TROPICAL LEGUMES III

Bulletin of Tropical Legumes

07
2016

About the bulletin

The Bulletin of Tropical Legumes is a quarterly publication of the Tropical Legumes III (TL III) project. The project is funded by the Bill & Melinda Gates Foundation (BMGF), and jointly implemented by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Center for Tropical Agriculture (CIAT), and the International Institute of Tropical Agriculture (IITA) in close collaboration with the national agricultural research systems (NARS) of target countries in sub-Saharan Africa and South Asia.

This quarter we will focus on the progress made under objective four: enhancing common bean productivity and production in focus geographies of sub-Saharan Africa, during year one of phase III implementation.

Introduction

Objective four of the TL III project aims to enhance the productivity and production of common bean through improving efficiency and effectiveness of the national common bean breeding programs of the countries involved (Ethiopia, Tanzania and Uganda). The NARS implementing this objective are: Melkassa Agricultural Research Center (MARC), Ethiopia, National Crops Resources Research Institute (NaCRRI), Uganda, Selian Agricultural Research Institute (SARI), Uyole Agricultural Research Institute (ARI-Uyole) and Maruku Agricultural Research Institute (MARI) in Tanzania and the CIAT bean program.

The expected intermediate results for the TL III breeding objectives include: (i) Trait discovery that involves improving the understanding of genetic mechanisms governing key constraints and utilizing molecular technology to improve the efficiency of selection, (ii) Breeding pipeline: NARS partners using improved breeding lines for developing better varieties, (iii) Testing for release: NARS partners regularly releasing superior cultivars, (iv) Best bet varieties: farmers using improved cultivars, integrated crop management (ICM) practices and realizing higher yields, (v) Enhanced genetic gain of CGIAR African hubs and partners that focus on breeding program improvement.

Ethiopia is the largest exporter of white pea bean in Africa, earning the country over US$100 million (2014). The crop is widely grown across the country covering approximately 350,000 ha with the highest concentrations being found in Oromia. The total production of common bean in the country was estimated at 362,890 tons and yield at 1.487 tons per ha in 2010. While Ethiopia is the largest exporter of white pea bean, Tanzania on the other hand is the largest producer and exporter of common bean in sub-Saharan Africa and the 7th worldwide. About 1.25 million hectares of common bean are planted per year, with the main production areas being: Arusha region (northern zone), the great lakes region (west zone) and the Southern Highlands. The total yearly production is approximately 933,000 tons. Although the area under bean production in Tanzania has been increasing at an average rate of 11% per annum over the last decade, yield growth rates have been modest in absolute terms increasing from 0.48 tons per ha in 1970 to 0.77 tons in 2001-2007 (Katungi et al. 2010) and currently at 0.9 tons per ha (FAO 2015). Uganda is second after Tanzania in common bean production volumes in the East African region, with production estimated at 876,576 tons. Between 2001 and 2010, area under common bean production increased by 28.7%, but resulting in 7.7% increase in bean supply as yield stagnated due to a range of biophysical constraints (soil fertility,

Quality declared bean seed field in Njombe-Southern Tanzania.

Project: Tropical Legumes III (TL III)

This work has been undertaken as part of the CGIAR RESEARCH PROGRAM ON Grain Legumes

Investor: Bill & Melinda Gates Foundation

Partners: CIAT 45, ICRISAT, IITA

drought, pests and diseases are the most important (Kimani et al. 2006)).

This bulletin is dedicated to objective four: 'common bean achievements' in the first year of the project (2015-2016).

Capacity building initiatives for common bean breeders

This is being addressed through targeting the key production constraints to ensure that there is continuous flow of superior breeding material and release of farmer and market demanded varieties while also enhancing the capacity of the breeders to be able to face the challenge.

Though all the CIAT supported national breeding programs in Africa are using market-led breeding strategy guides there has been no formal training on market-led breeding and, in fact, no curriculum is in place for this important aspect of breeding. The project 'demand-led plant variety design', an innovative breeding approach supported by the Syngenta Foundation for Sustainable Agriculture (SFSA), the Australian aid agencies (Australian International Food Security Research Centre of the Australian International Agricultural Research Centre (AIFSRC/ACIAR) and the Crawford Fund), various universities in Africa, BeCA and CIAT, developed a demand-led plant variety course that is suitable for inclusion in post graduate training programs and is a very useful resource for professional breeders. The TL III project, in collaboration with the 'demand-led plant variety design' project, supported a two-day training to cover the principles of demand-led breeding (DLB). The training was attended by 20 common bean scientists drawn from 15 countries across the three networks of Pan-Africa Bean Research Alliance (PABRA) (www.pabra-africa.org/), including Ethiopia, Tanzania and Uganda. The training included: (i) Principles of demand-led plant variety design, (ii) visioning and foresight for setting breeding goals, (iii) Understanding clients' needs, (iv) Variety design and product profiling, (v) Variety development strategy, stage plan, timelines and variety registration, vi) Investment decisions in variety development and vii) Monitoring, evaluation and learning (MEL).

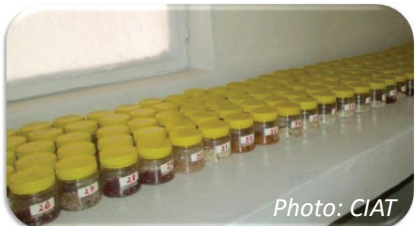
Group discussion during DLB training.

PABRA breeding working group meeting participants.

In addition, a two-day PABRA breeder's workshop involving 33 bean breeders from 17 countries including Ethiopia, Tanzania and Uganda was conducted in Nairobi (16 - 17 December 2015). The workshop discussed experiences and updates on four key themes: i) Progress in breeding for specific traits (pest resistance: bean stem maggot (BSM) and bruchids; biofortification (iron and zinc grain content), tolerance to abiotic stress, drought and low soil fertility; and disease resistance (angular leaf spot, anthracnose, common bacterial blight and bean root rot), ii) Review of the utilization of the breeding data management (breeding management system), iii) Regional nurseries and germplasm exchange, and iv) Variety release systems (utilization of current variety release policies and their implications to Southern African Development Community (SADC), Economic Community of West African States (ECOWAS), Common Market for Eastern and Southern Africa (COMESA) and East African Community (EAC)).

Phenotyping platforms for key common bean traits

Bruchid resistance: Bruchids (*Ancanthoscelides obtectus* and *Zabrotes subfasciatus*) are major post-harvest pests of beans. Though reports of economic damage vary, weevil damage in the warehouses may result in as much as a 48% reduction in quality and quantity (Slumpa & Ampofo 1991) and 5-20% seed weight loss. Bean seeds have been reported to sometimes turn into hollow shells filled with powdered cotyledon and insect frass due to bruchid attack (Schoonhoven et al. 1983; Schoonhoven & Cardona 1986). Other important losses include nutrition quality loss due to protein and carbohydrate degradation, low market value of edible bean seeds and eventually loss of seed viability (Kusolwa 2008). Both bruchid species are widely distributed in Africa, due to warm temperatures that favor the development of *Z. subfasciatus* and high altitudes with a cooler tropical climate coinciding with harvest time favoring growth of *A. obtectus* (Kusolwa 2008).



Bruchid rearing and screening at EIAR-Melkassa.

Ancanthoscelides obtectus is the most prevalent species in the bean producing regions of Uganda and Tanzania (Misangu 1997) while *Z. subfasciatus* are the major problem for the navy bean farmers, bulkers and exporters in Ethiopia (Negasi 1994).

Efforts to identify sources of resistance and understand the mechanisms of resistance have progressed faster for *Z. subfasciatus* compared to *A. obtectus*. Antibiosis expressed as adverse effects of seed protein 'arcelin' in extending the time of adult emergence, growth and lifecycle of bruchids in wild bean accessions has been exploited in developing bruchid-resistant common bean germplasm.

A nursery of 100 lines (MAZ) with arcelin based resistance has been developed by CIAT and field evaluated in Ethiopia and Uganda. Molecular markers tagging this resistance have also been developed. To further improve molecular markers for *Z. subfasciatus* resistance, 150 genotypes were evaluated at CIAT headquarter which were largely MAZ lines and recent breeding lines. Several SNP based molecular markers around the arcelin locus have been developed to identify best linked markers that can be broadly used in breeding.

Lack of an effective resistance screening protocol is a challenge that is slowing the progress with *A. obtectus*. NaCRRI Uganda and Melkassa Agricultural Research Center (MARC)-Ethiopia, initiated activities to develop a validated protocol for the two species using a laboratory based 'no choice' method.

Previously identified resistance lines were challenged due to bruchid infestation with Uganda targeting both bruchid species and Ethiopia targeting only *Z. subfasciatus*. Data was collected on initial grain weight (IGW), final grain weight (FGW), percentage weight loss, bruchid progeny emergence (F1), median development period (MDP) and Dobie susceptibility index (DSI). The screening method resulted in consistent ranking of test lines according to the measured parameters. In Uganda, the method revealed differences in the reaction to the two bruchid species implying possible differences in the genetic mechanisms governing resistance to the two species.

Five lines: Tapara, KK25/Maluwa/184-mw, KK25/ Maluwa/19-mw, Maluwa//KK25/443-mw, Maluwa/ KK25/ 9-mw, showed good levels of resistance in Uganda and seven lines: RAZ-11, RAZ-36, RAZ-2, RAZ-44, RAZ-120, RAZ-40 and MAZ-203 showed consistent complete resistance to *Z. subfasciatus* in Ethiopia.

Cooking time platform

Mattson cooker at CIAT-Kawanda.

Short cooking time has been identified as a major trait demanded by consumers to save on time and energy required for cooking. Breeders have hence prioritized the assessment of cooking time in all breeding pipe lines. Two automated Matson cookers were acquired by the CIAT regional bean program in Uganda to phenotype cooking time of developed breeding lines. A Matson cooker is a stand-alone machine monitored by a computer and the test results are automatically recorded on the computer. Cooking time is calculated when 80% of the beans are soft enough to be pierced through by pins. This is an equivalent of when 20 of the 25 pins in the cooker have penetrated the seeds. To date the cookers have been utilized to assess cooking time of a set of 150 released bean varieties in the PABRA. Cooking time ranges of 28-100 minutes have been obtained. Similar systems have been purchased for installation at three participating national programs (MARC, NaCRRI and ARI-Uyole).

As a further development of the semi-automated cooker a thermometer has been integrated to capture temperature data during cooking process. This will help to standardize different types of cookers and electric supply variations.

Breeding pipelines and testing for release

This component seeks to develop: drought, low P, N tolerant, high mineral content lines, heat and drought tolerant lines, and insect pest and disease resistant lines breeding pipelines for Ethiopia, Uganda and Tanzania.

At CIAT, the elite common bean nursery - vivero elite de fijol (VEF) panel that consists of elite breeding lines was evaluated in the second drought season of 2015

Bean pollination at EIAR-Melkassa.

and sown again in Palmira site for drought evaluation. In addition the VEF panel is being evaluated for iron (Fe) and zinc (Zn) levels for biofortification. Lines with repeated best performance were chosen as parents for new crosses.

New crosses with elite parent for high Fe, drought resistant, and virus resistant are now being developed. F1 seed of double crosses for marker assisted stacking of Angular Leaf Spot (ALS) disease resistance loci have been harvested and will be genotyped. Two new molecular markers linked to the 'I' gene tagging resistance to Bean Common Mosaic Virus (BCMV) disease have been developed. Phenotyping and genotyping of the VEF panel is in process to identify most robust and best linked markers.

Crosses of Andean bush types with heat tolerant sources from the Mesoamerican and Andean background have been advanced and are now sown in Alvarado, a newly established heat evaluation site in Colombia. Lines previously selected for grain quality and agronomic properties are to be selected under heat stress for the first time.

Selection from segregating populations is conducted on developed populations based on yield performance, maturity time, growth habit, seed size, color, tolerance/ resistance to occurring biotic and abiotic stresses. New nurseries received from CIAT, Michigan State University and other PABRA member countries were evaluated in the three countries both on-station and on-farm in multiple locations.

Preliminary and advanced yield trials (PYT and AYT) were conducted across the three partner countries. For example, a nursery comprising of 20 promising lines was evaluated in seven on-station locations in Uganda. The average yield performance across the sites was 1201 -1980 kg per hectare. One line, KBRL10 was the highest yielder across the sites. Ten promising drought tolerant bean lines: SCN 1, SCN 11, SCR 26, SCR 48, SEN 56, SEN 70, SEN 80 SEN 95, SEN 98 and SEN 99 were evaluated in nine agro-ecologies that are prone to drought in Uganda. Three of these lines: SCN1, SCN11 and SCR 26 were best in terms of yield performance and were selected for possible release. ARI-Uyole field evaluated four lines: HM-2PN302, HM-2PN102, HMPN306, and HM 212 developed under Fe and Zn improvement program at three locations. The line HM 212 proved superior and is targeted for release. The line has orange color, medium large seeds and good seed quality.

During the evaluation process, emphasis was put on the involvement of farmers in the selection process (farmer participatory variety selection - FPVS) to ensure that selected varieties possess the preferred consumer and market traits.

In Tanzania, three FPVS trials were conducted for bush lines at Dareda, Bashnet and Karatu with a total of 46 farmers of which 17 were female. The criteria for selection included: high yield, marketability, culinary characteristics, tolerance/resistance to pests and diseases, early maturity and drought tolerance. Two of the best bean lines (KATB1 and KATB9) were selected based on the above criteria. These selected lines are already released in other East African countries namely: Burundi, Kenya and Ethiopia, therefore Tanzania will closely follow up to fast track their release based on EAC or SADC regional trade agreements.

Tanzania bean research program receives training on general common bean breeding principles and variety release process

During April, 2016 the Tanzania Bean Research Program benefited from two trainings; i) Breeding principles and practices and ii) Variety release process. The trainings were conducted at Selian Agricultural Research Institute (SARI) in Arusha, Tanzania.

The breeding principles and practices training was attended by 14 bean research teams (researchers (5 male and 3 female) and technicians (3 male and 3 female)) from ARI-Selian, Sokoine University of Agriculture and ARI-Maruku. It was facilitated by Dr Catherine Madata from ARI-Uyole. The training covered: (i) Principles and objectives of plant breeding, (ii) mode of inheritance, (iii) identification of traits based on breeder objectives and market demand, and (iv) breeding process (parent selection, crossing techniques, breeding methods and the two centers of origin/genepools and their implication to breeding of common bean). Thereafter all participants were involved in a practical pollination exercise under supervision by the facilitator. More than 100 crosses aimed at introgressing angular leaf spot and anthracnose resistance into highly adaptable and marketable bean varieties, were developed.

The second training 'variety release process' was attended by 33 researchers (24 male and 9 female) from six research institutions: ARI-Naliendele, ARI-Maruku, ARI-Selian, ARI-Uyole, CIAT Tanzania, and Sokoine University of Agriculture (SUA). The aim of the training was to expose young plant breeders to policies governing variety release as well as the guidelines needed to be followed in order to release a new variety. The training was facilitated by the Ministry of Agriculture, Livestock and Fisheries and Tanzania Official Seed Certification Institute (TOSCI - body responsible for variety release in Tanzania). This was the first training focusing on legume crops in Tanzania. Jean Claude Rubyogo (TLIII objective 6 leader) and Emmanuel Monyo (TLIII project coordinator), were

Trainees practicing crossing of beans under supervision of Dr Catherine Madata.

Participants practicing developing variety descriptors under the supervision of facilitators from the Ministry of Agriculture and TOSCI.

present during the trainings. The training covered topics such as: (i) Distinctness, Uniformity and Stability (DUS) testing and characteristics, (ii) development of variety descriptors for DUS, (iii) highlights on use of FPVS to fast track release of varieties for TLIII target countries, (iv) seed quality control, (v) variety release and registration process, (vi) application of Marker Assisted Selection (MAS) in breeding, (vii) seed legislation (seeds act and seed regulations), and (viii) seed trade harmonization acts such as the EAC and SADC regional trade agreements. These acts facilitate safe movement of seeds within member countries in a transparent manner, encourage investment in seed business, and increase access to existing varieties in the member countries. They also stimulate the breeding and availability of improved seed varieties resulting in increased variety choices by all stakeholders.

Researchers, particularly breeders gained new information on how to fast track varieties using the seed harmonization protocols across our regions. All training materials were shared with all participants.

Release of biofortified bean varieties in Uganda

According to the Uganda Demographic and Health report 2006, nearly 38% of Ugandan children below 5 years are stunted, 6% are wasted (thin for their height) and 16% are underweight. This puts Uganda among the few countries with the highest malnutrition rates. These persistent high rates of malnutrition in children are symptomatic of the larger problems of inadequate access to food and suboptimal infant feeding practices leading to poor health. Malnutrition plays a major role in child morbidity and mortality. Micronutrient deficiencies like iron and zinc are a major component of child malnutrition and various health complications in especially expectant mothers and other adults.

The development and eventual utilization of crops biofortified with increased levels of micronutrients would be one strategy to overcome malnutrition caused by micronutrient deficiencies. As a way of finding remedies for micronutrient malnutrition, the Uganda National Beans through: the PABRA, the National Agricultural Research Organization (NARO) together with partners including HarvestPlus, CIAT, USAID Feed the Future and TL III, tested regional iron rich varieties (comprising of varieties already released in Democratic

Mr Sembatya of Kasanda village in Mubende district, Uganda examining the pod load of NAROBEAN 1 (RWR 2154) during on-farm evaluation trials.

Farmers preparing and conducting organoleptic tests to identify suitable bean varieties for home consumption needs in Uganda.

Republic of the Congo and Rwanda) and released the first high iron and zinc bean varieties which include three bush and two climber growth types on 22 July, 2016. The TLIII project in particular played a great role in supporting the participatory variety selection process and variety demonstration trials.

During the development, a set of 16 moderately high iron (>70ppmg) and zinc (>30 ppm) containing bean varieties including bush lines: HM 21-7, MORE 88002, RWR 10, RWR 2154, RWR 2245, CODMLB 001, DO 500, MIB 456, KAB06 F2.8-12 and climbers lines: Icyana 2, Kivuzo, MAC 44, Nyiramuhondo, RWV 3006, RWV 2361, Garukurare, NGWN x CAD 2/2/3/1/1, were evaluated in six agro-ecologies in Uganda encompassing the central, southern, southwestern, east, northern and western regions. The evaluation included assessing yield potential, ability to accumulate iron and zinc micronutrient and farmers preferences for both production and organoleptic properties. After these evaluations, applications for variety release were made for five varieties that fulfilled all the test requirements. These were three bush (MOORE 88002, RWR 2154 & RWR 2245) and two climb (MAC 44 & Nyiramuhondo) varieties. On the 22 of July 2016 these varieties were accepted to be released as new bean varieties in Uganda under the NAROBEAN name series (see Table 1).

"The varieties, also known as NAROBEAN 1, 2, 3 4C and 5C, are an excellent source of iron. Instead of buying expensive supplements, communities can now buy and grow these beans as a way of boosting nutrition and reducing anemia– (a major health concern in Uganda) knowing that they will get yield despite drought," said Dr Stanley Nkalubo, breeder and leader of legumes research program at the National Crops Resources Research Institute (NaCRRI). Dr Stanley Nkalubo evaluated and effected the release of these varieties.

The new biofortified bean varieties are expected to provide a cheap source of micronutrient nourishment and improve health and livelihood of the most vulnerable group, through growing and consumption of these new bean varieties. These varieties will be promoted under objective 6 of the project.

Field demonstrations of common bean varieties

Demonstrations were conducted in all three participating countries. In Ethiopia, over 120 demonstration trials were planted but 50% of those were destroyed by drought and were not visited. These demonstrations had been conducted in collaboration with N2 Africa, SIMLESA, Haramaya University, Ministry of Agriculture, regional and federal research centers in Areka, Sirinka, Pawi, Yabello, Pawi, Adet, and Bako. Over 720 individuals (20% female) mainly farmers and agents from the Ministry of Agriculture and experts visited the successful fields.

In the northern zone of Tanzania, the TLIII and SSTP projects conducted 14 and 32 demonstrations respectively in Karatu, Babati, Mbulu and Hanang districts. A total of 652 stakeholders (376 male and 276 female) categorized into farmers, seed companies, agro dealers, and extension officers participated. Bean varieties that were demonstrated included; JESCA, Selian 94, Selian 97, Selian 05, Selian 06, Cheupe, Njano-Uyole, Lyamungu 85 and Lyamungu 90. In the South of the Tanzania, 20 demonstrations were conducted in pilot sites for the newly released varieties, insect-pest, fertilizer options and weed control. Among the tested technologies was the use of bean clean herbicide that proved to perform better than other options. In the case of fertilizer, a combination of triple superphosphate (TSP) and calcium ammonium nitrate (CAN) followed by diammonium phosphate (DAP) performed better than other options.

Table 1. Newly released biofortified bean varieties with corresponding attributes.

RWR 2154/NAROBEAN 1  Photo: CIAT	• Bush • Large seeded • Iron: 65.8-72 ppm • Zinc: 31.4-34.2ppm • Yield potential:1500-2000 kg/ha • Maturity: 60-68 days • Best suited for low-mid altitude area
RWR 2245/NAROBEAN 2  Photo: CIAT	• Bush • Medium seeded • Iron: 66.1-72 ppm • Zinc: 32.5-36.2ppm • Yield potential: 1600-2200 kg/ha • Maturity: 58-68 days • Best suited for low-mid altitude area
MOORE 88002/NAROBEAN 3  Photo: CIAT	• Bush • Medium seeded • Iron: 65.4-69ppm • Zinc: 35-38ppm • Yield potential: 1500-2000 kg/ha • Maturity: 58-68 days • Best suited for low-mid altitude area
MAC44/NAROBEAN 4C  Photo: Stanley Nkalubo	• Climber • Large seeded • Iron: 77.4-83ppm • Zinc: 32.1ppm • Yield potential: 2500-3700 kg/ha • Maturity: 82-88 days • Best suited for Mid-high altitude area
NYIRAMUHONDO/NAROBEAN 5C  Photo: CIAT	• Climber • Large seeded • Iron: 72.2-80ppm • Zinc: 34.7ppm • Yield potential: 2500-3300 kg/ha • Maturity:88-96 days • Best suited for mid-high altitude area

Field day in Karatu/Mbulu (Northern Tanzania).

In collaboration with N2 Africa, 40 demonstration trials were established in South Western Uganda (Kisoro, Kanungu and Kabale) and Kapchorwa in Eastern Uganda to show case newly released bean varieties: NABE 12C, NABE 26C, NABE 15, NABE 16 and NABE 19 in combination with proper agronomic practices. The demonstration and accompanying field days were able to reach 346 famers of whom 218 (63%) were women.

Field days were held to promote the technology of using improved bean seeds and fertilizer increasing common bean productivity. Specifically, four field days were held at Babati, Karatu, Hanang and Mbulu districts where 174 male and 99 female farmers participated. In addition 56 primary school students and two representatives from agro-dealers participated. The events were broadcasted on Independent Television (ITV) that reaches more than 1.5 million people across Tanzania.

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OBITUARY


Photo: IITA

Issa Drabo, PhD, Cowpea breeder, Institut de l'Environment et de Recherches Agricoles (INERA), Koudougou, Burkina Faso

It is with great sadness we report the passing away of our colleague and friend in the Tropical Legumes III community Dr Issa Drabo on 14 December 2016. Dr Issa Drabo was a renowned researcher and collaborator in several legumes research innovations including the Tropical Legumes with ICRISAT and International Institute of Tropical Agriculture (IITA), Legumes Innovation Lab; Bean/cowpea CRSP and Dry Pulse CRSP with Michigan State and Cowpea Breeding and Seed Systems with IITA. After receiving his PhD from McGill University in Canada in 1980, Dr Drabo began his career breeding improved varieties of cowpea at INERA. During his tenure with INERA, he has helped develop more than 20 improved cowpea varieties, which have increased cowpea yields almost five-fold since 2003—from 240 kg per ha to about 1,200 kg per ha.

Dr Drabo, was an outstanding cowpea breeder who helped move cowpea from a subsistence crop to a real commercial opportunity (especially for women) in Burkina Faso. Dr Drabo's cowpea breeding activities have been combined with ensuring adequate seed supply of improved cowpea varieties to resource poor farmers to ensure that the improved varieties are available to those who need them most.

Dr Issa Drabo, was awarded the Chevalier de l'Ordre des Palmes Academiques (Order of Academic Palms) for his outstanding research on cowpea in Burkina Faso by the Minister of Higher Education and Research on behalf of the Chief of State on October 5 2008. The Ordre des Palmes académiques (Order of Academic Palms) is an order of Chivalry of France for distinguished academics and figures in the world of culture and education. Dr Drabo also received the Legume Innovation Lab's Meritorious Achievement Award on May 15 2014, at the 2014 global meeting, 'Improving Agriculture and Nutrition through Grain Legumes', in Athens, Greece. At the joint Pan African Grain Legumes and Cowpea conference in Livingstone Zambia IITA conferred him Lifetime Achievement Award on 3 March 2016.

Aside from his professional life Dr Drabo was loved by many for his caring, welcome smile and commitment. He will be greatly missed. We as the TL III community extend our sincere condolences to his family, friends and colleagues at INERA.

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