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Australian Centre for International Agricultural Research

Annual report

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1 Progress summary

The overall aim of the project "Establishing sustainable solutions to cassava disease in Mainland Southeast Asia" is to enhance smallholder livelihoods and economic development in Mainland SEA by improving the resilience of cassava production systems and value chains by addressing the rapidly evolving disease constraints. The project involves a multi-pronged strategy that includes breeding, pest and disease surveillance, agronomy, seed systems interventions, and engagement with government institutions and agribusiness.

The project was officially launched on the 11-13th of September with an inception meeting[1] held in Vientiane Lao PDR with partners from Australia (ACIAR, UQ), Colombia (CIAT), Vietnam (AGI, HLARC, PPRI, CIAT), Cambodia (GDA, CIAT), Lao PDR (NAFRI, PPC, CIAT), Myanmar (DAR), Thailand (KU, TTDI, TTSA), China (CATAS), India (CTCRI), Tanzania (IITA),and the USA (University of Florida). A presentation was also made by the ACIAR project (HORT/2018/192), on managing Fusarium wilt (TR4) of Banana in South-East Asia.

Economic analysis, business models and platforms

The cassava industry continues to be influenced by a range of internal and external factors impacting supply and demand, prices, trade flows and utilisation[2]. Data continue to be monitored and analysis presented in various forums. The project is supporting the development of the 'Cassava Lighthouse[3]' to archive data collected during previous ACIAR cassava projects and provide access to data collected during the project. There are ongoing efforts to establish relationships with private sector partners to move more of the data to real-time.

The economic impact of cassava disease continues to accumulate rapidly. Estimates from partner include 205,000ha in Cambodia, 57,000ha in Vietnam, 56,000ha in Thailand, and 10ha in Lao PDR. This represents about 14% of the total cassava area in those countries.

Plot level analysis is ongoing, drawing on results from objective 4. To date, this has highlighted the urgent need for a source of clean planting material (stems). Analysis of the impacts on household incomes has been delayed due to postponement of household surveys. Factories in highly impacted areas are operating well below capacity, particularly in Tay Ninh which relies heavily on Cambodian feedstock. An industry survey is planned

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[1] *Inception meeting presentation at: https://cassavadiseasesolutionsasia.net/inception-meeting/*

[2] *Summary of key indicators in Appendix 1 – Market Update June2020*

[3] *The Cassava Lighthouse can be accessed at: https://cassavalighthousetest.ciat.cgiar.org/*

for 2020-21 in conjunction with the ACIAR and DFAT funded TRANSIT project. There has been a significant reduction in the trade volumes into Vietnam from Cambodia, highlighting the impact on both household livelihoods, value chain actors, and national economies (see Appendix 2).

Willingness to Pay (WTP) for planting material have been designed but postponed due to travel restrictions. Piloting will take place in Lao PDR in 2020, but activities in Cambodia and Vietnam will be delayed until travel between the project countries is possible. Similarly, the seed system characterisation has been delayed.

Economic analysis of rapid multiplication procedures is ongoing. Initial breakeven and returns-on-investment analysis is helping target areas for technology refinement, and where public sector support is required. The 'Future Stems' site at NAFRI has been established and is a useful site to generate multi-stakeholder collaboration to scale.

Platforms in Lao PDR at this stage are informal and include donor projects (USDA-Winrock; SDC-Helvetas; LuxDev) and private sector partners. A southern Lao demonstration hub is being established in collaboration with local government, private sector partner and the project. In Cambodia the project maintains a working relationship with CAVAC and other donor projects. This will be expanded once travel resumes. In Vietnam there is less relevant donor projects and partnerships will be strengthened with private sector in the coming year. Market leaders have been identified.

Screening and breeding

Given the urgency of the situation, many activities were supported by national partners and through RTB to ensure the 2019-2020 cassava season was not missed. Partners in Vietnam, Laos and Cambodia established the procedure of receive materials from other countries, which has facilitate the collaboration. To date there has been several sources[4] of CMD resistance introduced to the region from CIAT-Colombia, IITA-Nigeria, & Hawaii-NextGen. The collaboration with CTCRI is still being negotiated.

The 48 asymptomatic clones from initial screening have been planted in advanced yield trials in Tay Ninh and Dong Nai in May 2020 to confirm the CMD resistance and evaluate the agronomic traits. These CMD resistant clones are being used as progenitors in crossing nurseries of HLARC and AGI. Flower inducing technology developed by CIAT and IITA has been established in Vietnam to promote flowering of erect clones and shorten the days required for the first set of flowers. The implementation of this technology will help to shorten the duration of breeding cycle and increase genetic diversity, in turn, increase genetic gains of the breeding programs.

Screening for CWBD resistance has been delayed due to COVID-19 and reduced operations at the CIAT genebank. The first part of the core collection will be shipped in Laos in August-September. The screening protocol was tested and is at the finalizing stage in Laos. The core collection will also be shipped to AGI for screening for novel sources of CMD resistance, which may also have relevance for countries such as Indonesia.

Samples for DNA extraction and fingerprinting are being collected during the household survey in Vietnam, Laos and Cambodia in the coming 6 months. Activities in Myanmar have been delayed due to travel restriction and no in-country CIAT staff.

Diagnostics and surveillance

Travel restrictions related to COVID-19 have had an impact on the planned activities in Objective 3. Instead of carry on with our planned large training meeting in Thailand at Kasetsart University, online meetings were held with the different country teams in the

[4] *Presentation on introduced sources of resistance can be accessed here: CMD sources of resistance for Asia*

SEA region. The main goal of this was to agree on running a standard diagnostics and a Basic Surveillance Protocol (BSP). Different PCR primers were tested initially by the teams in Thailand and CIAT, and detected a cross-reaction of primers targeting the *rep* gene of the virus with African virus isolates. We then validated the *cp* gene as a better target for diagnostics. Results have been published in *Virus Research*[5]. Teams in Cambodia, Laos and Vietnam agreed on a BSP for field sampling. This was designed after feedback from an initial sampling protocol tested in Thailand and after online meetings with each country team. The collection of 60 samples per hectare of cassava field could be completed in less than 1.5 hours, and included data for symptoms of CMD and Witches Broom disease (CWBD) and number of adult whiteflies in mature leaves[6].

The data is integrated with previous developed standards for data organization implemented in the PestDisPlace[7] platform; this received further support from RTB for 2020. Thus far the teams have collectively surveyed more than 200 fields and as a result, the protocol has been further optimized and SLCMV has been confirmed for the first time along the border between Thailand and Cambodia (including a rare virus variant), and in the south of Laos (Champasak Province) along the border with Cambodia. A significant percentage of asymptomatic infections were confirmed in both reports. In Vietnam, the team has currently confirmed the percentage of asymptomatic infections in the northern provinces. Currently, we are conducting further analysis (e.g. confirmation by PCR, barcoding of whiteflies, checking the identity of phytoplasma associated to CWB), for this, additional video training tutorial and protocols will continue to support our communication, as the SEA teams are ordering reagents and protocols for the molecular tests. Inoculation of CWB disease, via grafting of lateral chip buds, is underway in Laos Plant Protection Center (PPC). We have confirmed the association of Candidatus phytoplasma asteris 16Sr-I with CWBD symptoms of plants collected in Laos.

A strategic partnership has been established with a FAO-TCP that has resources to improve some of the physical capacity of partner institutions in Laos, Myanmar and Thailand and the use of the proposed BSP and CIAT's platform for data organization and sharing

A large number of SLCMV and CWBD genomic sequences were obtained and aligned to identify the genetically conserved regions to target for diagnostic detection. Ten sets of LAMP primers were developed to detect CMV and six sets to detect CWBD using the online LAMP primer development software 'Primer explorer' (https://primerexplorer.jp/e/). To ensure the specificity of the primers, a set of rigorous tests were repeatedly performed using healthy or SLCMV-infected cassava samples collected in Cambodia and Vietnam. Samples were also obtained from different parts of infected cassava plants including: old leaves and young leaves, petioles, and stems. From this analysis, we appear to have a number of reliable primer sets that are specific for SLCMV and that are ready for further testing in-field.

A similar set of rigorous tests were planned to ensure the specificity of the CWBD primers however, our planned trip to SE Asia to collect CWBD samples was cancelled due to the COVID-19 pandemic. Collaborators collect and shipped CWBD samples to Australia for testing.

Agronomy and seed systems

[5] https://www.sciencedirect.com/science/article/pii/S0168170219307567

[6] *Protocol can be found on the project website and in the Appendix of this report.*

[7] *PestDisPlace for cassava can be accessed at: https://pestdisplace.org/diseases/cassava*

Existing extension material from each country has been collated into one location to avoid duplication[8]. Additional efforts are ongoing together with development partners to produce videos on recognising CWBD and CMD. Additional extension material is being developed on rapid multiplication.

To test the susceptibility and associated yield penalty of cassava disease on existing varieties, experiments have been established in Vietnam (CMD) & Cambodia (CMD) and Laos (CWBD). Planting stems of different known disease status have been used to establish the trails to determine the potential for positive selection and level of degeneration of clean stems which will inform the business models. Based on initial results, 500 in-vitro KU50 plants were imported into Laos and Cambodia from CIAT-Cali to be used as parent material for future multiplication.

Five IITA elite CMD resistant lines (TMEB419, IITA-TMS-IBA980581, IITA-TMS-IBA980505, IITA-TMS IBA972205, IITA-TMS-IBA920057) currently in a yield trial in Vietnam. Clones were shipped to Laos and Cambodia in late August. Ongoing negotiations are occurring with ICAR-CTCRI for access to germplasm. The yields from these introduced varieties needs to be competitive against clean planting material from existing Asian elite varieties which will be tested in the coming season.

A review of rapid multiplication systems has been complete. A modified tunnel multiplication system has been established at NAFRI, Laos. Four tunnels for rapid multiplication have been established and operational with an additional two being built in September. Optimization of the system (e.g. automation of sprinkler systems) will also be carried out once the travel restrictions are lifted. Currently multiplication of variety-KU50, Rayong11 and Rayong72 in progress. From ~60 stakes 800-1000 plantlets are harvested every 6-8 weeks. One tunnel will produce around 5000-6000 stems per year. Tunnels with be established at partner institutions in Cambodia and Vietnam in the next 6 months.

Private sector and development partner has been identified to establish a multiplication tunnels. This include 10 tunnels in Champasak, Laos (Private); 6 tunnels in Salavan, Laos (Association with donor support); Stung Treng, Cambodia (PDAFF-Donor support).

On station experiments have been established in all three countries to optimise the planting density, planting time and harvest time for multiplication and to get optimum yield. To estimate irrigation water use efficiency (IWUE) for multiplication purpose has been included in the treatment. These trials will help establish the tradeoff between roots and stem production and whether changes in the agronomy are warranted for individual farmers or government agencies.

[8] *Extension material from other projects and initiates is being catalogued on the project website*

2 Achievements against project activities and outputs/milestones

2.1 Achievements to date

Objective 1: Assess the opportunities, challenges and risk for the development of sustainable solutions for cassava disease management in mainland Southeast Asia

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Understand the macro-level drivers for the development of the cassava industry and development of plausible market scenarios	Annual market update and revised market scenarios Reported in June each year	Ongoing	Market database maintained. Initiation of the 'Cassava Light house' for public access to datasets. Policies and pandemics: https://youtu.be/3IDkuB_x2Cg https://youtu.be/FpBwo_0iRjc
1.2	Assessment of the economic impact of cassava diseases on cassava producers and industry stakeholders.	Report June 2020 Publication submitted December 2020		**Plot level** ***CMD*** impacts from 1st year trial in Cambodia analysed. New trial established (Obj 4) and data will become available in 2021. ***CWBD*** trial data available in 2022. **Household level** Survey has been delayed. I**ndustry level** Trade data analysis has occurred and key informant interviews with a number of factories. Industry survey to be complete later in 2020 in conjunction with Transit Project.
1.3	Analysis of household decision making under production and market uncertainty, including on-farm management an market engagement for stems	Report June 2021 Publication submitted December 2021	Ongoing	**Household survey** has been developed. Implementation of the household survey has started in Vietnam but delayed due to COVID. **Experimental auction** protocol has been developed. Initially planned to be carried out in Cambodia and Vietnam, change will likely see a move to Laos as first country.
1.4	Characterisation of the cassava seed system and trader network	Report June 2020 Report Dec 2020 Report and maps Dec 2020 Publication submitted June 2021		Survey of traders postponed due to travel restriction

1.5	Develop innovative business models to strengthen the value chain for the production and movement of 'clean' planting material	Report June 2022 Application test and reported June 2023		Initial breakeven analysis has been conducted on current model. Intervention points to reduce costs have been identified. Analysis helping to develop public-private arrangements.
1.6	Map existing national and regional stakeholder networks, develop and strengthen multi-stakeholder national and regional platforms	Report June 2020 Report June 2021		**Thailand** – Continued engagement with TTSA and TTDI. **Vietnam** – Continued engagement with ViCaAs and several processors. **Cambodia** – collaboration with CAVAC. **Lao PDR** – initial opening of "Future Stems" was postponed due to COVID. Developing relationship with the Lao Cassava Association; USDA-Winrock project; SDC-Helvetas Project; LuxDev; Several private sector partners.
1.7	Investigate alternative models for public-private funding to core activities at a local, national and regional scale	Report June 2023		Ongoing discussions with different partners.

PC = partner country, A = Australia

Objective 2: Enhance the capacity and collaboration between breeding programs in mainland Southeast Asia to develop new product profiles for commercially viable cassava varieties by identifying and incorporating known and novel sources of resistance to Cassava Mosaic Disease (CMD) and Cassava Witches Broom Disease (CWBD) into national breeding programs:

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	**Activity 2.1** Develop protocols and enhance capacity of national programs for the safe and effective transfer of genetic material between partners and countries, including receiving resistance material from Africa and India for evaluation in the region.	Protocols has been developed in Vietnam, Cambodia and Laos. They are able to receive and maintain in vitro plants from CIAT and IITA and other collaborators.	June 2021	Partners in Vietnam, Laos and Cambodia established the procedure of receive materials from other countries, which will facilitate the collaboration. AGI, Vietnam has good tissue culture lab and routinely receive germplasm from CIAT, and Laos and Cambodia, each received 500 KU50 in vitro plantlets in 2020 from CIAT and 100 x 5 IITA clones. Ongoing discussion with ICAR for transfer of genetic resources to CIAT under the existing MOU.
2.2	**Activity 2.2** Introduce and evaluate selected botanical seeds from the CIAT-IITA Hawaii breeding program for resistance to CMD	HLARC has imported 4,991 seeds with CMD resistance from Hawaii. Quarantine permit is required to release the seeds to HLARC. AGI has imported 474 seeds from CIAT to establish GS based breeding scheme in Vietnam.	June 2023	This is the first time for both AGI and HLARC to import cassava seeds. The procedure was established in both teams. These seeds were derived from the elite germplasm in CIAT and IITA, which will provide CMD resistance and increase genetic diversity of the breeding population. Moreover, implementing genomic selection will modernize the AGI breeding program and increase their capacity and genetic gains.
2.3	**Activity 2.3** Conduct convention field breeding to develop new high yielding commercial acceptable varieties with resistance to CMD	From the CMD trial in Tay Ninh, containing 102 CIAT clones, 5 IITA clones and local elite varieties, we identified 48 clones asymptomatic. Both polycrossing and paired crossing nurseries with elite varieties and CMD resistant clones were established in June 2020 in both AGI and HLARC.	June 2023 and continue	The 48 asymptomatic clones were planted in advanced yield trials in Tay Ninh and Dong Nai in May 2020 to confirm the CMD resistance and evaluate the agronomic traits. These CMD resistant clones are being used as progenitors in crossing nurseries. Flower inducing technology developed by CIAT and IITA will be implemented in HLARC and AGI to promote flowering of erect clones and shorten the days required for the first set of flowers. The implementation of this technology will help to shorten the duration of breeding cycle and increase genetic diversity, in turn, increase genetic gains of the breeding programs.

	Activity 2.4 Evaluate CIATs core collection, CMD resistant varieties from Africa and India, and advanced CIAT clones for resistance to Cassava Witches Broom Disease	The 220 accessions of the core collection is ready for shipping to Laos. A protocol of screening Cassava Witches Broom is also under development	June 2023 and continue	Due to COVID-19, the accessibility of tissue culture lab is limited. The activities were slowed down. The first part of the core collection will be shipped in Laos in August. The screening protocol was tested and is at the finalizing stage in Laos.
	Activity 2.5 Analyse the current varietal composition of cassava cultivation in Cambodia, Lao PDR, Myanmar and Thailand using DNA fingerprinting technology	Distribution of released and landraces known throughout the region. Identifying areas with large area of highly susceptible varieties Informing seed system analysis	Dec 2020	Samples for DNA extraction are being collected during the household survey in Vietnam. Samples will also be collected in Laos and Cambodia. Activities in Myanmar have been delayed due to travel restriction and no in-country CIAT staff.

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Objective 3: Develop and deploy diagnostic protocol, tools and information platforms fit for purpose in monitoring, surveillance, and certification applications.

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	**Activity 3.1** Conduct training and capacity building of plant protection institutes in key diagnostic tools, sampling design, and data management platforms	A standard and basic surveillance protocol (BSP) in major cassava growing region in SEA Training material developed for use within the region Training reports December 2019	Ongoing	Training material was developed as videos and protocols, adjusted after exchanging feedback from the teams doing field-sampling tests. An initial protocol was implemented together with the group in Thailand, resulting in confirmation of CMD (no records of CWB) along the border between Thailand and Cambodia and the occurrence of a different isolate of the virus (the results have been published) The next group to start the field sampling protocols (after online training), was Laos-PPC. First results already detected CMD in 4 out of 39 surveyed fields along 10 provinces. Peer-reviewed First report of CMD in Laos, is underway. The team in Vietnam has just finished the first survey in the Red River Delta and Northern Midland and Mountain provinces, and the results are being validated by the CIAT-HQ group.
3.2	**Activity 3.2** Design, implement and communicate regional surveillance activities for CMD and CWBD in Vietnam, Cambodia, Lao PDR, Myanmar and Thailand, with results shared in a common platform	Protocols for uploading and accessing data – Report Dec 2019 Generate and update maps with "confirmed/suspected/non-infected" data. Sampling in Sep-Nov Yr 2,3,4 Report in June	Ongoing	Implementation was delayed due to COVID19-related travel restrictions, but surveys have started in Laos and the North of Vietnam. Surveys in Thailand were carried out before COVID. Maps are being updated in near real-time in the PestDisPlace platform and symptoms recorded are confirmed by the CIAT-HQ team. Image data from all teams are accessible to each other are a good teaching resource used during online meetings to improve the recognition of symptoms from e.g. herbicide treatment. Significant percentages of SLCMV asymptomatic infections are being recorded by PCR.

2.3	**Activity 3.3** Understand the distribution and diversity of whitefly populations throughout the cassava production regions of Vietnam, Cambodia, Lao PDR, Myanmar and Thailand	A first regional indexed collection of cassava whiteflies Sequence diversity of whitefly populations in SEA identified and characterized Online access to SEA Whitefly Distribution maps via PestDisPlace July 2021	Ongoing	The data collected so far includes data on adult whiteflies (WF) as recorded in the first extended leaf of 3-4 months old cassava plants. WF samples have been collected in Laos and Vietnam, and are stored in ethanol. We had experienced delays in obtaining import permits from the Colombian phytosanitary office (ICA), to run the first barcoding analyses. In the meantime, partners are preparing the labs for running the tests themselves. Once again, the planned laboratory training activities have been postponed and we will have to rely on video training and testing of the samples first in CIAT-HQ labs.
	Activity 3.4 Evaluate new technologies for rapid field diagnostics with particular applications in seed systems	June 2020 June 2021		**SLCMV and CWBD-specific primer development** A large number of SLCMV and CWBD genomic sequences were obtained and aligned to identify the genetically conserved regions to target for diagnostic detection. Ten sets of LAMP primers were developed to detect CMV and six sets to detect CWBD using the online LAMP primer development software 'Primer explorer' (https://primerexplorer.jp/e/). To ensure the specificity of the primers to target CMV, a set of rigorous tests were repeatedly performed using healthy or SLCMV-infected Cassava samples collected in Cambodia and Vietnam. Samples were also obtained from different parts of infected Cassava plants including: old leaves and young leaves, petioles, and stems. From this analysis, we appear to have a number of reliable primer sets that are specific for SLCMV that are ready for further testing in-field. A similar set of rigorous tests were planned to ensure the specificity of the CWBD primers however, our planned trip to SE Asia to collect CWBD samples was cancelled due to the COVID-19 pandemic. Collaborators collect and shipped CWBD samples to Australia for testing.

	Activity 3.5 Develop and validate protocols for screening and biological characterisation of cassava diseases, particularly CWBD	Testing chip bud grafting of CWB on cassava rootstocks	ongoing	Protocols and video training material developed and shared with our partners in Laos, showing the procedure for graft transmission of pathogens in cassava. Progress is not as expected, as symptoms take too long to develop under greenhouse conditions. Advances in the development of a LAMP test for molecular detection will accelerate the confirmation infection. At CIAT-HQ we have confirmed by PCR the association of a phytoplasma 16Sr-I with CWBD in Laos and will use this PCR test to confirm infection in the grafting assay.
	Activity 3.6 Develop and evaluate the effectiveness of communication products and strategies utilising different public and private sector stakeholders			Communication products are being developed and distributed through government and private sector partners.

PC = partner country, A = Australia

Objective 4: Develop and evaluate economically sustainable cassava seed system models for the rapid dissemination of new varieties and clean planting material to farmers in different value chains and production contexts

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	**Activity 4.1** Developing communication products for effective field level management of cassava diseases (i.e. CMD, CWBD)	Publication & distribution of brochures, video cds, posters Training materials developed for use within the region	December 2020	Existing information products are being catalogued on the project website https://cassavadiseasesolutionsasia.net/thai/ https://cassavadiseasesolutionsasia.net/khmer/ Additional products are being developed involving development projects to avoid duplication and maintain a common message.
4.2	**Activity 4.2** Evaluation and on-farm demonstration of CMD resistant exotic cassava varieties from IITA (Africa) and ICAR-CTCRI (India) against clean available SEA varieties	Adapted CMD resistant cassava varieties identified on-farm from local and exotic germplasm from IITA and ICAR-CTCRI. Conduct training in improved cassava practices, demonstration trials, and participatory research methods, including public sector extension services (where present)	July 2021 (elite SEA cassava varieties) July 2023 (exotic cassava varieties)	To test the susceptibility of popular varieties to CMD and CWBD, experiments have been established in Vietnam & Cambodia and Laos, respectively. This includes using stems of different disease status. With and without fertiliser treatments are included in some trials to demonstrate the impact of good management. Protocols are in the Appendices to this report. Advanced yield trials using the IITA clones and elite Vietnamese clones have been established in two locations in Southern Vietnam Field days are planned for mid-season and harvest.

4.3	**Activity 4.3** Evaluation and comparison of rapid multiplication innovations in SEA context	Review document: Equipment and facilities for rapid multiplication innovation Semi-Autotrophic Hydroponics (SAH) technology /or Jiffy Pots established and equipped for rapid dispersal of planting materials into the seed system	July 2020 July 2021	Draft of the review document has been completed. From the recommendation of draft review document and due to difficulties in implementing SAH multiplication system, modified tunnel multiplication system have been established in Laos (see detail below). Vietnam: At HLARC a site has been selected to establish rapid multiplication tunnel system. Laos: Establishment of four tunnels for rapid multiplication have been completed and operational; plan to build another two tunnels by end of September 2020. Private partner has been identified to establish a multiplication tunnel Cambodia: A site has been selected to establish rapid multiplication tunnels under GDA Development partner CAVAC is in discussion to establish rapid multiplication tunnel system (i.e. six tunnels) in partnership with PDAFF at Stung Treng. Economic analysis is ongoing as modifications and performance improves.
4.4	**Activity 4.4** Optimize agronomic practices (variety, density, fertilizer) for the economic production of both cassava roots and clean planting material	On-farm trials successfully established in different agro-ecological and value chain contexts. Training report	July: 2022 and 2023 July: 2022 and 2023	On station experiments have been established in all three countries to optimise the planting density, planting time and harvest time for multiplication and to get optimum yield. To estimate irrigation water use efficiency (IWUE) for multiplication purpose has been included in the treatment. Economic and tradeoff analysis will occur after harvesting.

PC = partner country, A = Australia

2.2 Summary of achievements to date (for ACIAR website)

The project was officially launched on the 11-13th of September with an inception meeting held in Vientiane Lao PDR. In the meantime CMD has now been recognised in 60 Provinces across Cambodia, Vietnam, Thailand and Laos with an estimated impacted area 320,000 hectares across the region.

To date there has been several sources of CMD resistance introduced to the region from CIAT-Colombia, IITA-Nigeria, & Hawaii-NextGen. The 48 asymptomatic clones from initial screening have been planted in advanced yield trials. Flower inducing technology has been established in two crossing blocks in Vietnam.

Agreement on running a standard diagnostics and a Basic Surveillance Protocol (BSP) was developed between partners. Different PCR primers were tested and detected a cross-reaction of primers targeting the *rep* gene of the virus with African isolates.

A strategic partnership has been established with a FAO-TCP that has resources to improve some of the physical capacity of partner institutions in Laos, Myanmar and Thailand.

The data is integrated with previous developed standards for data organization implemented in the PestDisPlace platform. Teams have collectively surveyed more than 130 fields and as a result, the protocol has been further optimized and SLCMV has been confirmed for the first time along the border between Thailand and Cambodia (including a rare virus variant), and CMD has been detected in the south of Laos (Champasak Province).

Inoculation of CWB disease, via grafting of lateral chip buds, is underway in Laos Plant Protection Center.

A large number of CMV and CWBD genomic sequences were obtained and aligned to identify the genetically conserved regions to target for diagnostic detection. Ten sets of LAMP primers were developed to detect CMV and six sets to detect CWBD using the online LAMP primer development software ‘Primer explorer’

To test the susceptibility and associated yield penalty of cassava disease on existing varieties, experiments have been established in Vietnam (CMD) & Cambodia (CMD) and Laos (CWBD). Planting stems of different known disease status have been used to establish the trails to determine the potential for positive selection and level of degeneration of clean stems which will inform the business models.

Five IITA elite CMD resistant lines are currently in a yield trial in Vietnam. These have also been shipped to Lao and Cambodian partners.

A modified tunnel multiplication system has been established at NAFRI, Laos. Four tunnels for rapid multiplication have been established and operational with an additional two to be built. Private sector and development partner has been identified to establish a multiplication tunnels in each country.

On station experiments have been established in all three countries to optimise the planting density, planting time and harvest time for multiplication and to get optimum yield. To estimate irrigation water use efficiency (IWUE) for multiplication purpose has been included in the treatment.

3 Impacts

3.1 Scientific impacts

There have been no significant scientific impacts in the first 10 months of the project.

3.2 Capacity impacts

Physical capacity has been developed at NAFRI for rapid multiplication and agronomic trials. This includes the construction of a screen-house and tunnels jointly supported by the project and CIAT infrastructure fund.

3.3 Community impacts

In the first 10 months of the project most activities have focused on diagnostics and on-station research. As such there has been no significant community impacts to date.

3.3.1 Economic impacts

There have been no substantial economic impacts to date. Early results suggest significant impacts will be achieved in the future. Using some very conservative estimates of an estimated infected area around 320,000ha, a yield decline of 15t/ha, and a fresh root price of 60USD/t -the farm level losses due to CMD alone are likely approach $30 million this harvest season.

3.3.2 Social impacts

There have been no significant social impacts to date.

3.3.3 Environmental impacts

There have been no significant positive or negative environmental impacts to date.

3.4 Communication and dissemination activities

The project seeks to build to the cassava community established during the ACIAR Cassava Value Chain and Livelihood Program. The projects online and social media presence includes:

- A project website: https://cassavadiseasesolutionsasia.net/
- A project Facebook Group: https://www.facebook.com/groups/2394808117512232
- A project twitter account: @CassDiseaseAsia
- A project SlideShare account
- A project Youtube account has been established

The Facebook group to date has 231 members of which 220 have been active in the last 60 days. The twitter handle has 120 followers. Activities are also promoted by the CIAT and RTB accounts.

The team presented at the Starch World Conference in January 2020. This is the largest industry meeting held each year.

Blogs and articles

https://blog.ciat.cgiar.org/ciat-and-partners-fight-cassava-diseases-in-southeast-asia-with-new-project/

https://reachout.aciar.gov.au/protecting-incomegenerating-cassava-from-virus-duo

Field days will be conducted during the harvest of trials in late 2020-early 2021.

4 Training activities

Due to the COVID restriction all major training events have been postponed or moved to online training and mentoring of individual teams and scientist.

- PCR diagnostics of SLCMV in PPC, Lao PDR (December 6th, 2019)
- Video training and teleconference on cassava chip bud grafting (May 12th, 2020)
- Video training and teleconference on field sampling for CMD, CWB and whiteflies (June 4th, 2020)
- Video training for transfer of tissue culture material to screen house (Laos and Cambodia)

Training videos are being developed for key skills required for partners to complete activities.

5 Intellectual property

No significant IP has been generated to date.

6 Variations to future activities

Industry survey in Vietnam

There is a common interest in establishing a database of processors in the region for a number of modelling activities and engagement. Together with the CSIRO TRANSIT project (supported by both ACIAR and DFAT) a survey in Vietnam is being planned. This will not have budget implications for the project.

Screening of core collection in Vietnam

Screening of the cassava core collection for CMD resistance was initially planned to occur in Cambodia with the movement of stems from Rayong Research Centre (DOA Thailand) to a heavily infected area in Cambodia. Due to uncertainty over the phytosanitary status of the complete collection in Thailand, the plan is to now send in-vitro accession with certain status from the core collection in Cali to AGI for screening in TayNinh, Vietnam.

Cross-block established in Northern Vietnam

The original plan was for the breeding activities to be undertaken by HLARC with the establishment of a crossing block in Lam Dong Province in the Central Highlands. AGI will now also undertake breeding activities with a second crossing block established at the NOMAFSI station in Sonla Province in Northern Vietnam.

CARDI involvement

The activities in Cambodia depend on the safe movement of germplasm into Cambodia. Given that GDA does not have tissue culture facilities, a separate arrangement has been develop with CARDI using other funding sources. CARDI will remain involved in the project as an associate partner until the funding situation and certainty warrants a variation for formal inclusion.

7 Variations to personnel

CIAT – Dr Hernan Ceballos will retire and has been replaced in the project by Dr Xiaofei Zhang. Both scientist were able to visit partners together prior to COVID restriction and facilitate an introduction to partners and handover of activities.

Ms Cu Thi Le Thuy has become responsible to supporting and the implementation of breeding activities with Vietnamese partners under the supervision of Xiaofei Zhang and Augusto Becerra.

PPRI - Ms Hang Thi Le is a new member of the PPRI team. She will be responsibility for molecular biology.

NAFRI – Dr. Siviengkhek Phommalath, Deputry Director of the Maize and Cash Crop Research Center has been appointed as the project coordinator for NAFRI.

Mr Phunthasin Khanthavong is currently completing his PhD in Japan. Mr Saythong Oudthachit has taken over the day-to-day management of field activities at NAFRI related to Objective 4.

8 Problems and opportunities

COVID-19 is the main challenge faced by the project. To date, the impact has been mainly incurred in Objective 1 with delays in surveys, interviews and group discussions that require face-to-face interaction with communities.

Training and capacity building activities have also been impacted across the project objectives, with travel restrictions not allowing staff from CIAT-Colombia to come to the Asia. Travel between countries is currently not permitted, impacting team meetings and planning activities. These impacts are being mitigated through frequent online conference calls and through CIAT National staff.

Surveys have resumed in Vietnam, coordinated by the CIAT Hanoi office and training and implementation expected in second half of 2020 in Laos. Training is more challenging in Cambodia, however the household survey it is expected begin in 2020. Experimental auctions require the presence of CIAT International staff and will need to be delayed.

Breeding activities have been initiated in Vietnam and on-station agronomic trials have been established by partners and CIAT national staff in all countries. There has been delays in the delivery of the core collection to the region with the gene-bank working on a skeleton staff to maintain the collection rather than facilitate shipments.

Planned disease surveillance activities were initially delayed, but should be on schedule by the end of the year. Recruitment of staff for Objective 3 has also been delayed but will be initiated once travel allows.

The involvement of CATAS has also been impacted. It was planned for CATAS staff to spend time in the Laos office. This has not been possible due to travel restriction.

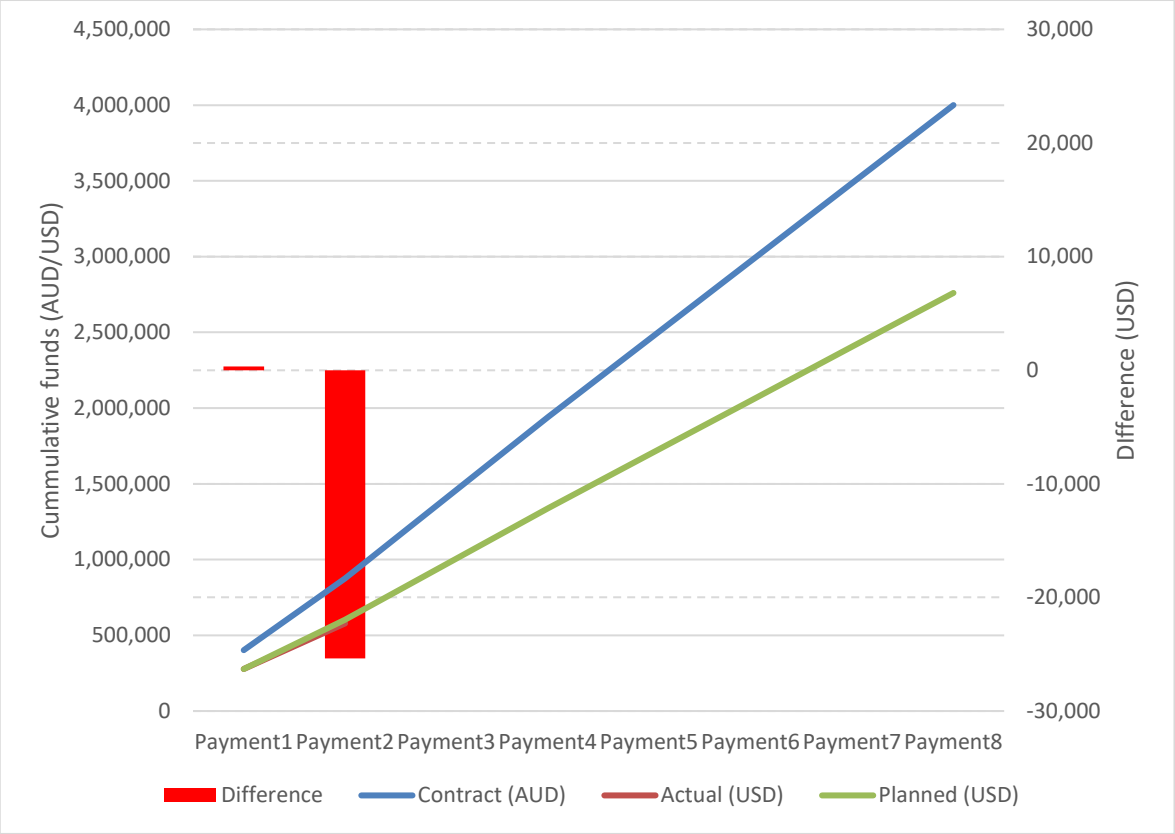
Opportunities

Several opportunities for partnerships have been developed and leveraging additional funding for the overall ‘program’ in line with Objective 1.7 on public-private partnerships.

1. FAO TCP for disease surveillance and diagnostics (Laos, Thailand and Myanmar)
2. Partnerships with several development projects in Laos is scaling out knowledge and innovations
3. Continued partnership with CAVAC in Cambodia, including supporting activities at CARDI aligned to the overall program implementation
4. Rapid multiplication activities in Laos have benefited from support from Mekong Timbers, a Forestry plantation company that utilizes micro-propagation.

9 Budget

The total budget has been impacted by a decline in the AUD:USD exchange rate relative to the planned rate. The impact has resulted in reduction in received funds by around $25,000 USD (less than 5%). Currently the AUD rate is slightly above the planned rate.



Delay in finalising contracts with partners also slowed some payments. This has resulted in significant carryover of funds for those partners who could not advance funds and begin expenditure.

10 Appendices

Appendix 1: Annual Project Report Appendix One Publications list (See link on ACIAR website - Microsoft Excel document)

Appendix 2: Market update

Appendix 3 - Activities planned for 2020-2021 growth season for Cassava breeding in Vietnam

Appendix 4 – Objective 3 Protocols

Appendix 5 – Agronomy and seed system