance. The results confirmed the presence of different lines possessing resistance genes including ALS, anthracnose, BCMV, CBB and bruchid and will assist the program in making decision on lines to advance, eliminate or combine to make breeding progress.

  ii) In another program; genomic regions associated with drought responses were determined using GWAS analysis and significant signals for yield component traits and photosynthetic traits on Chromosomes Pv01, Pv4, Pv05, Pv06, Pv9, Pv10, and Pv11 were detected in a panel of 256 lines (247 ADP and 9 local checks). Colocalized genomic regions were observed for yield component traits on Pv06 and for photosynthetic traits on Pv04 and Pv011.Using marker trait association effects, three accessions including ADP 657, ADP 119 and ADP 345 that carried alleles with high positive allele effects for pod weight per plant and seed weight per plant were identified.

- The following crosses were made in 2015 and 2016:
  - Thirty six crosses to introgress drought tolerance and bean stem maggot resistance with Pythium and anthracnose resistance.
  - Seventy five crosses to introgress Pythium and anthracnose resistance into 9 cultivars.
  - Thirty four new crosses to introgress rust, CBB, BCMV resistance, drought tolerance and high iron and zinc content into six market class bean varieties.
  - Sixteen additional crosses to introgress BSM resistance in a drought tolerance background.
  - Six parents were crossed to investigate the mode of inheritance of cooking time.
  - Four crosses were initiated to combine high micronutrient lines (RWR 2154 and RWR 2245) with bruchid-tolerant lines KK25/19MW, 1425/Muluwa and KK35/Muluwa 445MW.

- Selected CIAT introduced genotypes developed to contain high iron and zinc seed content were crossed with Ugandan market class varieties. The developed populations were advanced to F_4 during the course of 2017.

New crosses were conducted in 2017 as follows:

- Nineteen crosses were conducted to introgress CBB and BCMV resistance into commercial varieties (NABE 15, NABE 16, NABE 17, NABE 18, NABE 19 and NABE 21).
- Eighteen crosses combining Drought/BSM x Biofortification were conducted.

Based on the crosses and populations outlined above, the following germplasms with different traits were advanced at different levels in 2017:

- Thirty eight F_1 populations aimed at combining high Fe and Zn, BSM and drought were generated.
- A population developed to combine drought and BSM tolerance were advanced to F_4. Single plant selection was conducted resulting in 452 individual lines.
- Sixty one lines at F_3 were screened for anthracnose resistance, 22 lines were screened for BCMV and ALS resistance, 12 lines were screened for CBB resistance and 82 lines were screened for BSM, drought and market class. All these lines were evaluated on-station at F_3 and were advanced to F4 where they will undergo individual plant selections in year 4.
- Forty nine families from 89 BC_4F_3 (NABE 12C/RWR 719/G2333/Mexico 54) climbing bean families bred for ALS and root rot resistance showed good levels of disease resistance.
- Segregating populations arising from 75 crosses aimed at combining Pythium and anthracnose resistance into nine commercial varieties (NABE 15, NABE 16, NABE 17, NABE 18, NABE 19, NABE 20, NABE 21, NABE 22 and NABE 23) were field evaluated at F_4 and 103 individual plants (lines) selected for advancement.
- Four F_4 individual plants were selected from segregating lines arising from crosses developed to combine high nutrient (Fe and Zn) RWR 2154 (NAROBEAN 1) and RWR 2245 (NAROBEAN 2) and bruchid resistance; KK25/19MW, 1425/MULUWA and KK35/MULUWA 445MW.

- The program under took evaluations of several nurseries bred for different traits but the results are pending. They included:
  - Thirteen sets bred for resistance to different disease were evaluated for yield performance and disease resistance under field conditions.
  - Fourteen GRR and 24 DAD lines bred drought tolerance in the Andean background were evaluated for nutritional value.
  - A second preliminary yield trial (PYT) was conducted for 169 lines bred for drought and enhanced nutritional content.
  - Fifty nine lines with both heat and drought tolerance were evaluated for adaptability.
  - A nursery with 60 lines also bred for drought tolerance was screened using the terminal drought protocol during off-season under irrigation.
  - A total of 256 lines (247 ADP lines and 9 local checks) were evaluated to assess their response to drought stress and a PhotosynQ tool was used to measure photosynthetic traits. The results obtained indicated highly significant and positive correlations among yield component traits, harvest index, pod harvest index and pod partition index with yield component trait observed.
  - Thirty common bean lines with known reaction to *Sclerotium rolfsii* were evaluated for fusarium root rot resistance in the screenhouse and 9 of these lines showed resistance and tolerance reactions.
  - A PYT for 16- F_4:7 pyramided promising Pythium and anthracnose-resistant lines was conducted, resulting in an average yield of 758 kg/ha.
  - A nursery of 184 lines (Table 4.1.1), i.e., 167 ALB and 17 BFS bred for aluminium toxicity and drought/low soil fertility tolerance respectively was evaluated. The performance of different lines varied but lines with yield >1000 kg/ha have been selected for advancement.
  - Seventy three climbing bean genotypes (Table 4.1.2) bred for high Fe and Zn content were evaluated at BUZARDI and KAZARDI including 5 checks (NABE12C, NABE26C, NABE 28C, NABE 29C and NAROBEAN 5C). Yield was generally lower than expected (below 1000 kg/ha) in season 1 due to drought and high aphid infestation during the reproductive stage. In season 2, five lines (CMKN 1353, CMKN 753, CMKN 2141, CMKN 1713 and Deceleya) had mean yield >1500 kg/ha compared to 1333 kg/ha, 1333 kg/ha, 1100 kg/ha and 1417 kg/ha for the commercial checks NABE 12C, NABE 26C, NABE 29C and Narobean 5C, respectively, at BUZARDI.
  - At KAZARDI, only five test genotypes CMKN 748, CMKN 793, CMKN 181, CMKN1613, CMKN 1082 and Deceleya and check varieties (NABE12C, NABE29 and NAROBEAN 5C) had mean seed yield of 1500 kg/ha and above. The low seed yields are generally attributed to low soil fertility, which is characteristic of most of the fields at KAZARDI.
  - Preliminary yield trials for heat and drought tolerant genotypes were conducted on 66 PIC Andean RILs. Lines with average yield of >600 kg/ha will be advanced to AYT in heat and/or drought sites in 2018.
  - A set of 33 DAD lines that are heat and drought tolerant were evaluated for adaptability and initial yield increase. These genotypes will be subjected to off-season screening to identify promising heat and drought tolerant lines for possible utilization for breeding and as potential varieties.
  - Preliminary yield trials were conducted for a total of 114 families that had been formulated through the pyramiding of anthracnose and root rot resistances but most of these were hit severely by drought in the first season of 2017with only 16 lines surviving. These were evaluated in intermediate yield trials.

Year 3 activities were expanded to include:

- AYTs of eight climbing bean genotypes were conducted at BUZARDI, KAZARDI and Kitumba sub-county. Of these, 6 were mid-altitude climbers resulting from previous crosses/segregating populations generated at NaCRRI. During both seasons, released

varieties NABE 12C, NABE 26C, NABE 28C, NABE 29C, NAROBEAN 4C and NAROBEAN 5C were included as checks. In the same locations, AYTs of 17 genotypes arising from two-way and three-way crosses to introgress resistance to anthracnose and root rots were conducted. Also, PYT comprising of 26 drought-tolerant Andean (DAD) lines, 90 Drought Andean bush (DABS) lines; and 30 SEF-heat tolerant lines were performed. There were variations in the performance of the different trial lines, and analysis done will be used to select for advancement in the first season of 2018.

- A nursery of 116 bush lines developed for high iron and zinc were evaluated at 4 locations with results indicating varied performance across agro-ecologies.
- A set of 13 climbing bean genotypes developed for high Fe and Zn were evaluated at three locations; NaCRRI, Rwebitaba and Kachwekano ZARDI (2066 masl) where yield results varying from 211 kg/ha to 4000 kg/ha were obtained. These results will be used to make selections for lines to be advanced in 2018.
- AYT and PVS trials were conducted for 17 promising climbing bean genotypes including 5 checks (NABE 26C, NABE 28C, NABE 29C, NAROBEAN 4 and NAROBEAN 5) with 236 farmers (59.3% women). Two most promising genotypes, F_2:4 12C 40ML-1/19 (seed class similar to local landrace Kanyebwa) and F_5: 9 34 ML -2/20 (Pink round) were selected to be advanced to NPT in 2018
- A set of 23 pre-selected lines with superior foliar diseases resistance, drought tolerance, shorter cooking time and high mineral bioavailability were evaluated and 7 lines (ADP 0512, ADP 0009, ADP 0001, ADP 0468, ADP 0521, ADP 0098 and ADP 0522) were selected by farmers based on both consumer and market traits. These 7 lines will be advanced to NPT in 2018.
- FPVS was conducted on a set of 73 climbing bean lines bred for high Fe and Zn grain content. A total of 263 farmers participated (178 female and 85 male). A total of 6 genotypes including CMKN 1353 (69), CMKN181 (61), CMKN 1713 (60), CMKN 753 (58), CMKN 1454 (42) and CAB 2 (41) were the most preferred. Overall, NABE 12C was the most selected genotype.
- Two hundred and thirty climbing bean lines bred for high Fe and Zn content, mild altitude adaptability and BCMV resistance; NUV, MAC and MBC respectively, were evaluated at KAZARDI and exposed to 243 stakeholders (148 women), mainly farmers. A total of 65 genotypes (Table 4.1.3) were selected for advancement in year 4 based on the yield data, farmer selections and visual observations for reproductive adaptation.
- Thirty lines bred for heat tolerance (SEF lines) were evaluated together with 65 farmers (39 female and 26 male) at BUZARDI in PVS trials.

- In 2015, 2016 and 2017, tests for release included:
  - Thirteen promising high nutrient beans that were evaluated in NPT
  - Four drought-tolerant bean lines (SCN 1, SCN 11, SCR 26 and SEN 98) were sent to MAAIF to undergo the first NPT in 2017. Three more lines were included in the NPT that was conducted in 10 locations during 2017. From these NPTs, 4 best performing genotypes (SCR 26, SEN 98, SCN 11 and SCN 1) were obtained and submitted for DUS test in the second season of 2017.
  - In 2017, DUS test was conducted on these 4 drought tolerant bean lines (SCN 1, SCN 11, SCR 26 and SEN 98) with 3 checks (NABE 2, NABE 3 and NABE 6). These lines were sent to MAAIF during year 3 and official variety release has been requested for. By the end of year 3, documents requesting for release of at least 2 varieties were prepared and are due for release.

- Other activities related to testing for release: (1) 5 varieties under DUS and 4 submitted to undergo the DUS testing in 2017; (2) 8 drought-tolerant genotypes evaluated in 30 FPVS sessions and two varieties were preferred by the farmers (12C 40ML-1/19; Sugar bean type similar to local landrace “Kanyebwa” and 34 ML -2/20 - pink, round) and 5 varieties were released (Narobean 1 -RWR 2154, Narobean 2 - RWR 2245, Narobean 3 - Moore 88002, Narobean 4c -MAC 44 and Narobean 5c - Nyiramuhundo). Fifteen FPVS were conducted in 2017 consisting of a set of eight drought tolerant genotypes (SCN 1, SCN 11, SCR 26, SCR 48, SEN 56, SEN 80, SEN 98 and SEN 99) with a total of 365 farmers participating (122 male and 243 female). Five genotypes (SCN 1, SCN 11, SCR 26, SEN 80 and SEN 98) were identified as the most preferred from the year 3 FPVS.

- A trial to document the nutrient profiles of released varieties and assess genetic gain made by NARO in bean improvement was initiated in 2017. All the available and accessible bean varieties released in Uganda since the 1960s (MUTIKE 4, BANJA 2, K20, K131, K132, NABE2, NABE 3, NABE4, NABE5, NABE6, NABE7C, NABE8C, NABE 9C, NABE10C, NABE11, NABE12C, NABE13, NABE14, NABE15, NABE 16, NABE17, NABE 18, NABE 19, NABE20, NABE21, NABE 22, NABE 23, NABE 26 C, NABE 28C, NABE 29C, NAROBEAN1, NAROBEAN 2, NAROBEAN 3, NAROBEAN 4C and NAROBEAN 5C) were collected. Trials including local checks like Kanyebwa, Massindi yellow short, Massindi yellow long and Kahur were established in three locations (Namulonge, Kachwekano and Nakabango). Soil samples were taken and analyzed. Data was and will continue to be collected on yield attributes, diseases including CBB, BCMV, ALS, rust, anthracnose, majorly and for pests, scores on aphids, bean leaf beetle, pod borer and whitefly recorded. Nutrient profiling will be conducted and the analysis will be undertaken at Cornell University.

4.1.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- From the Ugandan seed road map, the project targeted to cover about 30% of the beans area with improved varieties i.e. 151,275 ha. To achieve this, the project targeted to produce 28 t of breeder seed, 747 t of foundation seed and 11,200 t of certified/QDS seed by year 4.

- In the last 3 years, a total of 14,269.2t of seed has been produced and this represents about 111% of the targeted common beans seed production in Uganda for the project, of which 37.5t (134% of the target) was breeder seed, 657.2 t (82% of target) was foundation seed and 13,574.5 t (113%) certified certified/QDS (Table 4.1.4). Some certified seed producers, have a tendency of

recycling their foundation seed a couple of times and thus the production of certified/QDS seed does not directly correspond to the foundation and breeder seed produced. Several partners are involved in seed production as shown in Table 4.1.8. Details of seed production by variety over the 3 years of the project are given in Table 4.1.5, Table 4.1.6, Table 4.1.7.

- The national program has partnered with private seed growers (seed companies and NARO Holdings) under their supervision to increase foundation seed production. Seed production of old varieties like NABE 1, NABE 2, NABE 4 and K132 has been replaced by new varieties such as NAROBEAN 1, NAROBEAN 2, NAROBEAN 3, NAROBEAN 4C and 5C, whose basic seed production is still low.
- Also, there was a drop in demand of prominent varieties like NABE 15, NABE 4, NABE 16, NABE 17 and NABE 19 because of the changes in government priorities to favor biofortified varieties (NAROBEAN series) which had only been recently released (2016). This will speed up the variety replacement.
- Three MSPs were established and 2051 members (1145 female and 906 male) of 66 seed producer associations were trained in seed production and marketing in addition to 3616 farmers (2196 female and 1420 male) trained in good agronomic practices for beans production. In 2016, 1 MSP was established and 4453 members (2425 female and 2028 male) trained while 3 were established and 2147 (1180 female and 967 male) members were trained in 2015.
- A total of 61,089 small seed packs (SSPs) were marketed (representing 40% of seed sale) to an estimated 55,194 farmers during 2017, up from 40,580 SSPs marketed to 28,902 farmers in 2016 and 20,450 SSPs marketed to 13,490 farmers in 2015. The entities marketing small seed packs through stockists and agrodealers included CEDO, Kyazanga Farmers' Cooperative Society, BRAC, Pearl Seed Company and NASECO Seed Company.
- A total of 146 demos were conducted in 2015 to promote new varieties (NAROBEAN1, 2, 3, 4 and 5, NABE 15, 16, 17 and 19), 40 of them in collaboration with N2Africa project. The demos were hosted by 146 (102 female and 44 male) representatives of farmer groups and were visited by 2147 farmers (1180 female and 967 male). In 2016, 135 demos were conducted and were visited by 2296 farmers (1245 female and 1051 male). In 2017, 168 demos were conducted, with 3594 farmers visiting (2130 female and 1464 male).
- Five field days were held in 2017 with 850 farmers attending (553 female and 297 male) in addition to the 3 attended by 525 participants (275 female and 250 male) in 2016.
- Twenty radio programs were aired in 2017 while 22 were aired in 2016 and 10 in 2015. Six agri-seed fairs/shows/exhibitions were conducted in 2017 attended by 6034 participants (2585 female and 3449 male), up from 4 attended by 3578 farmers (2539 female and 1039 male) in 2016 and 3 attended by 2147 farmers (1158 female and 989 male) in 2015.
- In 2017, 19 international print and electronic media widely publicized the role of NABE 15 (Magic Bean) in helping fight hunger in northern Uganda, among southern Sudan refugees and in other regions of Uganda. The international media included New York Times, The Guardian, BBC Associated Press, ABC, Deutsche Welle, China Daily, Boston Herald, Fox News, Shanghai Daily, etc.
- A socioeconomic study was conducted in 2017 to measure farm productivity of common beans by variety and sex of the bean plot manager. A total of 452 households were randomly sampled from 9 districts in the greater Masaka region (Masaka, Lyantonde and Rakai), greater Mubende region (Kiboga, Mityana and Mubende) and the near-Eastern region (Tororo, Iganga and Manafwa).
- Preliminary results show that there is no gender yield gap or access to productive resources (training, credit, land, varieties, etc.) in the study area. These results support the findings in other studies that women are as efficient managers as men when given equal access to productive resources.

4.1.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- The program procured 4 more tablets to assist in electronic data capture. Furthermore, through the assistance of both CIAT's MLE team and IBP support team, 6 NARS staff (3 female and 3 male) were trained in the use of Open Data Kit (ODK) to help the transition of data capture from paper to tablets.
- By the end of 2017, 50% of the breeding data and 70% of seed production data was being captured electronically using tablets.
- The Uganda beans breeding program defined 6 product profiles (Uganda Common Bean Product Concepts): (1) Large-medium red mottled biofortified bean with drought and disease tolerance (80% local; 20% export); (2) large-medium sugar biofortified bean for local market, canning, and export market with drought and disease tolerance (95% local; 5% export); (3) large-medium yellow biofortified bean with drought and disease tolerance (75% local; 25% export); (4) large red kidney beans for local and export market with drought and disease tolerance (45% local; 55% export); (5) small-medium white bean for canning with drought and disease tolerance (40 local; 60% export) and (6) small-medium red bean for export market with drought and disease tolerance (30 local; 70% export).
- The program engages the socioeconomics team identify traits that are important to farmers and thereby help with better targeting to respond to market demand and preferences of other beneficiaries, seed businesses, consumers, and processors. Results of the current socioeconomic analysis will include estimating the market size of each group with homogenous preferences and profiling by sex, wealth, production orientation etc.
- The socioeconomics team contributed to developing, adopting, reviewing and institutionalizing the product profile approach for the key varieties needed in the region. Some of the traits and goals in bean product profiles were informed by the bean case study that was developed and presented in the Genomics, Breeding and Gender in 2016 with Clare, Stanley and Aseete as co-authors

where the economic value of traits derived by different farmers/consumers and the current and projected demand for traits of different classes of beans are articulated.

4.2 Common bean crop improvement in Tanzania

4.2.1 Developing superior high yielding stress tolerant farmer-preferred common bean varieties

- In 2016, evaluation of segregating population for bruchid resistance (RAZ lines) was undertaken with F_4 lines confirmed to have APA marker. Eighty six bean genotypes were screened in the lab and in the field to validate resistance to bean bruchid and identify agronomically superior lines. An experiment was also conducted to evaluate the levels of resistance to bruchids on commercial bean varieties and commonly grown landrace (Kablanketi) during 2015 and 2016.
- Drought resistance breeding pipeline activities in 2015 and 2016 included evaluation of 28 drought Andean bush (DAB) lines. In 2017, a trial of lines bred for tolerance at CIAT (DAB, DAA, GRR, and SSIN) was established at Uyole for agronomic evaluations under non-stress and moisture stress (screenhouse).
- Crosses to introgress angular leaf spot (ALS) resistance from 2 parents (MEX 54 and G5686) into 6 preferred market class varieties were done in 2015 and 2016. Besides, 78 crosses were made to introgress anthracnose resistance, Pythium Root Rot (PRR) resistance, Common Bacterial Blight (CBB) resistance into the 6 cultivars.
- In 2017, six populations aimed at improving resistance to root rot, ALS and rust disease were generated. The donor parents RWR 719 (root rot), VAX 3 (CBB) and MEX 54 (ALS) were used to generate F_1 plants. The recipients were the commercial varieties that mostly succumb to root rot and leaf rust (Uyole 04, Njano Uyole and Urafiki) at ARI Uyole.
- Nine F_1 populations for anthracnose resistance in six commercial varieties (ADP14, Njano ndefu, Jesca, Lyamungo 85, Lyamungo 90 and ADP080) were developed. Two donor parents (PI 207262 and G2333) were used to generate the populations at SARI.
- Similarly, 15 populations aimed at addressing bean stem maggot resistance were generated from three donor parents (SINON, CIM-RIM-02-126LN01 and CIM-SUG-03-03-09-1625) and five commercial varieties that are susceptible to BSM attack (Uyole 04, Uyole 96, Uyole 03, Calima Uyole and Njano Uyole).
- The F_1 populations were advanced to F_2. Also, 3 populations for bruchid resistance were developed from 60 crosses between a RAZ line as the donor parent and Uyole 04, Uyole 03, Calima Uyole at Uyole. F_1 was advanced to F_2. Other disease/pest screening activities in 2017 included:-
- Five F_1 populations were developed to improve resistance to root rot in five commercial variety background (ADP14, Njano ndefu, Jesca, Lyamungo 85, Kigoma) using AND1062 and RWR719 as sources of root rot resistance at SARI.
- Two F_1 populations aimed at improving resistance to BCMV in Njano Ndefu and Jesca using UBR25 as a source of BCMV resistance were generated at SARI.
- Two populations aimed at improving resistance to CBB in ADP080 and Jesca using MCM5001 as a source of BCMV resistance were generated at SARI.
- A total of 22 bean lines (BFS) bred for drought and low soil fertility (LSF) tolerance at CIAT were evaluated at ARI Uyole. SINON was used as resistant check and KABANIMA as the susceptible check. Four resistant lines (BFS 18, BFS 23, BFS 60 and BFS 24) Were selected
- A total of 22 bean lines bred for bruchid resistance (MAZ) were evaluated for bean bruchid resistance on farm. One hundred seeds per line were placed in a vial per line and inoculated with 10 bruchids (5 male and 5 female). Four lines (MAZ 171, MAZ 175, MAZ 4 and MAZ 190) showed resistance with MAZ 171 being the most resistant.
- At SARI, 18 bean genotypes (MAZ) were screened for bean bruchids in the lab. There was significant difference whereby MAZ 37, MAZ 46, MAZ 49 and MAZ 72 showed resistance against *A. obtectus* in two seasons.
- A nursery of 46 lines (KWP, KFRR) developed for PRR, Fusarium Root Rot (FRR), Angular Leaf Spot (ALS) and CBB were field evaluated and preliminary analysis shows that 19 lines succumbed to one or more diseases and others exhibited good levels of resistance.
- A total of 72 bush bean breeding lines developed for root rot disease resistance (KWP and KFRR), root rot/ALS resistance (KWC), common bacterial blight resistance (ACC) and LSF/drought (BFS) were field evaluated. Thirteen genotypes (KWP 14, KWP 5, BFS 14, BFS 29, BFS 20, BFS 27, BFS 34, BFS 39, BFS 47, BFS 60, G90, KFRR72a and ACC1) were selected for AYT in 2018.
- Four F_1 populations aimed at improving resistance to ALS in 4 commercial varieties (Jesca, Lyamungo 85, Kigoma and ADP080) using MEX54 as a source of ALS resistance (phg2 gene) were developed at SARI.
- Six populations aimed at enhancing Fe and Zn grain content were developed in 2015 and 2016 from 3 high Fe lines and 6 adapted bean genotypes. In 2017, several activities were undertaken with the following deliverables:
- Fifty five new crosses of MAC 44/CIM-SUG-05-01-02 with Uyole 03 were conducted for high minerals content and F_1 population developed. One cross of Salundo x Uyole 04 was developed at Uyole and the F1 is being advanced to F2
- Eleven new populations were developed at Selian with the aim of enhancing Fe and Zn grain content in backgrounds of popular grain market classes of Njano Ndefu, ADP14, Kigoma, Ruhondera, Njano Glory, Manyulane, ADP 080, and Lyamungo 90 with Mlembegwa sungs RWR154, ACC714 and Jesca as sources of high Fe.
- A trial of 46 climbing bean lines bred for high Fe and Zn grain content (NUV, NCC, MNC) originating from CIAT and Uyole was established at Uyole for field evaluation.
- In 2015 and 2016, a total of 18 common bean genotypes were evaluated for low soil fertility tolerance, while in 2017, a total 150 new crosses targeting improvement for low soil fertility tolerance were conducted and F_1 will be advanced to F_2 in 2018.
- Several activities were undertaken that involved soil fertility alongside other traits:
  - Twenty lines (BFS) developed for combined tolerance to drought and low soil fertility tolerance were planted at Uyole and Mbimba sites for adaptability evaluation under moisture stress (screenhouse) and non-stress conditions.
  - Eighty five lines (drought, low soil fertility, high Fe and Zn (i.e. BFS, DAB, DAA, GRR, SSIN) were field evaluated and results obtained from different field sites did not show any significant difference.

- Populations from Bilfa Uyole, MAC 44, Maini and Uyole 03 and parents for low soil fertility materials, high minerals (high Fe and Zn) and high yield potential were evaluated for adaptability.
- Forty four lines (NUV, NUC, MNC, CMKN) bred for high Fe and Zn content, 85 for heat tolerance lines, 20 for low soil fertility and drought (BFS) and 200 for drought tolerance (DAB, DAA, GRR, SSIN) were evaluated in the southern highland and Lake Zone for agronomic performance and adaptability.
- Twelve drought Mesoamerican bean genotypes were evaluated for high Fe and Zn.

- The following multiple trait evaluations were started in 2017:
- A total of 131 lines developed for combined drought tolerance and high mineral (Fe and Zn) grain content were evaluated at Kitengule. The yield was highly significant (P ≤ 0.001) with an overall mean yield of 1.76 t/ha. Thirteen genotypes had yield ranging between 3-4 t/ha, whereas 40 genotypes had yield ranging from 2-2.9 t/ha. ALS symptoms were observed. However, the incidence and severity were low (10% and score 2, respectively). The best 13 genotypes included: SSIN 502, SSIN 73, SMC 28, SSIN 70, SSIN 514, SSIN 1026, SMC 29, SCR 63, SSIN 831, SER 353, SSIN 1064, SSIN 624 and SCR 61.
- Sets of 44 genotypes and 36 genotypes (series SEF, EAP, INB, RCB, ALB and G) were evaluated for agronomic performance and adaptability to heat stress at Kirando Nkasi site. The yield was highly significant (P ≤ 0.001) by genotypes, whereas, the overall mean yield was 1.23 t/ha. The highest yield was 1.65 t/ha whereas the lowest yield was 0.28 t/ha. ALS was observed.
- One hundred and forty one drought tolerant lines received from CIAT were planted for agronomic performance and adaptability on different sites in the Southern highlands of Tanzania. Seventeen drought tolerant Red Kidney type were selected (DAB 545, DAB 776, SER 83, DAB 528, DAB 541, DAB 527, DAB 523, DAB 501, DAB 491, DAB 71, DAB 55, DAB 474, DAB 96, ALB 129, CZ 102-37, CZ 102-29 and KG 111-17).
- In 2015 and 2016, a total of 190 entries entered PYT (64 entries consisting of lines with multiple traits; 62 entries for Fe and Zn content and 64 entries of small white beans – navy beans). In 2017, 142 new entries of PYTs [76 by Uyole and (DAB, SMB and SMC); 66 for SARI (SMB, SMR, SMC, BFS and MIB)] were evaluated. Out of the 66 entries from SARI, 40 genotypes were selected for drought tolerance and will be advanced to AYT in 2018.
- Twenty two genotypes bred for bruchid resistance and for high Fe and Zinc grain content selected in 2016 were evaluated in AYT together with 4 released varieties (Jesca, Selian 97, Selian 94 and Lyamungo 90). Thirteen red mottled/large (MAZ 47, MAZ 48, MAZ 49, MAZ 50, MAZ 84, DOR 771, VAX 1, DOR 766, TU, NUA 30, NUA125, NUA 9 and NUA 152), one red mottled/medium (NUA 200), and one sugar bean medium (NUA 211) were selected in 2017 for advancement to UCT testing stage in 2018.
- In 2017, uniformity cultivar trials (UCT) was conducted on 12 lines that were selected from AYT established in 2016. The trial included 3 local checks (Lyamungo 90, Selian 97 and Selian 09). Seven lines (KG 4-20, CZ 114-51, KG 71-4, KG 4-3, CZ-102-29, CZ 102-24 and CAL 113) selected for agronomic and market traits will be advanced to on-farm trials.
- During 2015 and 2016, 10 candidate lines and 13 genotypes were evaluated in 4 UCTs to promote rapid release of varieties (series KAT B1, KAT B9, MAC 44 and RWV 1129). In 2017, 12 lines (KG 4-20, KG 15-6, CZ 114-50, CZ 114-51, KG 71-4, CZ 102-29, CAL 113, CZ 102-24, KG 114-177, KG 4-3, CZ 114-46 and F9 kidney) were evaluated in UCT.
- Fourteen candidate varieties were submitted to Tanzania Official Seed Certification Institute (TOSCI) for DUS and NPT and 2 varieties (Uyole 16 and Uyole Nyeupe) were released in 2016.
- During 2017, a total 4 FPVS were conducted using 8 lines (Kabl CR -Uyole 18, CIM-RWV 1081-1-2-1, CHAUREMBO - Uyole 17, CIM-RWV-1081-1-1-1, CIM-CLIMB 01-09-30 - Kablanketi type, CIM-CLIMB-01-04-11, CIM-CLIMB-01-03-14, 2 popular farmer varieties as checks). The data was added to 3 FPVS conducted with a total participation of 77 farmers (44 male and 33 female) in 2016 and 3 FPVS conducted with a total of 46 farmers (17 female and 29 male) in 2015 to support the release of 9 varieties in 2017 (SWP-09 named Selian 09, SWP-11 named Selian 10, SWP-12 named Selian 11; two high iron and zinc climbing beans MAC 44 named Selian 14 (large red mottled), RWV 1129 named Selian 15 (large kablanketi type) and two early maturing and high yielding KATB 9 named Selian 12 (red) and KATB 1 named Selian 13 (yellow); Uyole 17 (Kablanketi Nyota) and Uyole 18 (Cha Urembo).
- Nutritional analysis was done in 2016 and a repeat trial was conducted by SARI in collaboration with Maruku and Uyole consisting of 10 candidates for release (RWR 2154, KAB 06F2-8-36, COD MLB 001, NGWANKUNGWANKU, COD MLB 033, SMC 17, CAL 96, DOR 500, KAB 06F2-8-35 and SMC 18) and one local check (Jesca) in multilocation yield trials in different agro-ecologies. Fe and Zn grain analysis were conducted using XRF as the analysis platform. The highest Fe content was recorded on line RWR 2154 with 126.4 ppm and 42.13 (Zn) at SARI. Lines such as KAB06F2-8-36, KAB06F2-8-35, CAL96, RWR2154 and CODMLB 033 recorded high Fe and Zn content in addition to having good agronomic performance and were selected to proceed to the variety release process.

4.2.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- Since project inception, 4479 t of common bean seed has been produced in Tanzania with support from TL III project. Out of these 4479 t, 36.5 t of breeder seed produced so far represents about 152%; 621.1 t of foundation seed represents 83% and 3821.4 t of certified/QDS represents about 34% of what was targeted by the end of the project (Table 4.2.1). Details of how breeder, foundation and certified/QDS were produced by variety over the last 3 years are presented in Table 4.2.2; Table 4.2.3; Table 4.2.4, respectively.
- Among the strategies which will be used to ramp up the production of certified and QDS seed production will be to increase breeder and basic seed production, engage more seed companies (three more have expressed interest) and continue building the capacity QDS producers including rigorous data collection.

The project has also engaged several stakeholders in seed production as shown in Table 4.2.5.

- In 2017, a total of 12 MSPs were established and one training held for 2347 (1166 female and 1181 male) members in addition to 5 district-based MSPs strengthened and 3091 members trained (1633 male and 1458 female) in 2016 and 10 district-based platforms established and 398 members trained (270 male and 128 female) in 2015.
- • Existing high performing (Uyole Njano, Calima, Jesca, Wanja, Lyamungun 90 and 85, Uyole 03 and Uyole 96), new varieties (Uyole 16, Uyole 17 and Selian 14) and allied technologies (fertilizers, Apron Star, appropriate plant population/spacing) were promoted through demonstrations, field days, agri-seed fairs/shows/exhibitions, etc.
- A total of 178 demos were conducted (79 hosted by females and 99 hosted by males) and 4520 farmers visited the demos (1528 female and 2992 male) in addition to the 239 held in 2016 and 58 demos in 2015.
- A total of 51 field days were held in 2017 with 2945 participants (1604 female and 1341 male), in addition to the 9 in 2016 with 591 participants (348 male and 243 female) and 8 in 2015 with 443 participants (360 male and 83 female).
- Five agri-seed fairs/shows/exhibitions were conducted in which 23,657 participants attended (10,595 female and 13,062 male).
- The project had 2 TV and 33 radio program mentions, 1 print media mention; 8340 leaflets were printed and distributed to farmers in the course of 2017.
- Partner seed companies, ASA and few QDS producers sold a total of 86,800 small seed packs of 2 kg (173.6 t equivalent to 28% of seed supplied).
- The seed was marketed through village-based agro-dealers and sold to about 46,390 farmers (21,575 female and 24815 male) through agro-dealers. The average price of seed was USD 1.6 – 1.8 per kg. In 2016, 27,500 SSPs (65 t) of various sizes (0.5, 1.0, 2.0 and 5.0 kg) were sold through village-based agro-dealers to an estimated 25,670 farmers while in 2015, 27 tons were sold through agro-dealers to about 13,708 farmers.
- Preliminary results from adoption and impact studies show that new varieties were grown by 42% of the farmers in the southern region. These varieties are still spreading and gained 3.4% area share between 2013 and 2016, while the percentage of households that grew the varieties increased by 10% in the same period. Impact assessment survey results show that plots cultivated with improved varieties maintained a higher yields (yield difference of 162 to 375 kg/ha) when compared with those planted with non-project varieties. Further, the gender yield gap analysis results show that male managed plots yielded 757 kg/ha compared to 739 kg/ha obtained from female managed plots, but yield difference was not statistically significant.
- There is a strong and growing interest in canning bean varieties (Selian 09 to Selian 13), biofortified bean varieties (Selian 14 and Selian 15) supported by the government to fight malnutrition, specifically iron deficiency.

4.2.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- In year 3 of the project, 2 acres of land were rehabilitated with drip irrigation. The program developed seven product profiles (Tanzania Common Bean Product concept Nov 11 2017): (1). Small white beans tolerance to major foliar diseases with canning quality for industrial processing; (2) medium round yellow beans for import and export market with early maturity and better culinary characteristics; (3) high yielding large yellow bean variety with resistance to major diseases; (4) medium red mottled climbing bean with high Fe and Zn grain content and tolerance to economical diseases v. Large red mottled bean varieties with resistance to foliar diseases; (6) sugar bean varieties with drought and disease tolerance and (7) improved kablanketi bean type with high yield and better market characteristics.

4.3 Common bean crop improvement in Ethiopia

4.3.1 Developing superior high yielding stress tolerant farmer-preferred common bean varieties

- The program undertook three MAS activities: (i) improving resistance to common bacterial blight and validating the SNP-based marker in two advanced populations of 638 individuals; (ii) validating APA markers based on a temperature (Tm)-shift SNP genotyping method for bruchid resistance in 5 populations; to date one Andean population of 322 F_2 individuals (MAZ200 x SCR15) has been genotyped with the Tm shift marker (CB 00253) and 32 plants were found positive; (iii) confirming arcelin marker for 15 lines (candidates for release) and a check (completed national variety trial) and NVT for 16 CBB lines. The result shows that all the Tm shift markers tested work best in the Andean background. CB 00253 gave three different peaks in the different RAZ lines proving not to be useful for MAS.
- An F_2 population of 322 individual seeds (MAZ200 x SCR15) developed for bruchid resistance was evaluated in 2016 and 10% of them found positive for the arcelin SNP marker was advanced to F_3. In 2017, the F_3 population was screened for resistance to bruchid under lab conditions to confirm the results of the SNP genotyping. Sixty five percent of the lines showed resistant reactions to bruchid attack, possibly indicating additional mechanisms to the arcelin gene governing the resistance observed. The population is being field evaluated to assess the agronomic characteristic of the lines. The population has also been prepared for genotyping using 10 SNP markers at the Intertek Lab in New Zealand to enable MAS for different traits.
- A field study was conducted on a set of 52 lines to validate resistance to bean stem maggot (BSM) and characterize their agronomic properties. The lines included, 21 red mottled and 25 sugar beans and 6 introduced lines. It is important to note that by the end of 2017, a new study to identify QTL for drought tolerance in large white and large red population developed from SAB 626, SAB 713, BAT 477, SER 16, and SEA 5 had been initiated.
- Selections from a set of 753 (F_4-F_6) lines from 2015 have since been advanced to multilocation national performance testing. Four nurseries compiled from selections done in 2015 and 2016 (drought, low soil fertility, biofortified, and multiple constraint climbing bean) were evaluated in 2017.
- Forty eight crosses conducted in 2016 targeting drought tolerance on small red, small white, and large white bean pipelines were advanced to F_2/F_3 in 2017. Seventy new F_1 populations targeting improving tolerance to drought in large white and large red speckled beans were developed from SAB 626, SAB 713, BAT 477, SER 16 and SEA 5 in 2017.
- Another set of 150 lines bred for drought tolerance (DAB, DAN, DAD) from CIAT were evaluated and 81 lines were selected based on angular leaf spot and common bacterial blight resistance and seed characteristics in 2017.

- Further, a set of 121 lines from locally developed small white advanced population (G4445/G11239) were field evaluated in 2017 and 75 lines were selected to be advanced to Preliminary National Variety Trial (PNVT). The selection was based on their levels of disease resistance (ALS and CBB specifically), adaptability, seed characteristics and grain yield.
- Segregating populations for bruchid resistance from the RAZ lines were evaluated in 2016 and 19 populations were developed in 2017 for small white and small red beans from which 621 F_2 lines were developed. Besides, 87 F_4 segregating populations developed for bruchid resistance using RAZ and MAZ parents were advanced to F_5.
- Thirty eight fixed lines were evaluated for common bean bacterial blight (CBB) resistance to select potential parents for utilization in crosses to improve CBB resistance in 2015 and 2016. Twenty three F_4 segregating populations from CIAT that had been developed for CBB resistance were advanced to F_5. Thirty fixed ACC lines from CIAT developed for CBB resistance were screened and 12 lines were selected.
- In 2015 and 2016, analysis of Fe and Zn content of biofortified lines previously received from CIAT were evaluated in PYT. Another 2 PNVT each for large white and small white lines were conducted at two and three sites, respectively and 16 lines each were selected for NVT. In 2017, the 16 promising bean lines (NUAs and regional lines) developed for high Fe and Zn grain content were evaluated at 7 locations and promising lines were selected based on productivity, disease resistance, vigor and plant architecture.
- A nursery of 25 lines bred for high Fe seed content at CIAT was evaluated in seven locations during 2015 and 2016 and nutrient profiling of seed done using the HarvestPlus XRF platform in Rubona, Rwanda. Two lines were selected.
- In 2017, preliminary nutrient analysis of breeder seed of 65 varieties (Table 4.3.1) was conducted at Cornell University and the line SAB 632 had the highest Fe level (89.5ppm), followed by Biofort small seeded-15 (81.4 ppm). Others with >75ppm Fe included SCN5, Chore, SARI-1 and DAB107.
- Replicated trials comprising the 65 released varieties (Table 4.3.1) grouped according to market class (31 small beans, 14 medium and 20 large beans) were evaluated at 5 locations and seed harvested from this trial will be nutrient-profiled at Cornell University. In addition, yield and agronomic data collected from these trials will be used to estimate genetic gains made by EIAR over the years.
- Twenty five biofortified lines each of large red and red mottled bean that were evaluated in 2 NVTs at 7 locations and 16 promising lines were selected.
- 4 NVTs conducted at 6 sites for large red mottled, large red, large white and large speckled bean and the best 10 lines selected from each nursery; 9 varieties (small white: Biofort small seeded – 15, red mottled: Biofort large seeded - 5, Yellow: F10 B, sel new Bilfa 58, BZ- 2, DAB-277, SCR-26, DAB 489, MR14 152-43-2P, DAB 96) were released.
- Sixteen candidate lines in each organized by market class; red mottled, large red, large white (two sets) and large speckled were evaluated in seven NVT locations. FPVS in these locations were not conducted due to security concerns.
- Three verification trials (DUS) were conducted at four sites in 2017 though there were changes in the regulations and the trials were not visited by the variety release committee.
- Two pre-national variety trials (PNVT) were conducted. They include one comprising of 137 large seeded beans of white and red market class evaluated at two locations and promising, identified based on productivity, disease resistance, vigor and plant architecture. Another comprising of 76 small white lines was evaluated at two locations and promising lines were identified based on productivity, disease resistance, vigor and plant architecture.

4.3.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- A total of 14,270.2 t of common bean seeds have been produced with the support of the project, which represents 111% of the total target, of which 37.5 t is breeder seed representing 134%, 658.2 t is foundation seed representing 82% and 13,574.5 t is certified/QDS seed representing 113% of the project target (Table 4.3.2). Details of seed production by variety are shown in Table 4.3.3, Table 4.3.4 and Table 4.3.5.
- In 2017, nine MSPs were established and trainings were conducted to build the capacity of 1359 MSP members (198 female and 1161 male). This was in addition to the nine 9 MSPs established and training conducted for 1788 members (1477 male and 311 female) in 2016 and 2 MSPs established and training conducted for 140 members (99 male and 41 female) in 2015.
- The project engaged 20 partners in seed production during 2017 (3 seed companies, 14 farmer cooperative unions, 1 public seed enterprise, 3 public institutions (ARIS, universities) while the partners engaged in the other 2 years are shown in Table 4.3.6.
- The project promotes well performing released varieties (mainly Nassir, Awash 2, SER119 &125 and Hawassa Dume) through demonstrations, field days, agri-seed fairs/shows/exhibitions etc.
- In 2017, a total of 847 demonstration trials of improved bean varieties and complementary technologies (adequate crop density population, crop spacing and fertilizers) were conducted (186 female hosts and 661 male hosts), up from 114 demos established in 2016 in partnership with farmer groups represented by 25 women and 89 men and farmers' cooperative unions and 55 demos hosted by 49 farmer group representatives (32 male and 17 female) and 15 individual farmers (12 male and 3 female) in 2015.
- Twenty field days were held on the demos in which 2424 stakeholders (269 female and 2155 male) participated, up from 17 field days attended by 1923 participants (1685 male and 238 female) in 2016 and the 2 large field days held by NARS and 25 village/community-based field days led by district bureaus of agriculture with 697 participants (629 male and 68 female) in 2015.
- Five agri-seed fairs/shows/exhibitions were held with 6000 attendees (1800 female and 4200 male), up from 4 seed fairs attended by 4000 participants (3600 male and 400 female) in 2016 and 2 agricultural shows with 359 participants (289 male and 60 female) in year 1.
- Nine TV shows and 14 radio programs were aired to promote improved bean technologies, with an estimated 4.5 million listeners, up from 6 TV shows and 6 radio talks with an estimated 3.5 million viewers/listeners in 2016 and 4 TVs shows on bean production, post-harvest management and marketing with an estimated 2.5 million viewers in Oromia region in 2015.

- A total of 6741 promotional materials were produced and distributed to farmers up from 884 bean production guides and 3383 leaflets that were shared with extension service providers, farmers and other value chain actors in 2016 and the 2000 pre- and post-harvest management guides shared with farmers/extension and other value chain actors in 2015.
- A bean thresher, two types of planters and five metal silos were demonstrated in two districts in collaboration with farmer's groups comprising of 120 farmers (87 men and 33 women). Data on farmers' feedback are being collected. However early evaluation indicated farmers interest in the thresher, thus three more threshers were being fabricated (manufactured) by the end of 2017 to expand the demos and test business opportunities.
- Preliminary results of adoption and impact assessment studies show that approximately 37% of the bean fields cultivated in meher 2016 were planted with improved varieties. Improved varieties account for 15% while local varieties occupy 54% of the bean area. The remaining area is planted to varieties that could not be identified by farmers. The results are provisional and are expected to change when all varieties are identified with certainty after DNA analysis.
- The varieties supported under the project account for the biggest area planted with improved varieties in 2016, being 13% of the total national bean area. Varieties released between 2002 and 2010 occupying 7.4% area while those released earlier (i.e. Awash 1, Awash melka and Gobe rasha) account for 5.4% of the total bean area.
- When TLII started in 2007, bean seed systems that was initiated in 2004 was still at its infant stage. The system was still relying on old and poor performing ruling varieties of two major bean types: 1. White pea bean /canning export types were dominated by Mexican 142 (released in 1973) – good canning quality but highly susceptible fungal diseases and degeneration. Through TLII, Mexican 142 was replaced by Awash 1 (1.8-2.1 ton/ha) which was released in 1999. By 2010, Mexican 142 was phased out and Awash 1 took over. In 2013, Awash 2 (white pea bean with excellent performance of 1.9 tons/ha under farmers conditions) was released to replace Awash 1. This variety has been promoted under TLIII. 2. Small red types were dominated by Red Wolaita (released 1980s and susceptible to diseases. However since 2007, Nassir (released in 2003 with 2.0 ton/ha) was promoted and replaced Red Wolaita. In 2008, Hawassa Dume was released with good performance (2.2 ton/ha) but it is now outperformed by SER 119 released in 2013 with higher yield (2.5 tons in farmers' conditions).
- New emerging products (varieties) based on market demands were recently released including: SAB 632 (2.2 ton/ha), sugar types with export market and SAB 736 (2 ton/ha) large white (high yielding and export market). These two newly released varieties are the current focus of foundation seed production and promotion.
- The impact of adopting improved varieties of common beans when estimated for full sample (including non-intervention areas) and a sub-sample (consisting of intervention areas) suggest yield gain of about 336 kg/ha and 562-628kg/ha, respectively - nearly double the gain in the full sample. Female farmers allocated a larger proportion of their bean area to project varieties; they planted about 20% compared to 12.5% area allocated to improved varieties by male farmers.
- The technological progress in form of varietal change, improved agronomic practices have combined to provide positive growth trends in bean productivity in Ethiopia; yield grew from 1.0 ton/ha in 2008 to about 1.7 ton /ha in 2016. Using the survey data, the mean output harvest in Meher 2016 was estimated to 1.5ton/ha. 4.3.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs
- During Year 3. A total of 10 researchers were trained in BMS. All bean trials (18 in total) were designed using BMS and data entry in BMS was initiated. Implementation of the crossing designing using BMS is in progress.
- The Ethiopia common bean crop improvement program developed 6 product concepts (Ethiopia_Common bean product concepts 2017): 1. Large white bean for export market with drought and disease tolerance 2. Large red bean with drought and disease tolerance (75% export; 25% domestic) 3. Small white bean for export market with drought and disease tolerance 4. Small red bean with drought and disease tolerance 5. Large speckled bean for export market with drought and disease tolerance 6. Large red mottled bean with drought and disease tolerance.

5.1 Chickpea crop improvement in Ethiopia

5.1.1 Developing superior high yielding stress tolerant farmer-preferred chickpea varieties

- A total of 44 crosses (Table 5.1.1) were made among 18 selected parents and F_1 seeds collected. In addition, 16 crosses (Table 5.1.1) were made among 9 selected parents (4 extra-large seeded and 5 small to medium seeded with high yield potential) for developing large-seeded high yielding varieties and F_1 seeds were collected.
- Fifteen crosses (Table 5.1.2) were made among 8 selected parents (5 tolerant genotypes and 3 susceptible varieties) on desi and kabuli chickpeas for wilt/root tolerance.
- A total of 36 desi chickpea lines (Table 5.1.3) were evaluated for ascochyta blight, wilt/root rot resistance and other required characters and 7 lines (FLIP-10-77C, FLIP-10-84C, FLIP-10-83C, FLIP-10-246C, FLIP-10-182C, FLIP-10-195C and FLIP-10-116C) selected at Debre Zeyit.
- All the 27 released chickpea varieties (DA-10-4, DZ-10-11, Dubie, Mariye, Worku, Akaki, Arerti, Shasho, Habru, Chefe, Ejere, Teji, Natoli, Minjar, Dalota, Teketaye, Monino (Acos Dubie), Mastewal, Kutaye, Fetenech, Akuri, Kassech, Yelibe, Kobo, Dimtu, Hora and Dhera) were evaluated for resistance to herbicides Imazethapyr and Metribuzin but all were susceptible.
- A trial on sowing and mechanized harvesting was conducted using 2 varieties (Natoli and Dhera). Natoli was machine harvested without a problem. The trial will be repeated in 2018 to validate the results. A motorized locally fabricated thresher is being evaluated.
- A total of 160 lines (Table 5.1.4) received from ICRISAT-India will be evaluated in year 4 of the project.
- A total of 81 FPVs were conducted in 2015, 58 FPVS in 2016 with 537 farmers (407 male and 130 female) and 102 FPVS with a total of 2222 farmers (420 female and 1802 male) in 2017. The varieties included are shown in (Table 5.1.5).
- The most commonly selected varieties included Natoli (11 trials), Habru (9 trials), Ejere (8 trials), Arerti (7 trials), Dalota (5 trials) and Dimtu (5 trials).

- A total of 511 genotypes (Table 5.1.6) were nutrient profiled with special emphasis on protein, iron and zinc, where preliminary results indicated that protein content of lines ranged 13.276- 24.376%.

5.1.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- The project facilitated the production of 10,290.2 t of chickpea seed in Ethiopia which is about 60% of the total seed target, of which 29.5 t (74% of the target) is breeder seed, 1310 t (123% of the target) is foundation seed and 8950.7 t (56% of the target) is certified/QDS seed (Table 5.1.7). Detailed chickpea seed production by variety in Ethiopia are presented in Table 5.1.8; Table 5.1.9; Table 5.1.10. Skills and knowledge of over 100 trainers of MSP members were enhanced in chickpea innovative seed production and gender-considerate marketing in 2017 in addition to the 7 trainings of MSP members in 2016 and 1 in 2015 (Table 5.1.11).
- A total of 3143 small seed packs (2 -25 kg packs) of improved chickpea varieties were distributed to 3143 farmers (641 female and 2502 male) in 2017, up from 1000 small packs distributed each in 2016 and 2015. Details of the distribution of small seed packs in year 3 are shown in Table 5.1.12.
- A total of 949 chickpea demonstrations were set up in 2015 (190 female hosts and 759 male hosts), 679 in 2016 (81 female and 598 male) and 627 (75 female and 552 male) in 2017 using 7 improved chickpea varieties (Table 5.1.13).
- Eight field days were conducted in 2015 with 1136 participants (207 female and 929 male) and 11 varieties (Mastewal, Natoli, Minjar, Dalota, Teketay, Habru, Ejere, Arerti, Kutaye, Kassecha and Akuri); 16 in 2016 with 807 participants (109 female and 698 male) and 7 varieties (Habru, Ejere, Natoli, Dalota, Arerti, Mastewal and Teketay); and 19 in 2017 with 3316 farmers (603 female and 2713 male) and 7 varieties (Habru, Natoli, Teketay, Dalota, Arerti, Mastewal and Ejere).
- Four radio/TV programs were aired in 2015, 6 in 2016 and 4 in 2017. Three agri-fair/shows were conducted in 2016 and 1 in 2017 with 10 varieties (Arerti, Habru, Ejere, Natoli, Monino, Dalota, Teketay, Hora, Dimtu and Dhera).
- Twenty one districts were surveyed in seven zones of the three major chickpea producing regional states; namely, Oromia, Amhara and SNNP. Seventy farmers from each district were interviewed that made a total of 1470 sample farmers. Grain samples from the current produce of the interviewed farmers were collected for DNA fingerprinting to verify the varieties.

5.1.3 Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- A total of 25 chickpea researchers were trained in 2015 (21 male and 4 female) and have been implementing electronic data capture and curation on BMS. All data related to breeding trials, pedigree information, genotyping and phenotyping datasets has been uploaded in BMS. A total of 5 trials are in BMS, i.e., 2 desi trials (1 PVT and 1 NVT) were in BMS in year 2 and 3 trials (2 PVT for desi and kabuli each; 1 desi NVT) were in BMS in 2017. Beside these, chickpea product concept notes have been developed.
- The program has defined 4 product profiles (Ethiopia chickpea product profile 2017): (1) High-yielding export quality, large seed size kabuli chickpea varieties adapted to high potential region; (2) high-yielding desi chickpea varieties adapted to high potential regions; (3) high-yielding kabuli chickpea varieties adapted to moisture stress regions; and (4) high-yielding desi chickpea varieties adapted to moisture stress region.

5.2 Chickpea crop improvement in India

5.2.1 Developing superior high yielding stress tolerant farmer-preferred chickpea varieties

- In 2016, SNP markers for drought and heat tolerance QTLs were identified and validated on a panel of 94 genotypes for their use in early generation selection and by 2017, the NARS partners had started deploying the arrays for genotyping mapping populations and diversity panels.
- A set of 292 RILs (ICCRIL12-001 to ICCRIL12-292) developed from the cross ICC 4567 (heat sensitive) × ICC 15614 (heat tolerant) was evaluated under two heat-stress (late sown) and one non-stress (normal sown) environments. A genetic map spanning 529.11 cM and comprising 271 GBS-based SNP markers was constructed.
- Two consistent genomic regions harbouring four QTLs associated with heat tolerance related traits were identified each on CaLG05 and CaLG06. Four major QTLs for number of filled pods per plot, total number of seeds per plot, grain yield and percent pod setting, located in the CaLG05 genomic region, were found to have cumulative phenotypic variation of above 50%. A total of 25 putative candidate genes for heat stress were identified in the two major genomic regions.
- Following the heat tolerance variety screening and evaluation of varieties for machine harvesting and herbicide tolerance that was conducted in 2016, 54 tall and erect genotypes were evaluated for suitability for machine harvesting in 2017. Twelve lines (IPC 2014-28, IPC 2010-107, IPC 2006-27, IPC 2015-58, IPC 2014-100, IPC 2014-10, IPC 2015-54, IPC 2015-165, IPC 2014-143, IPC 2015-123, IPC 2014-167 and IPC 2015-116) performed well without lodging problem.
- Twenty elite breeding lines (Table 5.2.1) were evaluated for drought tolerance at IIPR Regional Research Station, Phanda by growing under rainfed conditions. Four elite breeding lines (IPC 2007-56, IPC 2015-126, IPC 2014-48 and IPC IPC 2016-44) performed and matured in less than 117 days and these lines are being evaluated at ICAR-IIPR, Kanpur location during 2017-18.
- Seventy six advanced breeding lines were sown under late sown conditions (17 January 2017) for heat tolerance screening from which 14 lines (IPC 2015-112, IPC 2015-185, IPC 2014-112, IPC 2015-19, IPC 2015-147, IPC 2015-149, IPC 2015-151, IPC 2015-153, IPC 2015-95, IPC 2015-120, IPC 2015-196, IPC 2015-37, IPC 2015-183 and IPC 2007-56) showed high level of heat tolerance.
- A total of 227 elite breeding lines i.e. 35 kabuli and 192 desi (Table 5.2.2) were screened for fusarium wilt resistance in wilt sick plot which is predominantly developed for race 2 of the pathogen, and 36 lines (1 desi and 35 kabuli) were highly resistant while 33 lines (24 desi and 9 kabuli) were moderately resistant.
- Six breeding lines (IPCK 2004-29, IPC 2008-69, IPC 2010-134, IPC 2012-98, IPCK 2009-165 and IPC 2008-11) were confirmed to be resistant in a validation screening trial.

- A total of 15 elite kabuli breeding lines (IPCK 15-111, IPCK 15-241, IPCK 15-68, IPCK 12-144, IPCK 15-267, IPCK 15-235, IPCK 10-124, IPCK 09-145, IPCK 15-265, IPCK 15-260, IPCK 15-275, IPCK 10-130, IPCK 11-174, IPCK 09-164 and IPCK 02 and 2 check varieties i.e. IPCK 02-29, IPCK 2004-29 with large seed size of 35 g/100-seed weight) were evaluated for water absorption capacity. In general, extra-large/large seeded kabuli showed more water absorption; hence these will take less time to cook (IPCK 02, IPCK 2009-164, IPCK 2015-267, IPCK 2010-130 and IPCK 2002-29).
- Eight elite breeding lines (desi: IPC 2013-70, IPC 2013-74, IPC 2007-100, IPC 2010-144, IPC 2010-14 and IPC 2014-28; kabuli: IPCK 2009-145 and IPCK 2011-175) contributed by ICAR-IIPR were evaluated in Initial Varietal Trials (IVTs) and 2 breeding lines (IPC 2012-98 and IPC 2011-141) were promoted from IVT to Advance Varietal Trial-1 (AVT-1).
- Thirty six elite breeding lines of chickpea i.e. 18 desi and 18 kabuli (Table 5.2.3) supplied through two International Chickpea Varietal Trials (ICVTs) by ICRISAT-India were evaluated at ICAR-IIPR, Kanpur for yield and yield attributes.
- Thirty PVS were conducted in 2017 (up from 18 in 2016) involving 9 varieties (kabuli: Shubhra and Ujjawal; desi: JG 14, RVG 202, JG 16, IPC 2005-62, IPC 2006-77, IPC 2004-98 and IPC 2004-1) and preliminary results indicated farmer preference for RVG 202, IPC 2006-77 and JG 14 in desi type and Shubhra in kabuli type. Finally, protein content was assessed for 98 chickpea varieties/lines (Table 5.2.4).

5.2.2 Strengthening seed production and delivery systems for improved varieties and practices for enhanced awareness, adoption and impact to small-holders, especially underserved women farmers

- The project established 2 MSPs in 2017 in addition to the 2 established in 2016 (Table 5.2.5) and conducted 5 trainings for MSP members in addition to the 5 in 2016.
- The final quantities of seed produced were not compiled by the time this report was put together, but it is expected to be ready by late August 2018. Tentatively, the expected quantities are 20 t of breeder seed, 110 t of foundation seed and 600 t of certified/TLS.
- If the expected 2017 production is met, then the project will have supported production of 914.42 t of chickpea seed in India in the last 3 years and this will be about 149% of the total target in the country, of which 55.04 t (413% of target) is breeder seed, 134.29 t (134% of target) is foundation seed and 725.09 t (145% of target) is certified/TLS (Table 5.2.6). Details on seed production by variety are shown in Table 5.2.7, Table 5.2.8 and Table 5.2.9.
- Further, a total of 30 FPVS were conducted on 9 varieties (kabuli: Shubhra and Ujjawal; desi: JG 14, RVG 202, JG 16, IPC 2005-62, IPC 2006-77, IPC 2004-98 and IPC 2004-1) in three districts covering 8 villages. Preliminary results indicate farmer preference for RVG 202, IPC 2006-77 and JG 14 in desi type and Shubhra in kabuli type.
- A total of 263 small seed packs (desi: 6 kg; kabuli: 8 kg) were distributed to farmers (248 male and 15 female) compared to 150 in 2015 and 170 in 2016 (166 male and 4 female). A total of 58 progressive farmers (58 male) were trained on quality seed production.
- Seventy demonstrations (4 female and 66 male) on farmer-preferred high yielding varieties (kabuli: Shubhra and Ujjawal; desi: RVG 203, JG 14 and JG 16) were conducted in 3 districts in 2017, up from the 30 in 2015 (30 male) and 33 in 2016 (3 female and 30 male).
- A field day was organized in which 101 farmers (101 men) participated in 2017 in addition to the 3 conducted in 2015 with 89 participants (89 male) and 1 in 2016 with 128 participants (3 female and 125 male). A special on-farm training for 50 women farmers was successfully conducted.
- Three TV programs that promoted project technologies were aired i.e. the *Vichar Vimarsh* on pulses including chickpea in addition to the 3 media mentions in 2015 (2 radio and 1 TV) and 4 TV mentions in 2016.
- Similarly, an agri-fair was organized in 2017 in which about 737 farmers attended (55 female and 682 male) compared to 2 that were conducted in year 1 and 1 in year 2 with participation of 2000 farmers (2000 male).
- A total of 300 copies of flyers/folders on chickpea seed production, marketing and business were distributed. Two articles on chickpea were published in year 3 of the project i.e. “Increasing pulses production in India” was published in Kurukshetra - A journal of Rural Development (Sandhu and Chaturvedi 2018; Kurukshetra Feb 2018, pp 54-59) i.e. Table 5.2.10. Another article on “An Overview of Chickpea Research: From Discovery to Delivery” was published in Pulse India (Thudi et al. 2017, Pulse India 2:22-25) published by Indian Pulses and Grain Association of India.

○ Strengthening legume breeding and delivery capacity of the partner CGIAR and NARS programs

- By the end of year 3, the detailed self-assessment report based on the Breeding Program Assessment Tool (BPAT) for chickpea program in India (Chickpea) was ready and implementation of the recommendations from the reports was rolled out. The chickpea breeding program of ICRISAT-India had fully implemented recommendations of the BPAT team by the end of 2017. These included (1) development of Product Concepts Notes (India Chickpea India product concept 2017) (2) early generation testing of breeding materials; (3) modified strategies for advancement of generations by taking one branch from each selected plant to have representation of all selected plants in the next generation; (4) started using P-rep experimental design in place of augmented design; (5) use of barcoded labels in all trials and nurseries, collected data using handheld tablets and entered data in BMS.
- By the end of 2017, the chickpea breeding program at ICRISAT-India had entered all trials and nurseries in BMS for the past two years, i.e. in 2016, a total of 90 trials and 52 nurseries were entered into BMS while in 2017, a total of 36 trials and 56 nurseries were entered. All experimental labels are barcoded and handheld tablets are being used for electronic data capture.
- Training programs were organized for the scientists of ICAR-IIPR, other ICAR institutes and Agricultural Universities for using BMS and digital data collection. Two trainees attended the training in 2016 on BMS. Similarly, 6 scientists in 2017 attended a training on BMS whereas one lecture on BMS was conducted by ICRISAT involving 23 scientists (20 male and 3 female).
- The Indian NARS developed and are implementing product profiles (India Chickpea India product concept 2017) including: machine harvestable varieties of both, desi and kabuli, chickpea and heat tolerant and early maturing varieties of desi chickpea.

- In collaboration with other projects, TL III contributed to developing a high density Axiom® CicerSNP Array with > 56K SNP markers that is now available to the chickpea research community for deployment in chickpea crop improvement (Plant Biotechnology Journal 2018; 16:890-901).
- In collaboration with NARS partners and supplementation of funds from TL III, molecular breeding lines with enhanced resistance to fusarium wilt (Super Annigeri 1 and JG 74) and ascochyta blight (Improved C 214) have been developed.
- Four major QTLs have been mapped for heat tolerance mapped on chromosome 5 explaining a cumulative phenotypic variation of 50% using recombinant inbred lines (RILs) developed from the cross ICC 4567 (heat sensitive) × ICC 15614 (heat tolerant).
- In collaboration with some other projects, TL III contributed to the construction of a high density genetic map with >9K markers using the MAGIC populations. MAGIC population were phenotyped for drought tolerance related traits for two seasons.

6.0 PROJECT MANAGEMENT COORDINATION

- The project has revised the MLE framework, indicators and MLE data collection tools developed in 2016 and used it for planning, monitoring, planning, evaluation, accountability, learning and implementation in 2017. The project is also in the process of training and rolling out a digital MLE tool (http://measure.icrisat.org) that will enable real time data collection in the field, aggregation and reporting. The Digital MLE is linked to the BMS for data curation and archiving.
- For monitoring purposes, the coordinator visited all the eight countries for at least 1 week, working with partners in refining their workplan, rolling out their program improvement plans, and implementing their product profiles as defined in the 2017 Annual Review and Planning Meeting.
- The project made adjustments in staffing of objective 1 which had been lagging behind in terms of implementation of the gender component of the project. Dr Esther Njuguna took over as the lead for gender activities in ESA supported by Dr Edward Bikketi, a post-doc. Dr Jummai Yila took the same role in WCA, supported by Dr Lilian Nkengla, also a post-doc as was the arrangement under CRP-Grain Legumes.
- TL III developed the digital seed catalogue (http://seedsystems.icrisat.org) linked to a seed production planning and adoption roadmap (http://seedroadmap.icrisat.org) and launched the tool at the Annual Review and Planning Meeting in Uganda. The presentation of the tool elicited interest among several non-project partners, particularly those running USAID Seed Scaling projects from ICARDA (Zewdie Bishaw), IITA (Simon Ncho) and ISSD (Amsalu Ayana), all of whom have asked for log-in credentials and are currently implementing it on their projects. National programs are also using it beyond the confines of TL III.
- The Project Advisor, Dr Emmanuel Monyo, was specifically tasked to follow up on the NARS BPAT self-assessment made during the TL III Annual Planning Meeting held at Patancheru, India on 26-27 Feb 2017 to firm up the findings and recommendations (Monyo.Country Breeding Program Assessments-final), and also to work out program improvement plans (Monyo. Country Progress on PIP's Details-final).
- Besides, all CGIAR programs were assessed externally and are currently working on the recommendations from these assessments. Key highlights on each program are already mentioned in section three above “Strengthening Legume Breeding and Delivery Capacity of the Partner CGIAR and NARS programs”. Some program improvement approaches have been reported by the cowpea breeding program (IITA Nigeria PIP) and CIAT common bean breeding program (CIAT Uganda breeding program).
- The TL III Annual Review and Planning Meeting was held in Kampala, Uganda from 3-7 April 2018, jointly with HOPE II Project (TLIII_HOPEII_Review_and_Planning_Workshop_Uganda_April_2018_documentation_20-04-2018) to (i) review the progress of the two projects and prioritize activities for the year 2018, (ii) review project planning, monitoring, evaluation, accountability and learning and reporting approaches including digital data collection and seed roadmap and; (iii) evaluate and analyze the speed, efficiency and quality of outputs of the partner breeding programs for enhanced genetic gains. During the workshop, partners gave highlights of TL III progress by different country, 15 legume crop improvement programs in terms of breeding pipelines, seed delivery, women inclusion and improvement in livelihood of the beneficiaries. The digital planning, monitoring, evaluation, accountability and learning (PMEAL) and digital seed roadmap tools were launched for real time data collection. The meeting was attended by about 170 participants from the different focus countries and representatives of sister projects.
- Produced four project Quarterly bulletins highlighting project successes during the past year; http://tropicallegumes.icrisat.org/wp-content/uploads/2017/03/TL-III-Bulletin-8_Final.pdf; http://tropicallegumes.icrisat.org/wp-content/uploads/2015/12/TL-III-Bulletin-9.pdf; http://tropicallegumes.icrisat.org/wp-content/uploads/2017/12/TL-III-Bulletin-10.pdf; http://tropicallegumes.icrisat.org/wp-content/uploads/2018/05/TL-III-Bulletin-11_Final.pdf
- A total of 25 articles (TL III Voices & Lessons_Featured Stories) were disseminated through the ‘ICRISAT Happenings’ newsletter and TL III website between 1 May 2017 and 30 May 2018, as compared to 13 articles during year 2. The details are available on the TL III website: http://tropicallegumes.icrisat.org/newsblogs/.
- Project outputs were disseminated through a total of 18 abstracts which were submitted in IFLRC VII conference held in Morocco, some of which are available on: http://www.iflrc.org/wp-content/uploads/2018/05/IFLRC-VII-2018-Conference-program-and-abstract-book.pdf
- A training manual on “Seed Business Management in the Context of Smallholder Farmers” was published and is accessible at http://tropicallegumes.icrisat.org/wp-content/uploads/2016/10/TL-III_Seed-Business-Management-in-the-Context-of-Smallholder-Farmers.pdf
- TL III’s presence on social media platforms has shown an overall reach of more than 2,151,837 (Facebook: 1,884,467 and Twitter: 2, 67,370) people virtually since December 2015. These platforms have facilitated knowledge sharing and dissemination of project outputs and outcomes across a larger audience.

- TL III has used several social media platforms over 3 years of its implementation, to serve as vehicles of information dissemination: Facebook (885 followers), Twitter (579 followers), Slideshare (94 presentations with 13,716+ views), and Flickr (646 photos).
- TL III website (http://tropicallegumes.icrisat.org/) has witnessed more than 213,096 hits (number of visitors) from 175+ countries since last year.
- The program has facilitated most of the programs to acquire tough pads, barcode printers, scanners, and printing ribbons (labels)

Country	Tough pads	Barcode printer	Ribbons
Tanzania	3	1	20000
Ethiopia	5	1	50000
Ghana	1	1	20000
Mali	1	1	20000
Nigeria	1	1	20000
Uganda	3	1	20000
Burkina Faso (INERA)	1	1	20000

- Before the annual TL III meeting in Kampala, Uganda, each national program (except India) held its country meetings at different times at the beginning of 2018 to review country progress and to develop new workplans responding to the objective targets agreed for 2018. A total of 14 annual meetings were held.

CHALLENGES

Ongoing insecurity and/or instability in some of our target countries (Northern Nigeria, Ethiopia, Burkina Faso and Mali) remain an issue of concern. There was delayed implementation of BMS in Ethiopia because of advice by MERCI project technical advisors from University of Queensland to give the country time to decide the database to use. There are procurement challenges with NARS partners. It normally takes too long to make purchases. We overcome this by procuring equipment for the NARS and back-charging their budgets where they consent. In some instances, there are challenges in sending funds to regional centers (e.g. Ethiopia) or to purchase flight tickets (e.g. India) to the extent that the respective CG partner bails them out and requests deduction at the time of sending the funds to the NARS. This may call for a rethink on resource allocation to some partners.