Australian Government

Australian Centre for International Agricultural Research

Annual report

project

Rapid breeding for reduced cooking time and enhanced nutritional quality in common bean (*Phaseolus vulgaris*)

project number	CROP/2018/132
period of report	1/8/2019 – 30/6/2020
date due	15/7/2020
date submitted	17/7/2020
prepared by	Wallace Cowling[1]
co-authors/ contributors/ collaborators	Clare Mukankusi[2], Renu Saradadevi[1], Winnyfred Amongi[2], Kadambot Siddique[1], Jean-Claude Rubyogo[3] [1]Perth, Australia: The University of Western Australia [2]Uganda, [3]Kenya: International Center for Tropical Agriculture (CIAT) and Pan African Bean Research Alliance (PABRA)
approved by	Mr Robert Roche, Manager, Research Grants, The University of Western Australia

Contents

1 Progress summary

The project began formally on 1 August 2019. In October 2019, the main contracts between ACIAR and The University of Western Australia (UWA) and International Centre for Tropical Agriculture (CIAT) were signed, and subcontracts between CIAT and six partner countries (PCs) in east Africa were signed before the end of Y1. The inaugural project meeting was held in Uganda 9-11 December 2019.

Work on project objective 1 (to incorporate new breeding methods into the CIAT/PABRA bean breeding programme) began before the project started with analysis of data on 160 genotypes in an African bean diversity panel, which resulted in significant genomic estimated breeding values (GEBVs) for cooking time (CT), grain yield (GY) and seed Fe/Zn content. Project-specific Research Associates were appointed at CIAT-Kawanda (Uganda) and UWA in early 2020. Variation 1 of the proposal in May 2020 expanded the range of germplasm in the African bean diversity panel to include bush and climber types, and provided six PCs with necessary database training and equipment to share field trial data. Research collaboration between UWA and University of New England (UNE) developed GEBVs for CT, GY and seed Fe/Zn. An economic index was calculated for each genotype based on weighted GEBVs for GY, CT, Fe and Zn, and genotypes were allocated to six market classes. An optimised mating design based on optimal contributions selection (OCS) was developed within each market class using software 'Matesel' from UNE. Crossing at CIAT-Kawanda and more than 1000 cycle 1 progeny were harvested in May 2020 for sowing in June 2020 for seed increase, phenotyping and genotyping in Y2 of the project. Technology transfer and training in data management, genomic selection and OCS to African partners is a major focus of project objective (1), and began with contracting the on-line Breeding Management System (BMS) of the Integrated Breeding Platform to create a dedicated sub-programme for this rapid cooking bean project (BMS-RCBP). BMS staff trained the project leadership team in operation of BMS, who then uploaded genotypes, crossing and pedigree data into BMS-RCBP. A breeding plan (Appendix 2) for the project was developed jointly by the team at UWA and CIAT-Kawanda, and a work-flow plan was agreed for Y1 of the project (Appendix 3).

Project objective 2 (to share data and germplasm across PCs) began with the seed increase of 113 bush and 44 climber varieties in the African bean diversity panel at CIAT-Kawanda, and distribution of seed in June/July 2020 to six PCs for field trials in Y2. Field trials were constructed for each PC in BMS based on partially replicated designs using Australian-developed public software DiGGer. Training began for transfer of skills and software for field trial design to CIAT-Kawanda breeders. BMS arranged PC-specific internet training sessions to teach key PC staff in the use of BMS-RCBP for downloading field trial plans, sowing labels and field books. Future training sessions in BMS-RCBP will include field trial data collection and data uploading to BMS-RCBP.

Project objective 3 (to integrate the breeding component into the Pan Africa Bean Research Alliance [PABRA] Wider Impact Initiative) was the focus of the Project Planning Workshop in September 2018 and the inaugural project meeting in December 2019, and PABRA interests are represented at monthly online project team meetings. The project team continued beneficial interactions with relevant international projects such as "Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa" (AVISA) funded by the Bill and Melinda Gates Foundation, and "Demand Led Breeding" (DLB) funded by ACIAR, Crawford Fund and Syngenta Foundation for Sustainable Agriculture. Several project team members are also active in PABRA, AVISA and DLB.

Project objective 4 (to train African breeders in the new methodology of pedigree and genomic selection and OCS in beans and gender responsive plant breeding) began at the inaugural project meeting in December 2019, and will continue throughout the project either in online training sessions or in-person as soon as COVID-19 conditions permit travel between Australia and east Africa.

2 Achievements against project activities and outputs/milestones

2.1 Achievements to date

Objective 1: To incorporate new breeding methods based on pedigree and genomic selection and optimal contributions selection (OCS) into the CIAT/PABRA bean breeding programme to rapidly reduce cooking time in beans by at least 30% and improve Fe and Zn content by 20% over five years, while improving Bruchid resistance, Pythium root rot and agronomic traits.

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Choose parent lines	Estimate genomic breeding values (GEBVs) in the Africa diversity panel for grain yield, cooking time, Fe and Zn content. Develop optimised mating design based on OCS.	August 2019	GEBVs were estimated for GY, CT, Fe and Zn in 160 genotypes in the Africa bean diversity panel. An optimised mating design in 6 market class groups was sent to CIAT-Kawanda breeders in August 2019. (This process will be repeated for 200 new genotypes in the Africa bean diversity panel in 2020.)
1.3	Crossing programme	Harvest cycle 1 S0 cross progeny and parent self-seed	May 2020	Cross progeny and parent self-seed were harvested and recorded on BMS-RCBP in May-June 2020.
1.4	Selfing	Sow S0 cross progeny and parent self-seed; tissue sample each plant for SNP genotyping.	Sept 2020	Sowing of S0 cross progeny and parent self-seed occurred in June 2020. This milestone will be completed in September 2020. Arrangements were made with Intertek Australia to send tissue samples in July 2020 for genomic evaluation by SNP chip developed by CIAT Colombia and DArT in Australia.
1.5	Breeding values for CT, Fe, Zn etc	Phenotype selfed S0:S1 progeny seed	Dec 2020	Capital items (data loggers, moisture meters, barcode scanners, barcode printers and laptops) were purchased in June 2020 at CIAT-Kawanda in preparation for phenotyping S0:S1 progeny (2 Mattson cookers and Thermo Fischer EDXRF for Fe/Zn). AVISA will share cost of latter with ACIAR (50:50).
1.6	Bulking of seed to send to PCs	Grow, harvest, dry, clean, weigh, package and send selfed seed to PCs	June 2020	Seeds of 113 bush and 44 climber varieties in the African bean diversity panel were increased at CIAT-Kawanda; cleaned, packaged and sent to PCs in June 2020.
1.7	Develop standard control varieties for each trait	Select standard control varieties for growth habit, Bruchid resistance, Pythium root rot.	Nov 2020	It was not possible to select standard control varieties before seed was bulked and delivered to PCs in June 2020. These varieties will be selected at the annual project meeting in September 2020.

1.8	Transfer new breeding technology to PCs	Workshops 1 per year	On-going	PC-specific internet training sessions were conducted by BMS in June-July 2020 to train staff to use BMS to sow, label and print field trial plans.
1.9	Evaluate BMS	BMS used by PCs	Sept 2020	Evaluate at annual project meeting

PC = partner country, A = Australia

Objective 2: To share data across project partners through a common database system (BMS) linked by land-line or mobile phone connection, and to make use of data on yield, drought tolerance, Pythium root rot (PRR) resistance scored in Kenya, Bruchid resistance scored in Ethiopia, and other traits from partners in future breeding decisions. Include smallholder women and men in selection of new varieties through PVS, and ensure that appropriate gender-preferred value is placed on short CT, Fe and Zn content in breeding and selection of new varieties.

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	PC Tanzania	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	January 2021	Sowing plan agreed for uploading to BMS in June 2020. Training on BMS expected July or August 2020. Expected sowing date late September 2020.
2.2	PC Ethiopia	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	December 2020	Sowing plan agreed for uploading to BMS in June 2020. Training on BMS occurred in June 2020. Expected sowing date July 2020.
2.3	PC Uganda	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	December 2020	Sowing plan agreed for uploading to BMS in June 2020. Training on BMS occurred in July 2020. Expected sowing date August 2020.
2.4	PC Rwanda	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	January 2021	Sowing plan agreed for uploading to BMS in July 2020. Training on BMS expected in July or August 2020. Expected sowing date late September 2020.
2.5	PC Burundi	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	January 2021	Sowing plan agreed for uploading to BMS in July 2020. Training on BMS expected in July or August 2020. Expected sowing date early October 2020.
2.6	PC Kenya	Evaluate 200 fixed parent lines for yield and adaptation; add data to BMS within 3 months of data collection	December 2021	Sowing plan agreed for uploading to BMS in July 2020. Training on BMS expected in July or August 2020. Expected sowing date July or August 2020.

PC = partner country, A = Australia

Objective 3: To integrate the breeding component into the PABRA Wider Impact Initiative (WII) and Bean Corridors approach, catalyse sustainable investments in

the seed system and facilitate access to quality seed of improved bean varieties to east African farmers.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Adoption of germplasm and new breeding methodology in PC	New germplasm and new breeding methodology adopted in PC	On-going	First batch of new germplasm received by PC June 2020; training in use of BMS for printing field plans, labels and field books completed July 2020.

Objective 4: To train African breeders in the new methodology of pedigree and genomic selection and OCS in beans and other food crops.

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Attach PhD and MSc students to project	At least one or two students trained at postgraduate level	On-going	Invited Dr Paul Gibson of Makerere University to inaugural project meeting December 2019 and promoted the project as an excellent location for student research training; CIAT-Uganda Research Associate Winnyfred Amongi commenced PhD studies at Makerere University June 2020 on research associated with the project.
4.2	Hands-on training workshops	Workshops on BMS database, DiGGer for prep trial design, GEBV and EBV analysis, OCS methodology for crossing designs.	Annual	Internet BMS training workshops in each PC for printing field plans, labels and field books to be completed July 2020. Project leader and RA-UWA will train senior breeder and RA at CIAT-Kawanda in DiGGer for prep field trial design July 2020. Training RA Uganda in uploading genotype names to BMS will be completed July 2020.
4.3	Annual project workshop	Effective project management and team training	September 2020	Annual meeting by internet is targeted for September 2020.

2.2 Summary of achievements to date (for ACIAR website)

Enter text (no more than 250 words)

- An analysis of phenotypic and genotypic data from CIAT (Uganda) showed significant variation for grain yield, cooking time, iron and zinc among genotypes in the African bean diversity panel.
- Genomic estimated breeding values for these traits were used to develop an optimised crossing plan in the African bean diversity panel which was implemented at CIAT (Uganda) in September 2019.
- Seed of varieties in the African bean diversity panel was increased and distributed to 6 partner countries in east Africa in June 2020. Field trial designs were constructed using publicly available software developed in Australia. Training began for transfer of skills and software for field trial design to partner countries.

- A project-specific online database was initiated in the Breeding Management System of the Integrated Breeding Platform, and key staff in partner countries began training in the project database for management of field trial data.
- The project provided equipment to improve infrastructure in partner countries for breeding and selection of high iron and zinc beans with rapid cooking time.
- The project committed to training in and implementation of gender-aware processes at the inaugural project meeting in Uganda in December 2019. Most of the project collaborating scientists attended a workshop in gender-based participatory variety selection in January 2020 during a Pan Africa Bean Research Alliance breeders' meeting in Tanzania. Collaborating scientists from Burundi and Tanzania participated in training in 'Gender-responsive Researchers Equipped for Agricultural Transformation' at Makerere University in Kampala, Uganda, funded by the Bill and Melinda Gates Foundation. This project is motivated and guided by the needs of women and children for biofortified and rapid-cooking beans.

Project Stories

If your project has a significant impact story or standout achievement that could potentially be shared by the ACIAR Outreach Team, please provide further information via question prompts at the link. Project Stories.

3 Impacts

3.1 Scientific impacts

This ACIAR project is based on the use of pedigree and genomic information in the selection of rapid cooking time and biofortification with Fe and Zn. Genomic selection would not be possible without the Commonbean DArTag SNP panel which includes >1200 informative SNPs across the genome of common bean. The SNPs were discovered in the Excellence in Breeding platform from genotype-by-sequencing data by colleagues in CIAT Colombia, who selected the most informative SNPs. A commercial assay was developed by DArT in Australia with Intertek. Demand for this service has increased as a result of this ACIAR project, and Variation 1 of this project allows us to commence SNP genotyping on progeny in cycle 1 in July 2020 (Appendix 3) through Intertek. This project therefore will stimulate the global development of genomic selection in common bean.

The project also involves collaboration with researchers in the Animal Genetics and Breeding Unit (AGBU) at University of New England (UNE), who are helping us to adapt their animal breeding software for use in self-pollinating crops. Prior to this ACIAR project, the project leader and UNE colleagues published the first use of optimal contributions selection (OCS) in self-pollinating crops (Cowling et al. 2017. Evolving gene banks: improving diverse populations of crop and exotic germplasm with optimal contribution selection. Journal of Experimental Botany 68:1927–1939) which has stimulated research globally on the use of OCS in crop breeding (e.g. Gorjanc et al., 2018. Optimal cross selection for long-term genetic gain in two-part programs with rapid recurrent genomic selection. Theoretical and Applied Genetics 131:1953-1966).

Future collaboration with UNE colleagues in this project will combine genomic and pedigree information in “single step genomic prediction”, which has been implemented by AGBU for sheep breeding in Australia, and is being evaluated in crops (e.g. Ashraf et al. 2016. Genomic prediction using phenotypes from pedigreed lines with no marker data. Crop Sci 56:957-964).

Research in this ACIAR project on OCS and single step genomic prediction will benefit plant breeding in Australia and Africa, and is of global importance to improve the efficiency of crop breeding. With appropriate training in quantitative genetics and data management, together with skills gained in pedigree and genomic selection with OCS in this project, plant breeders in Africa will be competitive with plant breeders globally. A major goal of this project is to train African partners to a level where they will teach others and promote these skills in Africa beyond the time horizon of this project.

3.2 Capacity impacts

Capacity-building impact in east Africa has begun with training and hardware/software developments in the project. The project engaged the Integrated Breeding Platform for access to the Breeding Management System internet-based software for housing data in a dedicated BMS component for the Rapid Cooking Bean Project (BMS-RCBP). BMS experts located in Kenya and Australia provided online training to project leadership team, and pedigree and genotype data from parent lines and cross progeny has been loaded into BMS-RCBP. Partially replicated field trial designs were constructed using Australian-developed public software DiGGer and uploaded to BMS-RCBP.

BMS training began in June 2020 with key breeders and associates in six PCs to access BMC-RCBP for downloading and uploading data for field trials.

Future training is planned for implementing field trial design based on DiGGer into the CIAT-Kawanda bean breeding programme, and this will flow on to six PCs during the project. Likewise, key breeders in CIAT-Kawanda will be trained in pedigree and genomic

selection during the project. This has begun with the uploading of pedigree information into BMS-RCBP in June 2020 for the progeny genotypes developed in first cycle of recurrent selection, and will continue with specific training at UWA and UNE for project leaders at CIAT-Kawanda (either internet-based or on-site in Australia after current travel restrictions are lifted), and this training will flow on to PCs during the project.

The project has contributed to infrastructure and capacity building in six partner countries through the purchase of capital items such as field data loggers, printers, barcode readers and laptop computers to operate the BMS database for field trials. CIAT-Kawanda purchased two Mattson cookers and a Thermo Fischer EDXRF for Fe/Zn assays. The Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA) project, funded by the Bill and Melinda Gates Foundation in partnership with ICRISAT, CIAT and IITA, will share the cost of the latter 50:50 with this ACIAR project. These infrastructure improvements will have flow-on benefits for improving and retaining the skill base in plant breeding in east Africa.

3.3 Community impacts

Community impacts from this project include the development of Participatory Variety Selection (PVS) in collaboration with PCs. Training in gender-sensitive plant breeding and PVS will increase female involvement in variety release processes for rapid cooking and biofortified beans. Evaluation of gender-sensitive project goals was the focus of the Project Planning Workshop in September 2018 and the inaugural project meeting in December 2019, and continues at monthly online project meetings of collaborating scientists. Many collaborating scientists attended a workshop in gender-based participatory variety selection in January 2020 during a Pan Africa Bean Research Alliance breeders' meeting in Tanzania. Collaborating scientists from Tanzania and Burundi participated in training in 'Gender-responsive Researchers Equipped for Agricultural Transformation' at Makerere University in Kampala, Uganda, funded by the Bill and Melinda Gates Foundation.

Community impact during and after the project will increase as a result of the PABRA Wider Impact Initiative which catalyses sustainable investment in the seeds system, and facilitates access to quality seed of improved bean varieties to millions of African farmers. In 2020, PABRA team members (Tanzania and Uganda) developed two prototypes of bean product profiles which will serve as tools for participatory variety selection and variety commercialization.

The project team continued beneficial interactions with relevant international projects such as "Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa" (AVISA) funded by the Bill and Melinda Gates Foundation, and "Demand Led Breeding" (DLB) funded by ACIAR, Crawford Fund and Syngenta Foundation for Sustainable Agriculture.

Collaboration with PABRA, AVISA and DLB will ensure that this project achieves community impact during and after the project through development of improved variety release systems for beans in Africa.

3.3.1 Economic impacts

While economic impacts of the project have not yet been realised, the potential for economic impact of faster CT beans will be large, with savings in time and cost of cooking. Women will be free to spend time on other economic activities such as raising animals or manning small shops, and children will have more time for school work. They will also save on the cost of the fuel (wood, charcoal or kerosene) used for long cooking beans. The developed beans will also be highly productive, and surplus beans will be available for sale and will contribute to household cash income.

Between 1997 and 2017, the PABRA Wider Impact Initiative facilitated access to quality seed of improved bean varieties to 27 million farmers. With PABRA support, it is plausible that faster-cooking bean varieties developed in this project could be adopted by 20% of target farmers within five years of the completion of the project.

3.3.2 Social impacts

While social impacts of the project have not yet been realised, biofortified and rapid cooking beans will improve health of men, women and children, and reduce infant mortality and child stunting on a wide scale. Healthier children will result from higher protein and Fe/Zn consumption, and the new varieties will result in higher household financial and physical health as a result of rapid cooking beans (less fuel consumption and smoke inhalation). Besides nutritional/health benefits in farmer households, the project will also benefit low income consumers in urban areas, who rely on beans as their sole protein and bioavailable Fe/Zn source. Beans have become predominantly 'women' crops (female farmers and small traders), and valuable market traits such as rapid cooking beans will contribute positively to their business volume and income. Rapid cooking and biofortified varieties will provide more business opportunities to processors (predominantly women) to produce more convenient bean based products e.g. bean flour.

Field trials in the project will be established on farmer fields where possible, to help advertise the goals of the project and to promote farmer awareness of the importance of rapid cooking and biofortified beans.

3.3.3 Environmental impacts

While environmental impacts of the project have not yet been realised, rapid cooking beans will reduce demand for fuel for cooking, and indirectly reduce destruction of forests for wood and charcoal for cooking fuel. Beans fix atmospheric nitrogen and provide organic nitrogen sources for companion crops or subsequent crops in rotation. Straw left behind after grain harvest is valuable for soil fertility and animal feeding.

3.4 Communication and dissemination activities

In the first year of the project, we set up monthly online project team meetings which link Australia (Project Leader and Research Associate-Australia), CIAT-Kawanda (Project Co-ordinator and Research Associate-Africa), collaborating scientists in six partner countries, and ACIAR representatives (Program Manager and Regional Manager Eastern & Southern Africa). The project leadership team (Project Leader, Research Associate-Australia, Project Co-ordinator-Africa and Research Associate-Africa) meets weekly online to ensure smooth operation of the breeding and administration plan.

In order to better communicate the project plans to PCs, the project leadership team developed a 5-year plan for the breeding and field trial system (Appendix 2), a breeding diagram for cycle 1 (Appendix 3), and a 5-year administration plan of the project (Appendix 4). These were submitted to PCs for feedback and modification during Y1 of the project.

The inaugural annual project team meeting was held 9-11 December 2019 and included a discussion on gender-based breeding goals and participatory variety selection processes in the project. Training in gender considerations will be facilitated at future annual meetings. The program finished with field trips to NaCCRI Uganda and CIAT-Kawanda bean breeding facilities, which was attended by representatives of all PCs. The project launch meeting was advertised widely on social media (Facebook, Twitter) and The UWA Institute of Agriculture April 2020 Newsletter: https://www.ioa.uwa.edu.au/__data/assets/pdf_file/0003/3453177/UWA0088-Institute-of-Agriculture-News-April-2020_F.pdf.

The CIAT-Kawanda Project Co-ordinator-Africa (Dr Clare Mukankusi) was invited to present a talk at TropAg2019 in Brisbane, Australia, in November 2019, on behalf of project partners and collaborators at UNE (see publication citation in Appendix 1). Her talk was titled “Diversity breeding program on common bean (*Phaseolus vulgaris* L.) targeting rapid cooking and iron and zinc biofortification”, and generated a lot of interest.

Several collaborating scientists from this project are also members of the “Demand Led Breeding” (DLB) project funded by ACIAR, Crawford Fund and Syngenta Foundation for Sustainable Agriculture. UWA hosted a DLB workshop 18-20 November 2019 titled “Crop R&D Funding in Australia.” The DLB workshop included many representatives of ACIAR project CROP/2018/132, and the opportunity was taken to prepare for the inaugural project team meeting in Uganda 9-11 December 2019. The DLB workshop focussed on R&D funding and levy systems operating in Australia. It included expert speakers from the grains industry and pulse programmes at UWA, and visits to the largest Grain Cooperative and export terminal in Western Australia (Kwinana CBH Grain) and Intergrain Pty Ltd, a major Australian wheat breeding company. This tour was constructed to explore current and future funding of plant breeding in Australia and sustainable research and development (R&D) funding mechanisms with a view to stimulating ideas on possible funding models with potential in Africa. The workshop was advertised on Twitter: https://twitter.com/KadambotS/status/1196685110038294528?s=20

4 Training activities

The project leadership team formed a contract agreement with IBP/BMS to provide online access to a project-specific databased BMS-RCBP, which is linked to the CIAT Phaseolus bean database. The IBP/BMS agreement included training and support, which began in April 2020 with transfer of skills on BMS to the project leadership team at UWA and CIAT-Kawanda. Following this, BMS arranged PC-specific online training sessions to teach key PC staff on the use of BMS-RCBP for downloading field trial plans, sowing labels and field books. This should be completed across 6 PCs in July 2020. Future training sessions in BMS-RCBP will include field trial data collection and data uploading to BMS-RCBP.

Australian technology skills in field trial design will be transferred to project partners based on the publicly available software DiGGer. This training will occur between UWA and CIAT-Kawanda breeders in July 2020. The use of partially replicated designs, generated in DiGGer, will be important for future field trial design in 6 PCs. Almost certainly, there will be limitations in seed supply which will limit the number of replicates of genotypes in each PC to be evaluated in Y2, Y3, Y4 and Y5 of the project. The partially replicated designs are flexible to meet the limitations of seed supply. The trial design will have sufficient concurrent genotypes across trials in PCs to enable a valid multi-environment trial analysis across countries.

Collaborators at University of New England (UNE) in Australia will develop training sessions for estimation of EBVs and GEBVs (based on pedigree and genomic relationship information, respectively). Originally, this training was to occur face-to-face during annual project meetings, but will most likely now occur in the next 12 to 18 months in online training sessions.

OCS for optimised mating designs will be based on the Australian software ‘Matesel’, and training will be led collaborators at UNE. This was to occur face-to-face during annual project meetings, but will most likely now occur in the next 12 to 18 months in online training sessions.

Training also occurs in associated projects. Many collaborating scientists attended a workshop in gender-based participatory variety selection in January 2020 during a Pan Africa Bean Research Alliance breeders’ meeting in Tanzania. Two collaborating scientists have participated in training in ‘Gender-responsive Researchers Equipped for Agricultural Transformation’ at Makerere University in Kampala, Uganda, funded by the Bill and Melinda Gates Foundation.

A budget exists (AU$10K) for the project co-ordinator in Africa to visit Australia for training. This should be implemented as soon as COVID-19 travel allows this to occur.

Training activities in Y1:

Names	Institution	Date	Topic	Funding
Wallace Cowling Renu Saradadevi Clare Mukankusi Winny Amongi	UWA UWA CIAT-Kawanda CIAT-Kawanda	7-8/4/20	Internet BMS training by Mable Mulanya, BMS Support Scientist (Kenya); and Mr Robin Wilson, Plant Breeding Consultant, Integrated Breeding Platform (Australia)	ACIAR Project: contract with IBP-BMS
Berhanu Fenta Abel Moges Samir Hashim Tigist Shiferaw	EIAR, Ethiopia	23-24/6/20	Internet BMS training by Mable Mulanya on Exporting field book for data collection, collecting data using field book application and importing data back into BMS	ACIAR Project: contract with IBP-BMS
Stanley Nkalubo Wilber Ssekandi	NaCRRI, Uganda	14/7/20	Internet BMS training by Mable Mulanya on Exporting	ACIAR Project:

Aogon George			field book for data collection and printing sowing labels	contract with IBP-BMS
Otsyula Reuben Shamir Misango Shadrack Odikara Faida Kelele Yona Masheti	KALRO, Kenya	15/7/20	Internet BMS training by Mable Mulanya on Exporting field book for data collection and printing sowing labels	ACIAR Project: contract with IBP-BMS

5 Intellectual property

The project will use publicly-available software wherever possible, for example R, R-Studio, and DiGGer. One licence for proprietary software will be required, for use of 'Matesel' for optimised mating designs based on OCS. This license will be signed in Y2 of the project with Prof Brian Kinghorn, UNE.

6 Variations to future activities

Variation 1 was proposed to ACIAR by the project leadership team in early 2020 and agreed by the ACIAR Program Manager on 8 April 2020. Variation 1 brought forward funds to Y1 to allow the following changes:

• Genotyping of Y1 progeny for genomic selection	$30,000 operating b/f to Y1
• Expand project scope from bush beans to include climbing beans (additional crossing and testing required)	$10,000 wages b/f to Y1
• BMS establishment and training in Y1	$9,000 b/f to Y1
• Capital items for BMS/field trials in PCs	$20,000 b/f to Y1
TOTAL to bring forward	$69,000 b/f to Y1

Suggested future variations to the project: we propose that the mid-term project review should be brought forward to mid-2021 rather than in mid-2022, as original proposed (Appendix 4). This is because Variation 1 allows us to begin genomic selection immediately on cycle 1 progeny, and this will allow us to combine genomic and pedigree information in “single step genomic prediction”. Results of genomic selection will be available in early 2021, and are vital to justify increased project funding for annual recurrent genomic selection (currently, the budget for genomic selection is only available in 2 annual cycles). An early mid-term project review in mid-2021 will permit a timely review of our proposal to resource the project for annual cycles of genomic selection.

7 Variations to personnel

Dr Renu Saradadevi was appointed to the new full time ACIAR project position at The University of Western Australia as Research Associate Level A, and began work on 9th March 2020.

Ms Winnifred Amongi was appointed to the new (80%) ACIAR project position at CIAT-Kawanda as Research Associate, and began work on 1st January, 2020.

The administrative contact at UWA, Mrs Christine Casey has retired and Mr Robert Roche is the new contact.

We are pleased to add Dr Teshale Assefa (CIAT, Tanzania) to the project team as the new Co-ordinator for the Eastern and Central Africa Bean Research Network (ECABREN).

No other changes were recorded in personnel in the project in this reporting period.

8 Problems and opportunities

The project remains on target to reach breeding and administrative goals (see Appendices 2, 3 and 4).

The COVID-19 pandemic has had some impact on project related activities. During April and May 2020, the project leadership team at UWA and CIAT-Kawanda were working exclusively at home and instructing staff on activities over the telephone and internet. Travel in Uganda was restricted to official vehicles driven by CIAT-Kawanda driver with one passenger. At CIAT-Kawanda, only one person was permitted to work in a screen house at one time. This slowed down harvest of cross and self progeny. However, these restrictions have mostly been eased as of 30th June 2020. In each of the PCs, agriculture is a priority area and field research continues with appropriate social distancing. Travel restrictions has not affected field locations or timing of sowing of trials, although operational costs in some PCs have increased due to restrictions on numbers of people that can travel in one car and labourers that can work in the field at a time to 3 and 10 respectively.

International travel restrictions related to COVID-19 caused cancellation of the travel plans of Project Leader and Research Associate UWA to Uganda in April 2020 to attend BMS training. However, an online BMS training module for the project leaders' team occurred in April 2020. This was coordinated by Mable Mulanya, BMS Support Scientist (Kenya) and Mr Robin Wilson, Plant Breeding Consultant, Integrated Breeding Platform (Australia). We receive ongoing support to implement our breeding design (Appendices 2, 3) into BMS and this is assisted by prompt responses to our questions from key BMS support scientists.

COVID-19 has also caused the proposed face-to-face training in BMS for 6 PCs to be converted to online training. Each PC was asked to nominate key associates for training, in addition to the Collaborating Scientist. Interruptions in internet connection in Africa have caused some disruptions to online training activities. Based on this experience, BMS training modules were reduced in length to cover essential topics that are necessary at each stage of the project. The first training module is being delivered currently and will train users in downloading field books, field plans, and sowing labels from BMS-RCPB. The second training module, scheduled after sowing in each PC, will train users in collecting data by e-field book, and importing data back into BMS-RCBP.

Budget

Y1 (Variation 1) budget: $481,051

Expenditure occurred as planned according to Variation 1 budget approved in Y1. A small reduction in travel expenditure at UWA occurred as a result of cancellation of a visit of Project Leader (Cowling) and Research Associate UWA (Saradadevi) to Uganda in April 2020 as a result of COVID-19 travel restrictions. A major invoice from CIAT is expected to be received at UWA in July 2020 for Y1 second payment according to costs incurred in CIAT and PCs according to the budget in Variation 1.

An signed acquittal form will be supplied to ACIAR from UWA administration before the end of July 2020.

9 Appendices

Appendix 1: Publications list – see attached standard ACIAR publications form.

Appendix 2: Diagram of 5-year breeding plan for ACIAR CROP/2018/132 rapid cooking bean project.

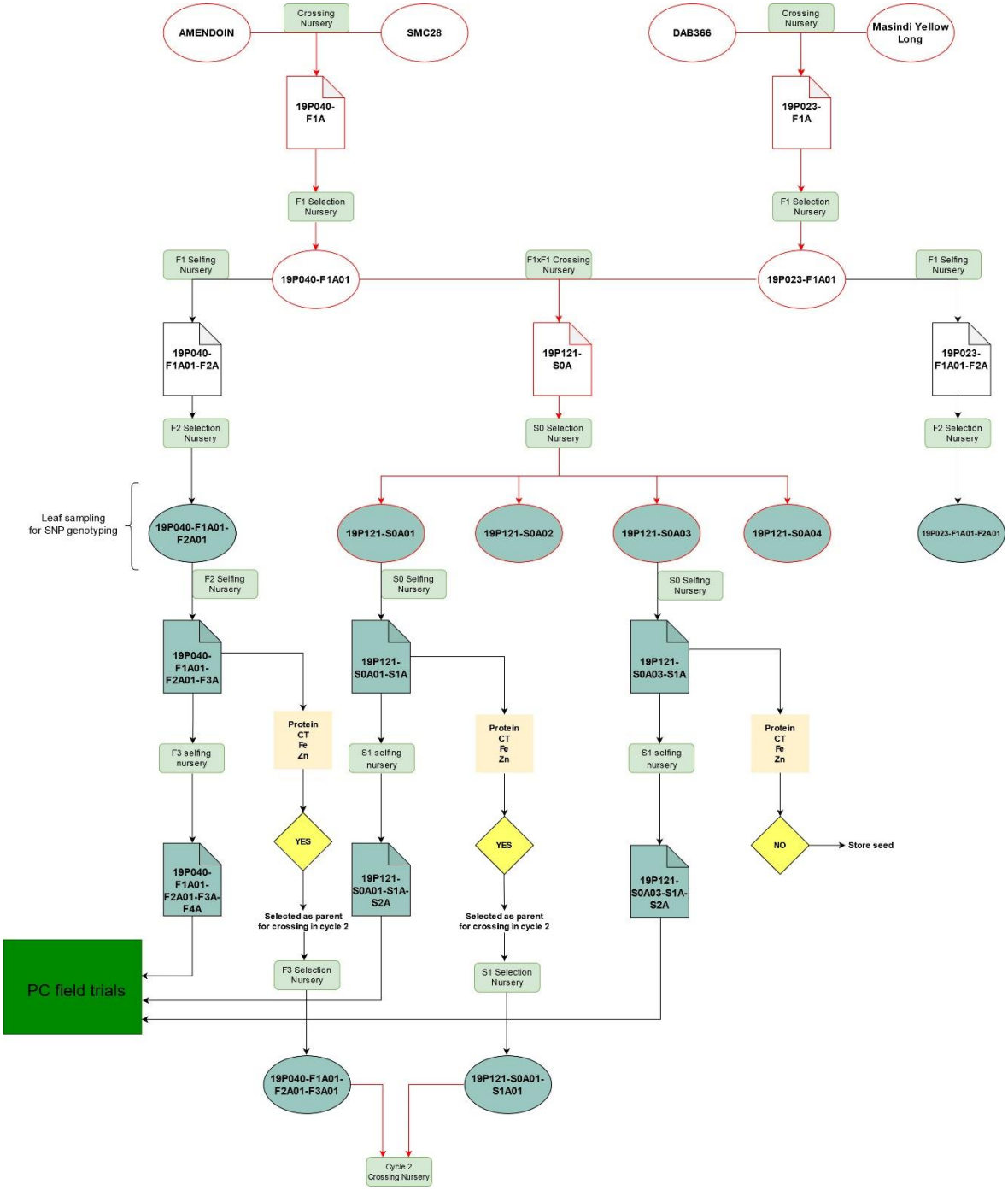
Timeline: Breeding Activities

ACIAR project CROP/2018/132

Rapid breeding for reduced cooking time and enhanced nutritional quality in common bean (Phaseolus vulgaris)

		Partner Activities - variety release	Partner Activities - base	Field activity CIAT Uganda for partners	Field activity CIAT Uganda base pogram	Lab activity CIAT Uganda	Database and analysis	Who?
2019	J						Phentoypic analysis CIAT-Uganda data parent lines	CIAT-Uganda, UWA
	F						Genomic analysis CIAT-Uganda data parent lines	CIAT-Uganda and CIAT-Colombia, UWA, UNE
	M				Set up crossing block of parent varieties following OCS design ("Matesel"), classified in 6 seed groups ~100 crosses			
	A							
	M							
	J							
	J							
	A							
	S							
	O							
	N							
	D			Grow and bulk seed of parent lines (~80 lines, target harvest 3 kg per line). Send seed + trial design to each partner	Cross F1xF1 in 6 seed grps, ~50 crosses; target >20 S0 cross seeds and 10 F1 self seeds (=F2) per cross (total 1000 progeny)			
2020	J						Record all crosses on BMS	CIAT-Uganda, UWA
	F							
	M							
	A							
	M				Self S0 and F2 progeny (1000 plants); target harvest >50 seeds (S0:S1 and F2:F3) per plant	Leaf sample each progeny (S0 and F2) (freeze) for DNA testing	Record each S0 and F2 progeny with GID on BMS, label each S0 and F2 plant; generate harvest labels **Decision needed on how/where DNA testing should be done!!	CIAT-Uganda
	J							
	J		Partner field trials of parent genotypes - design trial on BMS, data uploaded to BMS. Make selections? (pure lines already?)					
	A							
	S					S0:S1 and F2:F3 seeds: weigh 25 seeds, CT, dry, grind, evaluate Fe, Zn, protein in cooked powder	Run BLUP analysis and generate EBVs - CT, Fe, Zn, and data from partners (include pedigree and genotypic information if available)	CIAT-Uganda, UWA
	O							
	N							
	D			Grow and bulk 1000 progeny rows (S0:S2 & F2:F4). Target harvest 500 seeds per row; send seed + trial design to partners	100 crosses in 6 seed grps, target >7 S0 progeny seeds per cross and >3 self seeds per parent (100 x 10 = 1000 progeny)		Generate index, run Matesel, output crossing design	
2021	J							
	F	Grow selections and evaluate					Design partner trials (# progeny and g per partner)	CIAT-Uganda, UWA
	M							
	A							
	M				Grow S0:S1 progeny and parent selfs (1000 plants); target harvest >50 seeds per plant	Leaf sample each plant (freeze) for DNA testing	Record each S0 and parent self progeny with GID on BMS, label each plant; generate harvest labels	CIAT-Uganda
	J							
	J	Participatory evaluation	Partner field trials of S0:S2 and F2:F4 bulks - design trials on BMS, upload data to BMS (total 1000 progenies)					
	A							
	S					Dry seed, weigh 25 seeds, evaluate CT, dry, grind, evaluate Fe, Zn, protein in powder	Run BLUP analysis and generate EBVs - CT, Fe, Zn, and data from partners (include pedigree and genotypic information if available)	CIAT-Uganda, UWA
	O							
	N							
	D			Grow and bulk 1000 progeny rows (S0:S2 and parent plant selfs). Target harvest 500 seeds per row; send seed + trial design to partners	100 crosses in 6 seed grps, Target >7 S0 seeds per cross and >3 self seeds per cross (100 x 10 = 1000 progeny)		Generate index, run Matesel, output crossing design	
2022	J							
	F	Grow selections and evaluate					Design partner trials (# progeny and g per partner)	CIAT-Uganda, UWA
	M							
	A							
	M				Grow S0:S1 progeny and parent selfs (1000 plants); target harvest >50 seeds per plant	Leaf sample each plant (freeze) for DNA testing	Record each S0 and parent self progeny with GID on BMS, label each plant; generate harvest labels	CIAT-Uganda
	J							
	J	Participatory evaluation with goal for release	Partner field trials of S0:S2 and parent plant selfs - design trial on BMS, data uploaded to BMS (total 1000 progenies)					
	A							
	S					Dry seed, weigh 25 seeds, evaluate CT, dry, grind, evaluate Fe, Zn, protein in powder	Run BLUP analysis and generate EBVs - CT, Fe, Zn, and data from partners (include pedigree and genotypic information if available)	CIAT-Uganda, UWA
	O							
	N							
	D			Grow and bulk 1000 progeny rows (S0:S2 and parent plant selfs). Target harvest 500 seeds per row; send seed + trial design to partners	100 crosses in 6 seed grps, Target >7 S0 seeds per cross and >3 self seeds per cross (100 x 10 = 1000 progeny)		Generate index, run Matesel, output crossing design	
2023	J							
	F	Grow selections and evaluate					Design partner trials (# progeny and g per partner)	CIAT-Uganda, UWA
	M							
	A							
	M				Grow S0:S1 progeny and parent selfs (1000 plants); target harvest >50 seeds per plant	Leaf sample each plant (freeze) for DNA testing	Record each S0 and parent self progeny with GID on BMS, label each plant; generate harvest labels	CIAT-Uganda
	J							
	J	Participatory evaluation with goal for release	Partner field trials of S0:S2 and parent plant selfs - design trial on BMS, data uploaded to BMS (total 1000 progenies)					
	A							
	S					Dry seed, weigh 25 seeds, evaluate CT, dry, grind, evaluate Fe, Zn, protein in powder	Run BLUP analysis and generate EBVs - CT, Fe, Zn, and data from partners (include pedigree and genotypic information if available)	CIAT-Uganda, UWA
	O							
	N							
	D			Grow and bulk 1000 progeny rows (S0:S2 and parent plant selfs). Target harvest 500 seeds per row; send seed + trial design to partners	100 crosses in 6 seed grps, Target >7 S0 seeds per cross and >3 self seeds per cross (100 x 10 = 1000 progeny)		Generate index, run Matesel, output crossing design	
2024	J							
	F	Grow selections and evaluate					Design partner trials (# progeny and g per partner)	CIAT-Uganda, UWA
	M							
	A							
	M							
	J							
	J	Participatory evaluation with goal for release	Partner field trials of S0:S2 and parent plant selfs - design trial on BMS, data uploaded to BMS (total 1000 progenies)					
	A							
	S							
	O							
	N							
	D							

Appendix 3: Example of work flow in cycle 1 of ACIAR CROP/2018/132 rapid cooking bean project, and nomenclature for uploading genotype information to BMS-RCBP. In this example, leaf tissues of cycle 1 S0 cross progenies (19P121-S0A01, -S0A02, -S0A03, -S0A04) are sampled for SNP genotyping in July 2020, and S1 self seeds of each genotype are evaluated for CT, Fe, Zn in September-December 2020. GEBVs are calculated for CT, Fe, and Zn, and a weighted index of GEBVs for all available traits is calculated for each genotype. Crossing occurs in January-March 2021 following an optimised mating design based on index. S2 self seeds are sent to PCs for field trials in June 2021. From 2021 onwards, crossing will occur in January-March and each cycle will be completed in 12 months as shown in Appendix 2.



Appendix 4. Adminstrative plan for ACIAR CROP/2018/132 rapid cooking bean project.

Timeline: Project Administration

ACIAR project CROP/2018/132

Rapid breeding for reduced cooking time and enhanced nutritional quality in common bean (Phaseolus vulgaris)

Year	Mth	Activity	Where	Who	Reporting	Actions/notes
2019	J					
	F					
	M					
	A					
	M					
	J					
	J					
	A	Project starts 1/8/2019				
	S					
	O	Project signed all partners		CIAT invoices UWA		
	N					
	D	8-11 Dec: Inaugural project meeting	CIAT Uganda	Clare, Wallace, Elvira, others	Summary of project meeting sent to partners	**Claire and Wallace: summarise key action points
2020	J	Sub-contracts arranged by CIAT with partners		Elvira (Project Officer PABRA, Nairobi)	Subcontracts sent to partners	**email subcontract to project personnel directly
	F	Employ Research Associates (UWA and CIAT-Uganda)	UWA and CIAT Uganda	UWA and CIAT Uganda		**Inform ACIAR or new project staff details
		Skype CIAT Uganda/UWA/IBP-BMS to discuss BMS budget	UWA and CIAT Uganda	UWA, CIAT Uganda and IBP/BMS	Evaluate budget for BMS operation, plus field tablets, bar code scanners, moisture meter, balance, etc.	
	M	Set up BMS ready for site visit in April	Email/Skype	IBP-BMS team, Clare, Wallace etc		**BMS operating for project by end of March
	A	First site visit: UWA (Project Leader and RA); IBP-BMS training; enter cross information	CIAT Uganda	IBP-BMS delegate, CIAT Uganda and UWA project staff		**BMS must be operating before this meeting
	M	Revise budget needs for ACIAR		Clare, Wallace, Elvira, others	Send budget alteration request to ACIAR.	**This request can only bring forward existing budget
	J					
	J	Annual Project Team Meeting and Technical Workshop (July or August): Training in BMS/BLUP/Index/OCS Tour of partner trials (selected countries)	CIAT Uganda	All partners + Eric Huttner; BMS delegate; plus Brian Kinghorn?; Li Li?; Bodo Raatz	Annual report due - Wallace/Clare	Report against project plan
	A					
	S	BMS site visit during crop season? (depends on country)				
	O	BMS site visit during crop season? (depends on country)				
	N	BMS site visit during crop season? (depends on country)				
	D					
2021	J					
	F	Project leadership workshop and site visits	CIAT Uganda and sites	Clare/Wallace and Research Associates	Inform ACIAR of progress	
	M					
	A					
	M					
	J					
	J	Annual Project Team Meeting	CIAT Uganda or Ethiopia + site visits	All partners	Annual report due	Report against project plan
	A	Tour of partner sites (ET)				
	S					
	O	Tour of partner sites (KE)				
	N					
	D	Tour of partner sites (UG, BU, RW, TZ)				
2022	J					
	F	Project leadership workshop	UWA Australia	Project leaders Africa, Australia	Inform ACIAR of progress	
	M					
	A					
	M					
	J	Mid-term Review of Project - show significant genetic progress Tour of partner trials (selected countries)	CIAT Uganda Partner countries	All partners	Annual report due	Report against project plan and review budget constraints; work with ACIAR on revised budget
	J					
	A					
	S					
	O					
	N					
	D					
2023	J					
	F	Project leadership workshop and site visits	CIAT Uganda and sites	Clare/Wallace and Research Associates	Inform ACIAR of progress	
	M					
	A					
	M					
	J					
	J	Technical Workshop: BMS/BLUP/Index/OCS/genomic selection Tour of partner trials (selected countries)	Partner countries	All partners	Annual report due	Report against project plan
	A					
	S					
	O					
	N					
	D					
2024	J					
	F	Project leadership workshop and site visits	CIAT Uganda and sites	Clare/Wallace and Research Associates	Inform ACIAR of progress	
	M					
	A					
	M					
	J	Final Project Meeting Project finish 30 June 2024	CIAT Uganda	All partners	Final report due	Report against project plan
	J					
	A					
	S					
	O					
	N					
	D					