Developing cassava production and marketing systems to enhance smallholder livelihoods in Cambodia and Laos

Date: July 2020

Progress towards completion of project ASEM/2014/053

This report gives a brief overview of the progress towards completion of project ASEM/2014/053 as of July 2020. The activities and outputs of the project are presented in a table for each of the three Objectives, and comments are provided regarding the progress towards completion of each output. A summary of key outputs, achievements and challenges is also given for each objective.

Objective 1: Assess the current production, marketing, and institutional arrangements for cassava in major agroeconomic zones and value chains in Laos and Cambodia.

No.	Activity	Outputs/ milestones	Date Completed	Comments
1.1	Review information on global and national cassava production, utilisation, trade, and policies.	Review report	Annually	A database with updated information on regional and global cassava markets have been maintained through the duration of the project and updates on markets have been shared and discussed with stakeholders using the project website and via Facebook group updates. Results of the market analysis have also been presented at various workshops, symposia and conferences within Laos and Cambodia and internationally A interactive webpage is under development with co-funding from RTB to continue to make data collected available
1.2	Conduct value chain analyses in case study areas (primary and supporting actors, local policy environment).	Value chain reports	February 2017	Value chain assessments were undertaken in in Kratie, Bolkhamsay and Xayabouli. These assessments included farmer focus groups and semi-structured interviews with value chain actors in selected districts. Ongoing interviews were conducted with value chain actors with their inclusion in subsequent activities (field days, policy dialogues, symposium)
1.3	Conduct key informant and group interviews in case study areas to ascertain socio-economic relations affecting access to and collective management of farm resources and access to input and output markets.	Socio-economic analysis reports	April 2017	Key informant interviews and farmer focus groups were conducted in Kratie, Bolikhamsay and Xayabouly in conjunction with the value chain assessments. Ongoing farmers meetings occurred during farmer field days.

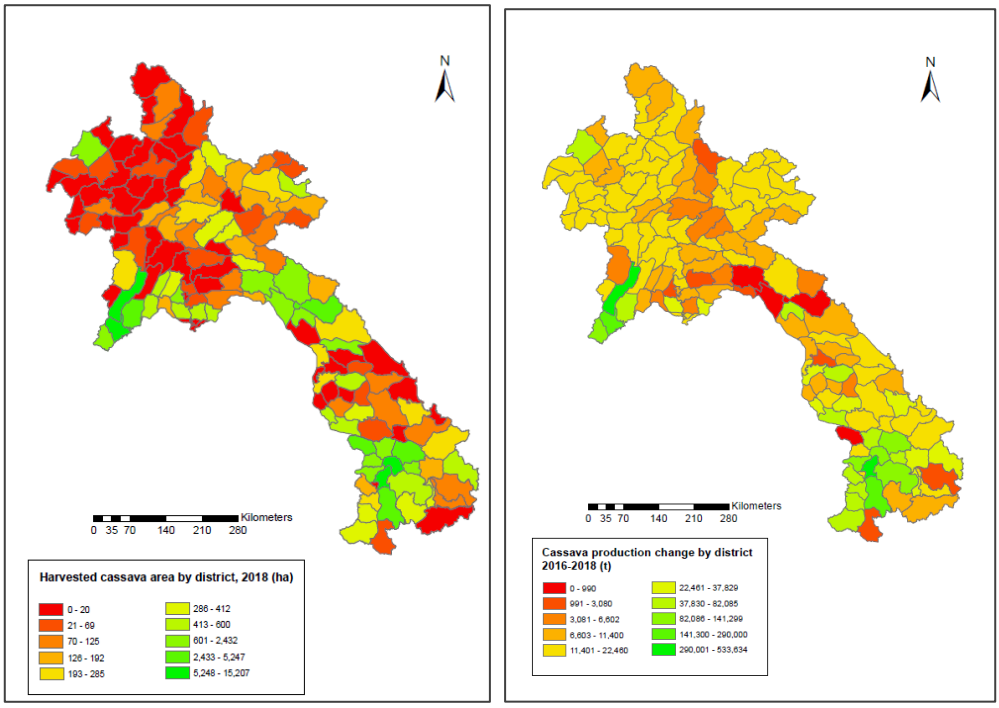
1.4	Conduct household surveys in case study areas to determine current farm-household types, livelihood activities, production practices, market linkages, decision-making, and constraints to adoption of improved practices.	Household survey reports	July 2017	**Laos:** Household surveys were completed in Bolikhan and Viengthong districts of Bolikhamsay betwee May-June 2017, with a total of 180 surveys undertaken for the province. Surveys were completed in Xayabouly Province in July 2017. A total of 180 surveys were completed in Paklai and Kenthao Districts. **Cambodia:** A total of 311 surveys were undertaken in Kratie and Stung Treng **Reports and Presentations** The results of the household surveys have been included in project discussion papers and presented in various workshops, symposia and international conferences.

1.1 Review information on global and national cassava production, utilisation, trade, and policies

The project has been monitoring developments in the regional and global cassava markets and communicating the information to stakeholders. A comprehensive database has been created to monitor price and trade flows utilising published data, online national databases, and industry contacts. However, price series data is more difficult to construct in Laos and Cambodia relative to Vietnam and Thailand.

Trade data from the Lao Ministry of Industry and Commerce was accessed, with a lag of around one year. However this data was useful as it separated the export of cassava roots and cassava chips and also specified which port products were flowing.

Production data was also problematic to collect beyond the Province level and with a year lag. In Laos, the District level data was accessed through the individual year books of the Province. This data is held by DOA and was accessed via contacts in the Department of Policy and Law. Similarly, there is no central repository of district level data in Cambodia. GDA staff were able to consolidate district level data for the main cassava producing provinces by contacting the PDAFF in each Province. As such, the project has assembled the most comprehensive dataset of district cassava production that exists and is working to make this available online. Serious issues remain with the accuracy of data reported with informal discussion indicating that this could be underestimated by a factor of five is some districts depending what the target is.



Example of district level data in Lao PDR. Panel a) District area in 2018; Panel b) Change in production 2016-2018

Results from an analysis of the collected information have been presented in a number of workshops, conferences, as well as through the web via blogs and social media.
The updated database has been maintained and summary information has been made available through the program website (www.cassavavaluechains.net), as well as through Facebook updates. Other direct outlets for information sharing have included presentations at local and national stakeholder workshops, research symposia and research and industry conferences including the World Roots and Tuber congress, Starch World , CIAT Cassava Retreat, Agribusiness Master Class, North-West Vietnam Research Symposium, Mid-term review/research symposium (Vientiane, 2018), GCP21 IVth International Cassava Conference (Contonou, Benin, 2018), NAFRI 20th Anniversary Symposium (2019), and the regional research symposium (North Sumatra, 2019). The theory and analysis of the importance of understanding global markets and how they impact rural livelihoods was also used as a case study in the ACIAR Agribusiness Insights Webinar Series[1].

1.2 Conduct value chain analyses in case study areas

Value chain assessments were initially undertaken in Kratie (Cambodia) during May 2016. This assessment included farmer focus groups and semi-structured interviews with value chain actors. Similar value chain assessments were also undertaken in Bolkhamsay (Laos) during May 2016 in Bolikhan and Vienthong Districts and in October 2016 in Xayabouli in Kenthao and Paklai districts.

Participants in the value chain training in Vientiane in May 2016 learned the basic principles of value chain analysis and conducted a preliminary value chain mapping exercise. This formed the foundation for site selection of key production and value chains for more detailed analysis in the field.

[1] Seminar can be viewed online: https://www.youtube.com/watch?v=3IDkuB_x2Cg

Members from NAFRI Policy Research Centre and Agricultural Research Centre and representatives of PAFO and DAFO conducted value chain analyses in Kenthao and Paklai districts in Xayabouli. The team from NAFRI worked independent from the UQ-CIAT team after the completion of activities in Bolikhamsay. Skills learnt were subsequently applied to the cassava value chain in other regions of the country and different commodities outside of the project with the results informing the broader body of knowledge and dialogues[2].

Importantly, these activities provided the entry point for many subsequent interactions with key value chain actors. This included frequent meetings and discussions, involvement in local field days, involvement in national stakeholder dialogues, and also the opportunity for some to join events beyond their own country[3]. The local value chain continued to evolve in each location over the life of the project with new factories, closers of factories, and new polices.

Significant consideration was given to which private sector were engaged with in the project based on interactions and assessment of their business sustainability.

1.3 Conduct key informant and group interviews in case study areas

In conjunction with the value chain analyses, focus group discussions were conducted with small groups of farmers ranging between 10 and 15 individuals. Some activities were conducted as a single group, others in mixed gender groups, and some by gender groups. The key topics discussed were:

1. Key village information (village chief and committee)
2. Listing of all livelihood activities (agricultural, non-farm, off-farm, migration)
3. Ranking of relative importance of activities for food security, cash income, labour utilisation (smaller groups by gender)
4. History of cassava production and marketing in the village and other key events
5. Seasonal calendars (smaller mixed gender groups)
6. Cassava production enterprise budgets (smaller mixed gender groups)
7. Mapping of the cassava value chain (smaller mixed gender groups)
8. Discussion of production and marketing problems (smaller groups by gender)
    - Ranking of these problems
9. Discussion on potential solutions and interventions (smaller groups by gender)
    - Ranking of these solutions

In addition to focus group discussions, information was gathered from value chain actors through face-to-face interviews using a standardized questionnaire. Value chain actors interviewed included large and medium scale starch and dried chip processors, small-scale collectors and assemblers, medium scale traders and larger scale traders and brokers.

Focus groups discussions with farmers and key informant interviews continued each year, particularly during harvest field days. Enterprise budgets were redeveloped and scenario analysis conducted based on the current prices and yields, as well as farmers perceptions of the downside and upside risk.

[2] Cassava value chain studies were conducted in Champasak and Salavan Province with support from SDC. Results were presented in the project policy dialogue workshop.

[3] Government and Private sector actors participated in the Research Symposium in Indonesia in 2019

1.4 Conduct household surveys in case study areas

Baseline household surveys to determine current farm-household types, livelihood activities, production practices, market linkages, decision-making, and constraints to adoption of improved practices were developed and implemented in conjunction with partners in Laos and Cambodia. Surveys were translated into Laos and Khmer and loaded onto electronic tablets running the Commcare app.

Training on the household survey and the use of electronic tablets for surveys was undertaken for the Lao survey teams in Vientiane in July 2017. Pre-testing was also undertaken in Vientiane and Bolikhamsay at that time to build the practical experience of the survey teams and to identify any potential challenges with the electronic surveys. Household surveys were undertaken in Bolikhamsay between May and June 2017 and in Xayabouly in July 2017. A total of 180 households were surveyed in each province, with the survey being undertaken in two districts per province.

Training on the household surveys and the use of electronic tablets for surveys was undertaken for the Cambodian survey team in Kratie in July 2017. Household surveys were completed in Kratie (201 households) and Stung Treng (110 households) during September and October 2017.

The survey tool was also shared with a sister ACIAR project operating in western Cambodia who have now also completed their baseline survey. Comparative analysis is planned between the projects.

Data from the household surveys in Laos and Cambodia have been collated, cleaned and country specific and cross-cutting analysis has been undertaken. The results of the survey have been presented at the MTR/Research Symposium in Vientiane (2018), the NAFRI 20th Anniversary Symposium, Laos, (2019) , Regional research symposium in North Sumatra (2019) and have also been included in Country Profile papers and in a series of Cassava Program Discussion Papers (available at www.cassavavaluechains.net).

Data has also been shared with other research groups within RTB who have published based on the dataset, including a recent publication on gender perspectives on pest and disease management.[4]

[4] https://www.frontiersin.org/articles/10.3389/fagro.2020.00007/full?&utm_source=Email_to_authors_&utm_medium=Email&utm_content=T1_11.5e1_author&utm_campaign=Email_publication&field=&journalName=Frontiers_in_Agronomy&id=554744

Objective 2: Increase the adoption of improved cassava production, resource management, and post-harvest practices by strengthening linkages between farmers and research, extension, and industry actors.

No.	Activity	Outputs/ milestones	Date Completed	Comments
2.1	Conduct workshops with identified stakeholders in each site to plan, prepare for, and review cooperative activities.	Workshops successfully conducted and reported.	March 2017	In Feb 2017 a small planning workshop was held in Vientiane with NAFRI, Province, and District staff, to plan activities and responsibilities. The team planning meeting was held at CARDI in March 2017 to plan activities and develop protocol.
2.2	Establish on-farm demonstration trials of improved cassava cultivation practices and conduct participatory evaluation of new varieties, fertility management, pest and disease management, intercropping, and post-harvest practices with farmers and other industry stakeholders.	On-farm trials successfully established Evaluation reports prepared	Establish Mar-Apr 2017 Harvest reports in Feb-March 2018-2019	A total of 87 on-farm demonstrations (i.e. 64 in Laos and 23 in Cambodia) were conducted to disseminate project recommended technology (i.e. sowing method, timely weeding and fertiliser application) and use of high yielding varieties. In all demonstrations with very few exception; average yield of project recommended technology produced higher yield compared to framers' practice.
	On-station research of key constraints, fertiliser balance and disease resistance (i.e. Cassava Mosaic Disease) to cassava production	Potassium balance in cassava production systems quantified; and partial resistances to CMD has identified	April 2020	Experiment on potassium balance was conducted. Result from the experiment was communicated to farmers via on farm demonstrations; commercially available fertiliser mix N:P_2O_5:K_2O (14-5-35) and N:P_2O_5:K2O (15-7-18) has been tested in Laos and Cambodia. Experiment on management of CMD was conducted in Cambodia. Best options from the results were communicated to farmers in on farm demonstrations (i.e. use of clean planting material, and variety KU50).

2.3	Develop business cases for value-chain actors to invest in adoption of improved technologies (e.g., production and supply of clean planting material, dissemination of information on pest and disease management, supply of suitable fertilisers and nutrient management information, provision of credit).	Business cases documented and discussed with stakeholders	April 2017 October 2017 July 2017-Jun2018	Economic Analyses and business case development was started in conjunction with the value chain analysis. Economic analysis of 2017-18, 2018-2019 and 2019-2020 trials have been conducted and have informed analysis of benefits and costs for different value chain actors.
2.4	Document successful models for supporting cassava smallholders in adopting improved practices, highlighting roles for farmer groups, industry stakeholders, and government research and extension services.	Working papers on smallholder models	July 2020	Working papers have been prepared on the role of value chains in disseminating technologies, including new varieties, fertilisers and improved soil management techniques. Potential models for cooperation between different stakeholder groups have been discussed at stakeholder meetings at both provincial and national levels Follow up interviews with farmers, government and industry stakeholders have been conducted in 2020.

2.1 Identification of priorities

The value chain analysis and focus groups provided some initial ideas from different stakeholder perspectives on the key limiting factors and potential interventions. Discussion on these topics were conducted at the mid-term review meeting, national and provincial stakeholder workshops, and other planning meetings to develop annual strategies related to project activities.

After the value chain assessment, it was decided that while some value chain actors would benefit from increasing productivity it was risky for strong engagement this early in the project due to the current market uncertainties, high levels of debt, and weak existing relationships. This is different to the situation in the parallel AGB project. Therefore, a stronger partnership with local government and NGOs in was pursued initially with private sector actors invited to participate in training and harvest field days.

An important point is that individual (people and personalities) rather than positions play an important role in determining the success or otherwise of engagement with government and industry stakeholders. Government staff and those working in the private sector are subject to relocation or reassignment.

2.2 Establish on-farm demonstration trials

During the project, recommended technology (i.e. sowing method, timely weeding and fertiliser application) for the cultivation of cassava was disseminated among farmers through

specific activities described below in project districts of Laos and Cambodia. The aim was to expand the use of new technologies among growers; and find the best and most economic fertiliser rate for achieving high cassava yields. A few experiments were also conducted to optimise recommendations. Focusing on injection of quality planting material, multiplication of popular varieties was also carried out on station and also in project districts.

Laos

Experiments, trials and demonstrations were undertaken at 4 Districts, Paklai, Kenthao of Xayaboury and Viengthong and Bolokhan of Bolikhamxai province of Laos.

Cropping season 2017-18

The first set of experimental trials were undertaken at 4 Districts, Paklai, Kenthao of Xayaboury and Viengthong and Bolikhan of Bolikhamxai province of Laos.

Germplasm evaluation: Six high yielding cassava varieties (Rayong9, Rayong11, Rayong72, KU50, KM21-12, KM140) along with farmers' variety were evaluated. Four on-farm demonstrations were conducted in four districts to demonstrate optimum cultivation practices (sowing method, timely weeding and fertiliser application) and expand the use of new technologies among growers.

Effect of fertiliser application: A total of four demonstrations were conducted in four districts to show the benefit of fertiliser application against farmers' practice. Five different fertiliser rate (i.e. N40 P10 K0, N40 P10 K40, N40 P10 K40 + Cow Manure 5 t ha^{-1}, Market available fertiliser- 15:15:15 = at 40N-40-P_2O_5-40K_2O, N80 P20 K80) were compared with No fertiliser application. In Paklai and Kenthao Districts 2 varieties KU50 and Rayong11; and Viengthong Districts Rayong72 were include in place of KU50 due to scarcity of planting material.

Intercropping of cassava with short duration crops: One demonstrations of intercropping of cassava was established in Paklai Districts. Farmers were very enthusiastic about the potential to get extra income from the same field where cassava was growing. However, due to heavy rain during establishment period both intercrop and Cassava could not germinate due to soil waterlogging for extended period. Following intercropping systems were established- Cassava + mung bean 2 rows, Cassava + peanut 2 rows, Cassava + yard long bean 2 rows to compare with Cassava mono culture.

Cropping season 2018-19

Objective of demonstrations were to engage farmers and allow them to experience in their own field the effectiveness of improved management practices (1) fertiliser application the highest root yield, (2) most monetary benefit taking into account input cost. Furthermore, on station experiment on nutrient [i.e. potassium (K)] removal from cassava system was evaluated and response to different combination of fertiliser was evaluated on farmers' field. This was seen as important due to a strong interest by government and processors for the production of organic cassava, which would likely lead to the mining of potassium from the soil. Multiplication of popular varieties were carried out on station.

Demonstrations on effect of fertiliser application: Focus was to ensure use variety that performed well during germplasm evolution in 2017-18 season (i.e. Rayong11) and use of appropriate management practices (i.e. fertiliser application and timely weeding). Each field was 400 m^2 (20 x 20) where 20 m x 10 m was fertilized and 20 m x 10 m was with un-fertilized. A total of 15 on-farm demonstration was carried out (Annual Report 2018). Commercially available NPK (15-5-30) 300 kg ha^{-1} was applied (i.e. 45N-15P-72K) to individual plants in two batches-at planting and at 8 weeks after planting.
Response to different fertiliser combinations along with commercially available fertiliser mix were evaluated on-farm in randomized complete block design (RCBD) with three replications in two provinces (i.e. Xayaboury and Bolikhamxay). There were 4 treatments: P_1- No

fertiliser, P_2- N: P_2O_5: K_2O (15-5-30): 300 Kg ha^{-1}, P_3- N: P_2O_5: K_2O (40-20-40), P_4- N: P_2O_5: K_2O (80-20-80). The experimental unit size was 30 m^2 and planting density was 10,000 plants ha^{-1}.

<u>*On-station experiment*</u>: To evaluate Potassium balance in cassava crop an experiment was carried out at the National Agricultural and Forestry Research Institute (NAFRI) at Naphok, Vientiane, Laos. In 2016, sweet potato was grown on the same field and in 2017, cassava was grown without management. A split plot completely randomized design was with three replicates and plots were 9 X 6 m. Cassava variety Rayong11 was used and five fertiliser treatments (NPK), T_1 No fertiliser, T_2 40-20-0, T_3 40-20-40, T_4 40-20-80 and T_5 40-20-120 were applied.

Cropping season 2019-20

The main aim of the 2019-20 season was to expand the number of farmers testing fertiliser on their own farms. During 2019-20 season a total of 40 demonstrations and one fertiliser experiment was carried out. Fertiliser experiment with 5 treatment in two districts, un-replicated on farm demonstration with 3 treatment and with 2 treatments in 4 project districts were carried out with farmers who were willing to participate. In these demonstrations, two commercially available fertiliser mix were tested N:P_2O_5:K_2O (14-5-35) and N:P_2O_5:K2O (15-7-18) along with single mix fertiliser and without any fertiliser (Annual report 2020).

Results

During cropping season 2017-18, six high yielding cassava varieties along with farmers' variety were evaluated. Varieties did not differ significantly in fresh root yield (P=0.064). However, location (i.e. Paklai, Kenthao and Viengthong) had significant (p<0.001) effect on root yield. On an average Paklai District demonstrated highest and Viengthong lowest yield (Annual report 2018). Among the cassava varieties Rayong11 produced the highest fresh root yield (25.9 t ha^{-1}, average from three Districts) and KM-21-12 yielded the lowest (19.2 t ha^{-1}) (Table 2.2.1). In these three trials farmers' variety yielded 22.6 t ha^{-1}. In these trails all plots were infected by CWBD. Presumably, all the plants were equally affected by the disease. Out of four trials, we managed to get data from three trails due to premature harvest by farmer from Bolikhan District as root price was higher compared to previous years.

Table 2.2.1 Mean fresh root yield (t ha^{-1}) and Starch content (%) of all three districts. Values are the means of three districts, Paklai, Kenthao and Viengthong, and values within a column followed by different letters are significantly different ($P < 0.05$).

Variety	Fresh Root yield (t ha^{-1})	Starch content (% fresh root weight)	Starch yield (t ha^{-1})
Rayong11	25.91[a]	30.67[a]	7.9[a]
KM140	23.59 [ab]	23.54[bcd]	5.5[b]
Rayong72	23.19 [ab]	23.60[bcd]	5.6[ab]
Local	22.58 [ab]	25.57[bc]	5.7[ab]
Rayong9	22.19 [ab]	26.70[b]	6.3[ab]
KU50	20.12 [ab]	21.65[d]	4.7[b]
KM21-12	19.16 [b]	22.76[cd]	4.7[b]

We demonstrated benefit of fertiliser application against farmers' practice in 4 districts during 2017-18 cropping season. Varieties responded similarly to fertiliser application- no fertiliser treatment produced the lowest and high fertiliser produced highest yield (Table 2.2.2). Fertilize treatment X variety interaction was not significant. The average fresh root yield was 19.0, 27.1 and 17.9 for Paklai, Kenthao and Viengthong Districts, respectively, considering all varieties and all fertiliser treatment. Considering all three Districts and 3 varieties included in the trails, highest yield (25.1 t ha^{-1}) was achieved by highest fertiliser application. Moderate fertiliser application with manure also yielded (24.1 t ha^{-1}) very close to highest rate of fertiliser input. In general fertiliser application yielded 1.4- to 1.7-fold higher fresh root

compared to Farmers' practice and without any fertiliser application. Fertiliser application did not show any effect on starch content.

Table 2.2.2 Fresh root yield (t ha^{-1}) of KU50 and Rayong11 while applied different fertiliser rate in three districts, Paklai, Kenthao and Viengthong Districts. **P_0** No fertiliser, **P_1** 40N-10P-0K, **P_2** 40N-10P-40K, **P_3** 40N-10P-40K + Manure (5t ha^{-1}), **P_4** N-P-K (15-15-15), **P_5** 80N-40P-80K.

	Fertiliser					
Variety	P_0	P_1	P_2	P_3	P_4	P_5
KU50	17.2	18.8	18.6	21.4	19.7	23.7
Rayong11	18.1	22.3	25.1	27.9	23.9	28.2
Variety	P<.001	L.S.D.= 2.51				
Fertiliser	P=0.005	L.S.D.= 4.34				
Variety x Fertiliser	P=0.808	L.S. D= 6.14				

Data for Rayong72 not presented and kept out of calculation as it was only used as replacement for KU50 in one district (i.e. Viengthong).

For scaling up of the results of previous year (2017-18) demonstrations of effect of fertiliser, large plot on-farm demonstrations were organised during 2018-19. The root yield was consistently low, ranged from 12.3 to 26.4 t ha^{-1} when grown without any fertiliser. The yield increase was 1.1 to 1.7-fold when fertiliser was applied (Annual report 2018). Bolikan district had the lowest yield for both treatments compared to other districts; however, demonstrated highest yield increase with fertiliser application. By contrast, Vienthong district demonstrated list yield increase with fertiliser; however, yielded highest (26.4 t ha^{-1}) without any fertiliser application. The district x fertiliser treatment interaction was not significant for fresh root yield.

During the final year of the project, commercially available fertiliser blend with two different K:N ratio (i.e. 2:1 and 1:1) were tested in 4 districts and compared with without fertilize application. Fertiliser application increased cassava root yield compared to cassava grown without fertiliser by 1.5-fold and 1.4-fold while K:N ratio was 2:1 and 1:1 in fertiliser blend, respectively (Table 2.2.3). Highest yield increase (i.e. 1.8 fold) and lowest yield increase (i.e. 1.2-fold) was observed in Viengthong and Bolikan district, respectively, with K:N 2:1 ratio.

Cropping history of the farmers' field presumably contributed to the response of the fertiliser application on cassava root yield. At Paklai the cropping history was the oldest, ~11 years, of continuous cassava without any fertiliser inputs (data not shown), where lowest yield was observed when grown without fertiliser application (13 t ha^{-1}), however, yield increase with fertiliser was high (1.7-fold). Bolikan district had the highest yield (24.1 t ha^{-1}) compared to other districts when grown without fertiliser had the cropping history of 6.5 years of continuous cassava without any fertiliser inputs (data not shown). Kenethao and Viengthong district had the cropping history of 4 and 5 years of cassava cultivation without fertiliser, demonstrated similar response to fertiliser application, average 1.7-fold increase in yield (calculated from Table 2.2.3). Furthermore, when analysed all 40 demonstrations fertiliser application increased yield by ~38% compared to without any fertiliser application.

Table 2.2.3 Fresh root yield (t ha^{-1}) and starch content in four districts of Laos during the season 2019-20. Values are the means of trails in each district (2 trials in each district. n.s., non-significant.

District	Fresh root yield (t ha^{-1})			Starch content (%)		
	No Fertiliser	With Fertiliser N:P_2O_5:K_2O (14-5-35)	With Fertiliser N:P_2O_5:K_2O (15-7-18)	No Fertiliser	With Fertiliser N:P_2O_5:K_2O (14-5-35)	With Fertiliser N:P_2O_5:K_2O (15-7-18)
Kenethao	15.3 ± 8.03	25.2 ± 6.40	25.3 ± 6.69	28.0 ± 1.03	27.6 ± 0.64	27.8 ± 2.16
Paklai	13.0 ± 3.57	21.6 ± 1.53	20.1 ± 1.57	23.1 ± 1.43	26.7 ± 1.14	26.7 ± 1.88
Viengthong	18.4 ± 5.95	32.5 ± 2.78	28.7 ± 3.97	30.6 ± 0.58	33.5 ± 0.07	32.3 ± 0.34
Bolikan	24.1 ± 0.10	28.9 ± 3.68	36.7 ± 3.26	26.9 ± 3.13	29.9 ± 1.87	26.6 ± 1.32
Fertiliser	n.s.			n.s.		
Fertilize X Location	n.s.			n.s.		

While the yield increases associate with the application on average produces a positive net benefits under all price scenarios considered, the marginal rate of return[5] (MRR) is relatively small when price decline to the lowest level experienced during the project life. Furthermore, when considered individually, there are households that either have negative net benefits or a low MRR at all prices considered.

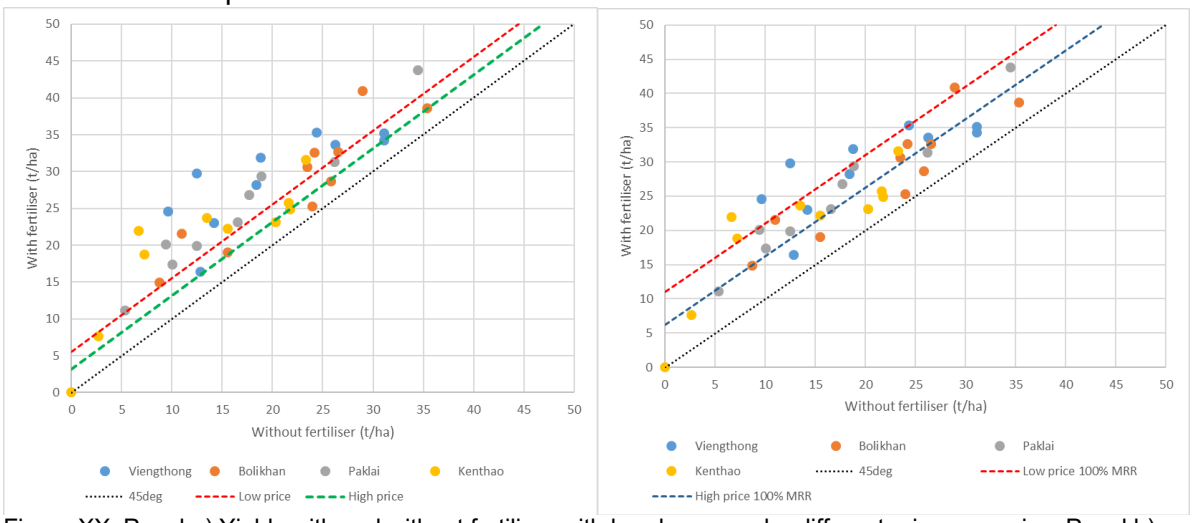


Figure XX. Panel a) Yields with and without fertiliser with breakeven under different price scenarios; Panel b) Yields with and without fertiliser with lines representing yield increase to achieve a 100% MRR.

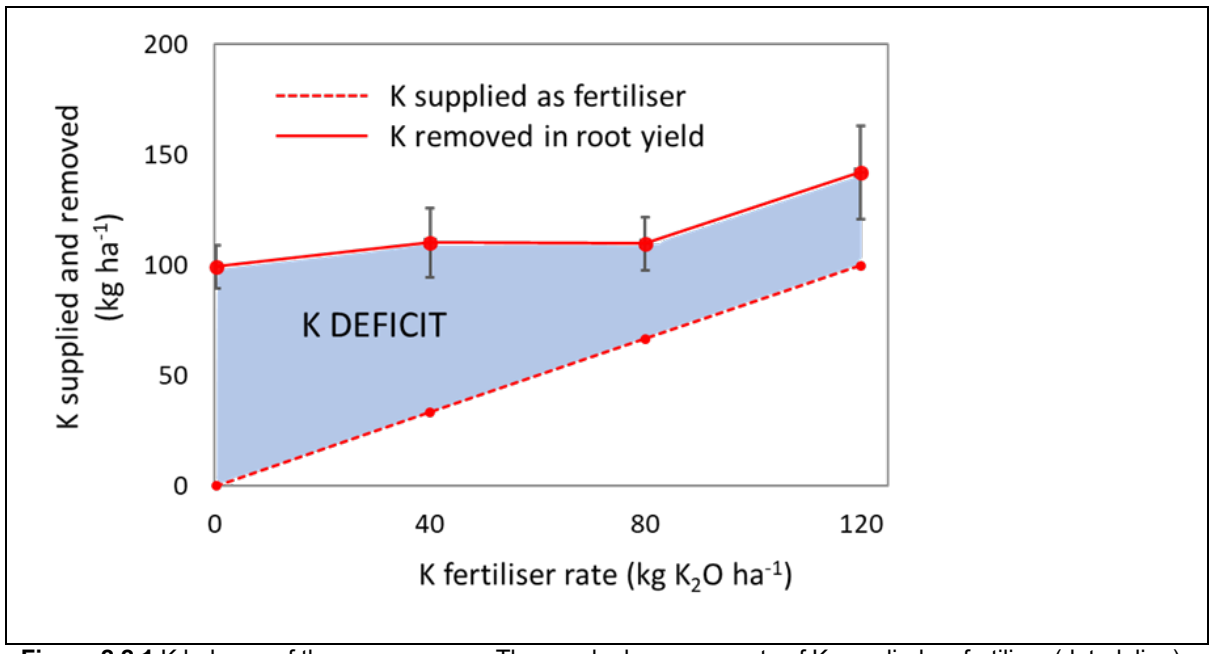


Figure 2.2.1 K balance of the cassava crop. The graph shows amounts of K supplied as fertiliser (doted, line) and removed in tuber yield (solid line) at the harvest 2, for treatments N-P_2O_5-K_2O (kg ha^{-1}) T_2 40-20-0, T_3 40-20-40, T_4 40-20-80 and T_5 40-20-120. Values are means of three replicates ± s.e. for K removed in tuber yield.

We also carried out an on-station experiment during 2018-19 season, to determine the growth response to K fertiliser and to examine the field's K balance over the cropping season We found a positive effect of K fertiliser (up to 39% yield increase compared to no K

[5] MRR = (Additional income from fertiliser – cost of fertiliser)/cost of fertiliser

fertiliser at early harvest, 21% at late harvest) and a positive effect of late harvest (on average a 35% increase compared to early harvest) on cassava root yield. Low-K crops benefited more from a late harvest. At 10 months, the harvested cassava contained 99-142 kg K ha^{-1}, indicating that there was a net removal of K from the fields, even at high K fertilisation levels. This experiment was carried out in comparatively fertile soil with relatively high background K levels, yet yield benefits of K fertilisation were observed and soil K reserves were depleted by the harvest. We concluded that K fertilisation of cassava is advisable for better yields and to avoid progressive depletion of the soil K capital.

Cambodia:

Experiments, trials and demonstrations in Cambodia were undertaken at 2 Districts, Snoul and Chet Borei of Kratie province; and also in Stung Treng and Kampong Cham provinces.

Cropping season 2017-18

Germplasm evaluation: Six high yielding cassava varieties (Rayong72, KU50, Hauybong60, KM-98-1, SC9 and SC8) along with farmers' variety were evaluated. Four on-farm demonstrations were conducted in 2 Districts (i.e. Snoul and Chet Borei) of Kratie provience. However, we managed to get data from only one trail due to premature harvest by farmers' as root price was higher compared to previous years. Furthermore, at DT Company field, Kratie province, we evaluate following verities SC8, KU50, SC9, KM 98-1, HauybBong60, Rayong1 and Company1 in 2016-17 season.

Demonstration for effect of fertiliser application: A total of 4 demonstrations were conducted in Snoul and Chet Borei Districts to show the benefit of fertiliser application against farmers' practice. Five different fertiliser rates (i.e. N80 P20 K80, N40 P10 K40, N40 P10 K0, N40 P10 K40 + Cow Manure 5 t ha^{-1}, Farmer practice- 20:20:15 = 100 kg ha^{-1}) were compared with No fertiliser application. Furthermore, at DT Company field, Kratie province, two varieties were evaluated to response to 12 different NPK combinations (see Table).

Demonstration for intercropping of cassava with short duration crops: A total of 4 demonstrations of intercropping of cassava was established. Farmers were very enthusiastic about the potential to get extra income from the same field while cassava was growing. However, we could not capture data as Farmers hurriedly harvested cassava when fresh root price went up early into the season. Following intercropping systems were established- Cassava + mung bean 2 rows, Cassava + peanut 2 rows, Cassava + corn 1 row to compare with Cassava mono culture.

Extending the harvest window: Cassava variety KU50 grown for extended period (i.e. up to 17 month) to see the effect on the yield. Experiment was carried out in three replicates and was planted on 25 June 2016. Harvest were done at 8, 11, 14 and 17 months after planning. Experiment was ended on November 2017.

Seed multiplication: Due to outbreak of Cassava mosaic disease (CMD) during 2017 season there was a scarcity of healthy seeds (i.e. stakes) for 2018 season. Following varieties were planted for multiplications during 2017: KU 50, Rayong72, Rayong60, Rayong 5, Hauybong60, KM98-1, SC8 and SC9. Multiplied seeds were used for on-farm demonstrations for 2018 season.

Cropping season 2018-19

Primary focus was to evaluate yield penalty due to CMD. In that light major activities were carried to demonstrate advantage of the planting disease free stakes and to minimize yield loss by adopting management package. Due to the results in Laos showing that Rayong11

featured good resistance to CWBD, the variety was introduced to Cambodia from TTDI in Thailand for inclusion in on-station activities, to be subsequently distributed to farmers.

Germplasm evaluation: A total of 6 popular varieties, comprised of 4 varieties from Thailand-Rayong5, Rayong60 Rayong72 and HuayBong60 and 1 each from Vietnam-KM98-1 and Local variety Farmer's choice were evaluated. A total of four trials, two trials in Snoul and 1 each in Chetborei and Steng Treng were conducted. The plot size and plant density was different in different trial (Annual report 2018).

Demonstration for effect of fertiliser application: A total of 3 fertiliser combination was evaluated and compared with no fertiliser application in the same area as described above for Germplasm evaluation trials. Three different fertiliser rates were N20-$P_2O_5$05-K_2O20, N40-$P_2O_5$10-K40 and N80-$P_2O_5$20-K_2O80 as mentioned for variety trial (Annual report 2018).

On station experiment: Screening for resistance to CMD was carried out in heavily infected area at Kampong Cham in two sites on GDA farm. In the experiment 6 varieties- KU50, Rayong11, Hauybong60, Rayong5, SC8 and KM98-1 were included. Two treatments, with (80N-20N-80K) and without fertiliser were also included to determine whether management impacted the appearance of symptoms and yield losses. Importantly, the results showed that Rayong11 was highly susceptible to CMD and the strategy for multiplication in Cambodia and Laos need re-evaluation.

Cropping season 2019-20

Demonstration for effect of fertiliser application: A total of seven demonstrations at five sites in project districts were carried out. Each site belonged to a farmer who agreed with the project. Variety KU50 was used and were collected as positive selection from farmer fields in Tboung Khmum province except for one farmers' trial (Annual report 2020). Each plot or variety was divided into two sub-plots with one sub-plot subject to the recommendation fertiliser rate of N20-P05-K20 (Urea: 44 kg ha^{-1}; single superphosphate: 16 kg $ha^{-1}$and KCl: 34 kg ha^{-1}) and the other sub-plot without any fertilisers. At Stung Treng, to test the efficacy of market-available fertiliser [N:P_2O_5:K_2O (14:7:35)] and compared with individual fertiliser application carried out where variety KU50 was used and was sourced from Thai Tapioca Development Institute (TTDI). Monitoring of the rate of CMD infection was recorded and number of asymptomatic plants at the end of the season recorded. Samples from Stung Treng were collected have been sent for PCR analysis with the results unknown at this stage[6].

On station experiment: To quantify the yield penalty due to planting infected (i.e. CMD) planting material was carried out in heavily infected area at Kampong Cham on GDA farm. In the experiment Six varieties of cassava—KU50, Rayong11, Hauybong60, Rayong5, SC8 and KM98-1(6)—were sown from three sources of planting material: (1) positive selected (i.e. visually healthy looking plants) planting material from 2018–19 multiplication block, (2) symptomatic planting material from 2018–19 experiment and (3) clean planting material from TTDI. Due to their disease susceptibility, no clean planting material of SC8 or KM98-1 (6) was available for planting. We replaced SC8 with another line (TME3), reputed to be cassava mosaic disease (CMD) tolerant, obtained from TTDI, and KM98-1(6) with HB80. Optimum fertiliser (80 N: 20 P_2O_5: 80 K_2O) was applied. The experiment had a randomized block design with four replications.

Results

During cropping season 2017-18, six high yielding cassava varieties along with farmers' variety were evaluated. Data from Snoul District demonstrated that varieties differed

[6] The CAVAC program provided additional funding for PCR analysis

significantly in fresh root yield (P < 0.05) (Table 2.2.4). Among the cassava varieties KU50 produced the highest fresh root yield (30.2 t ha^{-1}) and farmers' variety was the lowest (16.0 t ha^{-1}). In this trail all the plots were infected by CWBD and infested by mealy bug. Presumably all the plants were equally effected by the pest and disease. Varieties differed significantly (P < 0.05) in starch content. Highest starch content was achieved by Rayong72 (i.e. 28%) and the lowest was 23% for SC9 (Annual report 2018). At DT company land, there was variation among the varieties, however, it was not significant (Table 2.2.4).

Table 2.2.4 Fresh root yield (t ha^{-1}) of nine popular Cassava varieties of Cambodia from two trials, in Snoul district and in DT company land at Kratie province during the season 2017-18. Values are means of three replicates and within a column followed by different letters are significantly different (*P* < 0.05)

Variety	Fresh root yield (t ha^{-1})	
	Snoul district	DT Company land
KU50	30.17[a]	30.0 ± 1.7
Hauybong60	25.94[ab]	21.2 ± 1.0
Rayong72	25.41[ab]	-
KM-98-1	24.91[abc]	25.5 ± 1.5
SC8	22.29[abc]	34.3 ± 1.8
SC9	19.44[bc]	28.4 ± 9.7
Farmer variety	15.97[c]	-
Rayong1	-	17.7 ± 1.8
Company1	-	17.9 ± 0.4

There was no significant difference among the varieties at DT company land

At start of the project during 2016-17 season, two cassava varieties, KU50 and C1, were used in an experiment with 12 different NPK combinations (Table 2.2.5) on a company land. Fresh root yield increased for both varieties with increasing N level in the fertilizer. Highest yield for C1 (27 t/ha) and KU50 (41 t/ha) was obtained when 80 kg ha^{-1} N was applied (i.e. NPK-80:40:80). Although, data presented here is only one replicate as other three replicate plots were affected by soil waterlogging and yield was much less (i.e. between 2 to 12 t/ha). Further increase of N (160 kg ha^{-1}) fertilizer did not increase root yield, on the contrary it was decreased for both varieties.

Table 2.2.5 Effect of fertilizer rate on fresh root yield and root starch content of two varieties of cassava, C1 and KU50. Values represent means ± standards errors (n=4).

Treatment	Fertilizer	Fresh Root yield (t ha^{-1})		Root starch content (%)	
		C1	KU50	C1	KU50
0	0	13.5 ± 1.8	20.3 ± 1.8	19.5 ± 0.8	20.8 ± 1.5
NP	80:40	18.4 ± 1.6	23.6 ± 4.6	21.2 ± 2.3	21.3 ± 3.3
NK	80:80	14.6 ± 2.7	19.7 ± 1.4	19.6 ± 1.7	19.9 ± 1.6
NPK	24:12:66	17.0 ± 3.1	22.0 ± 2.7	18.9 ± 1.9	19.0 ± 3.0
NPK	40:40:80	18.0 ± 1.5	23.0 ± 0.0	18.4 ± 3.1	18.2 ± 1.5
NPK	80:40:80	27.0 ±*	41.0 ±*	20.0 ± 3.3	19.6 ± 2.3
NPK	160:40:80	18.0 ± 2.8	25.0 ± 2.8	18.3 ± 3.3	20.0 ± 2.3
NPK	80:20:80	13.7 ± 4.3	23.5 ± 6.1	19.9 ± 1.4	18.9 ± 0.7
NPK	80:80:80	17.7 ± 0.7	33.2 ± 2.8	19.6 ± 1.7	20.5 ± 1.1
NPK	80:40:40	15.5 ± 4.2	23.3 ± 3.4	19.0 ± 3.3	22.2 ± 1.7
NPK	80:40:160	18.6 ± 2.8	25.8 ± 3.1	20.2 ± 2.5	17.4 ± 2.6
NPK	160:80:160	14.9 ± 1.4	24.3 ± 1.9	20.2 ± 0.7	20.2 ± 1.3

*only 1 replicate.

Following year, we demonstrated benefit of fertiliser application against farmers' practice in 4 districts during 2017-18 cropping season. Root yield was significantly different ($p<0.001$) between two locations (Table 2.2.5). However, there was no difference between the treatments in each location due to large variability caused by biotic (root rot, CMD and CWBD) stresses. The average fresh root yield was 1.4- to 2.2-fold higher in the Snoul District compared to Chet Borei District. The highest yield (26.3 ± 6.7 t ha^{-1}, Snoul) was achieved with highest fertiliser rate, however, in Chet Borei District highest yield was 17.6 ± 1.0 t ha^{-1} with moderate fertiliser application. In general fertiliser application yielded higher fresh root compared to Farmers' practice and without any fertiliser application.
Fertiliser treatment responded similarly in both location and starch content was significantly different ($p<0.001$) between two locations. Application of fertiliser increased starch content in all treatments ranged from 22.1 to 28.9 % (Annual report 2018). Out of four trials, we managed to get data from two trails due to premature harvest by farmers from other two trials.

Table 2.2.5 Fresh root yield (t ha^{-1}) with different fertiliser rate in districts of Kartie province. Values are means of three replicates.

Treatment	Chet Borei	Snoul
No fertiliser	9.7	14.0
N40 P10 K0	14.2	21.2
N40 P10 K40	17.6	20.3
N40 P10 K40 + CM 5t ha^{-1}	11.0	24.2
N80 P20 K80	12.9	26.3
Farmer practice*	11.8	19.3
Fertiliser	P= 0.172, L.S.D.= 6.31	
Location	P<0.001, L.S.D.=3.64	
Fertiliser x Location	P=0.403, L.S.D.=8.92	

*(20:20:15=100kg/ha), CM, cow manure.

During 2018-19 season we conducted demonstrations in three districts in four farmers' field. Among the varieties across all locations farmer's choice variety yielded highest, ranged from 20.6 to 39.7 t ha^{-1} and Rayong 5 yielded lowest, ranged from 14.8 to 20.2 t ha^{-1}. While considering different locations, on an average for all varieties Snoul produced highest (i.e. 30 t ha^{-1}) and Chet borey produced the lowest (15 t ha^{-1}). Ranking of varieties following the criteria of the fresh root yield and starch content came out very different- considering fresh root yield Farmer's choice variety came out at the top; however, according to starch content the same variety came out at the bottom. Although when ranking was calculated following starch yield farmer's choice variety came out as second precede by variety KM98-1 (Figure 2.2.2). Ranking on the disease susceptibility (i.e. % of symptomatic plants), Farmer's choice variety ranked the top and Rayong60 bottom (Annual Report 2019).

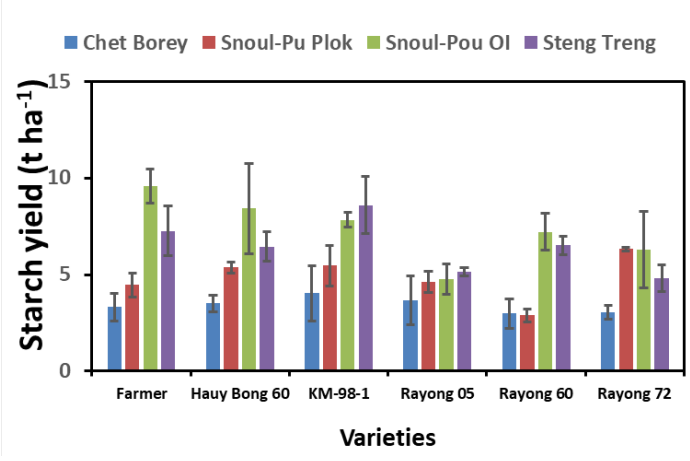


Figure 2.2.2 Starch yield (t ha^{-1}) of six cassava varieties grown in four farmer's field in three districts. Values are means ± standard error (n=3).

As there is interest among the starch factories to be able to operate most of the year, one experiment was conducted to extend the harvest season. Fresh root yield increased

progressively with increasing duration of the crop (Figure 2.2.3). After 8 months growth fresh root yield was 22 t ha^{-1} and it increased up to 42 t ha^{-1} at the end of the experiment (i.e. 17 months of growth. However, there was no effect significant on the starch content (Fig 2B), although highest starch content (i.e. 30.7 %) was recorded at 11 months of growth. These results showed that farmers would generate significant extra income by avoiding early harvest. The fact that many farmers continue to harvest early shows the high opportunity cost of capital, high levels of debt, and uncertainty about the market price as the season progresses.

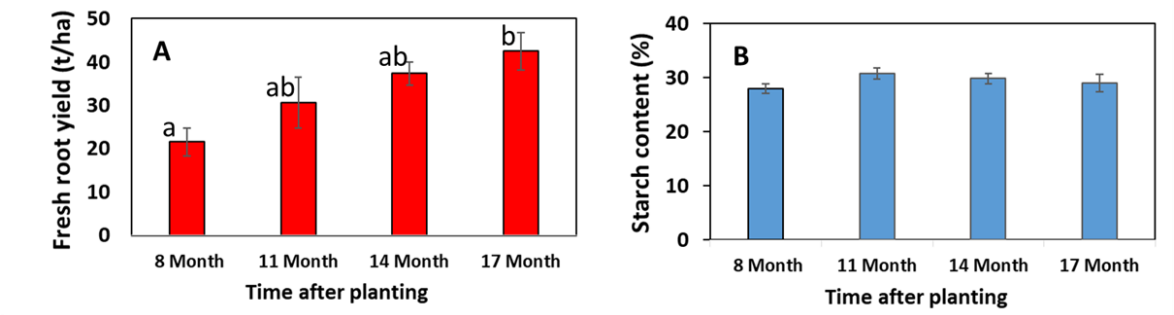
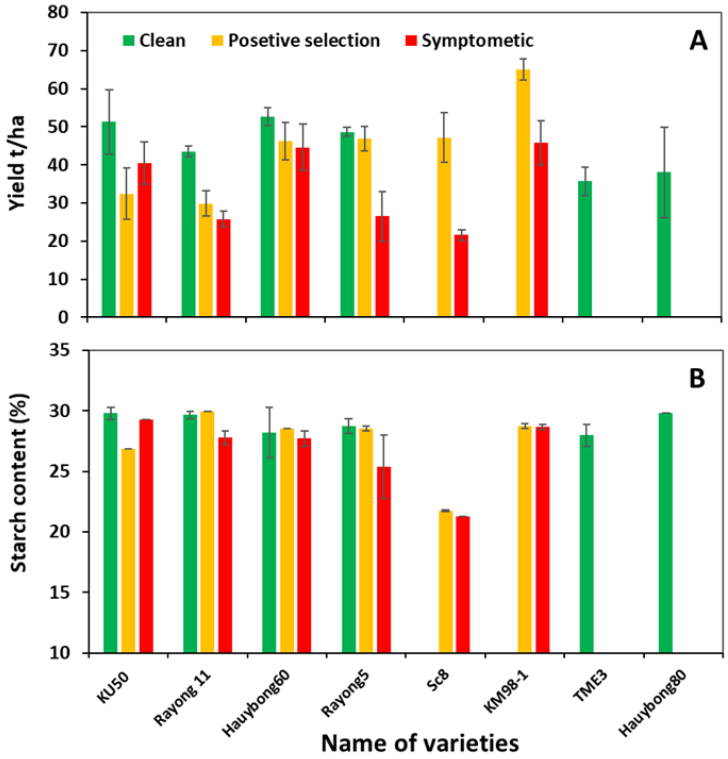


Figure 2.2.3 Fresh root yield (A) and root starch content (B) of cassava variety KU50 after different duration of growth. Values are the means of three replicates ± standard errors. Bars with different letters are significantly different ($p < 0.05$).

During 2017-18 season we first notice presence of disease (CMD) in our trials. However, in December 2015, Sri Lankan cassava mosaic disease (SLCMD) was first reported in a single isolated plantation in Eastern Cambodia (Wang et al., 2016)[7]. Consequently, project started focusing on infection of CMD and its consequences on farmers' livelihood. In the established demonstrations during 2018-19 infection rate (i.e. number of symptomatic plants) on different varieties were recorded. Number of CMD symptomatic plants differed among 6 varieties across all locations (Annual report 2019). Percentage of CMD symptomatic plants was highest (i.e. 29.3%) for Rayong60 and lowest for Farmer's choice variety (i.e. 5%). Among 4 locations percentage of CMD symptomatic plants were on average highest in trails Snoul-Pou Ol and Steng Treng for all the varieties, 20 and 19.3%, respectively (Annual report 2019).
During 2019-2020 season, fertiliser demonstrations were set in large blocks on farmers' field who were willing to participate. There were two treatments with fertiliser $NP_2O_5K_2O$ (20:05:20) and without fertiliser. In these trials, disease incidences were recorded and by the end of the season number of symptomatic plants ranged between 49 -80% in all trials in both treatments; however, the severity of infection was low (Sareth C. personal observation). The lowest disease incidence was recorded for fertilised and un-fertilised plots was from same site (i.e. 49% fertilized and 67 % unfertilized); presumably, due lower disease pressure in that region (Annual report 2020).

Screening for disease (i.e. CMD) tolerances among popular varieties were carried out during 2018-19 and 2019-2020 cropping season. During 2018-19 experiment, there was no effect of fertiliser application on disease symptoms (i.e. infection). Fresh root yield on both sites was similar ranging from 24.1 to 42.9 t ha^{-1} at site 1 and 17.1 to 46.0 t ha^{-1}. Variety SC8 yielded highest in both treatment at site 1, however, in site 2 KM 98-1 produced highest. Rayong11 yielded lowest in both treatment and both sites. Among the varieties, SC8 and Rayong11 showed the highest symptom (i.e. 100%) and KU50 the least at the end of the experiment (Annual report 2019).

[7] Wang H. L., Cui X. Y., Wang X. W., Liu S. S., Zhang Z. H. & Zhou X. P. (2016) First Report of Sri Lankan cassava mosaic virus Infecting Cassava in Cambodia. Plant Disease 100:129.



During 2019-20 experiment, plot root yield (calculated as t ha^{-1}) demonstrated clear advantage of clean planting material over symptomatic planting material (Figure 2.2.4A). Plot yield was1.2- to 2.2-fold higher in plants from clean and/or positive selection planting material than those from symptomatic planting material. The smallest yield difference (i.e. 1.2-fold) occurred in KU50 and Hauybong60, presumably due to their recovery ability from CMD, as many plants from symptomatic stakes remained asymptomatic during the experiment.

Figure 2.2.4 Fresh root yield (t ha^{-1}) and starch content (%) of cassava roots in plants infected with cassava mosaic disease (CMD) of six popular cassava varieties in Southeast Asia using disease-free stakes (clean), positive selected stakes from diseased fields (positive selection) and stakes selected from symptomatic plants (symptomatic). Twelve plants were harvested from each plot. In some plots, 2 to 6 plants were missing due to termite damage. Yields were adjusted for missing plants following Perez et al. (2010)[8]. Bars are standard errors of the mean (n=3 to 4). TME3 and Huabong80 were planted as clean planting material due to the scarcity of clean planting material of SC8 and KM98-1(6), respectively

[8] JC Pérez, H Ceballos, IC Ramírez, JI Lenis, F Calle, N Morante, G Jaramillo, M Lentini (2010) Adjustment for missing plants in cassava evaluation trials. Euphytica 172:59–65. doi:10.1007/s10681-009-0039-9

2.3 Develop business cases for value-chain actors

The economic analysis of household surveys and fertiliser and variety trials has shown that there are strong economic incentives for farmers to adopt new practices, but the incentive for value chain actors to facilitate the scaling of technologies was highly variable based on the structure of the value chain and the inherent characteristics of the technology. The experimental results cross referenced to historical trial data is important to better highlight the risks associated with these business models. Some conclusions have been drawn:

Variety and disease

- There is high incentive for farmers and processors in understanding how different varieties perform in local supply zones particularly under pest and disease pressure.
- There is a need of a reliable source of clean planting materials to introduce important varieties given that there are significant problems with CMD in Cambodia and CWBD in Laos. More work is required to understand the biology and economics around establishing and maintaining clean material supplies.
- The impact of disease on farmer yields and overall feedstock supplies are considerable. This goes beyond fresh weight yields with starch yields declining as a result of CWBD which are likely to impact starch recovery and profitability of processors.
- In value chains where there is a central processor or strong value chain links (Paklai, Viengthong, Bolikhan), demonstrating these risks and providing extension information and training to processors and agents for dispersal through the network of traders should provide benefits to farmers, with the processor also capturing benefits of enhanced feedstock (or by avoiding potential future losses). In value chains that are more dispersed with multiple actors and less exclusivity of any benefits generated at the farm level (Kratie, Kenthao), individual value chain actors are more difficult to identify with incentive to scale technologies. In Kenthao there is an association of processors who may provide an entry point.
- The ACIAR project AGB/2018/172 is building on these results and plans to establish rapid multiplication tunnels in partnership with factories in those regions with strong centralised actors. In the other production areas partnerships are being developed between local government and development projects.

Fertiliser

- Currently the adoption of inorganic fertiliser is extremely low in all the project sites. The available fertilisers are typically designed for rice production and there is limited knowledge within the extension system about the correct NPK balance, how much to apply, when to apply, and how to apply.
- On average, the use fertiliser in demonstration in Laos resulted in an 8 ton per hectare increase in yield. At the 2019-2020 price this produced an attractive rates of return at the farm level from the application of low levels of fertilisers. Even with low cassava prices experienced in the recent past the MRR was over 30%. However, extreme losses due to diseases or flooding can contribute to low returns. Links between fertiliser utilisation and clean planting material of suitable varieties are clear. Poor weed management also contribute to low returns to fertiliser in some demonstrations
- The fertiliser demonstration produced positive net returns at current prices in 87% of the demonstrations with a MRR greater the 50% in 72% of cases. If farm gate prices to the lowest level in the past 5 years only 67% of farmers would have positive net benefits from application and 44% with a MRR greater than 50%. These results show

the importance of continued extension on application techniques (type, timing, placement) and other agronomic practices (selecting healthy stems and weeding) to limit losses when prices fall.

- There is a stronger incentive for value chain engagement in those locations with starch processors concerned with starch yields and sustainability of their feedstock. At a minimum they should see the importance of ensuring appropriate fertiliser blends are available and continue with demonstrations and promotions. However, the cross border nature of the Kratie-TayNinh market means these incentives do not flow to farmers[9].
- Provision of credit from processors is risky given an inability to monitor how they are utilized by farmers. Engagement with support value chain actors is seen as more critical to ensure farmers purchase the correct fertiliser and have access to information. There is interest by some NGOs working on rural credit to link their activities to better technical information. Linking to 'risk-free' savings accounts are also seen as an option – i.e. not village funds where liquidity of savings is a concern.
- Treatments for 2019-20 included demonstrating the response to commercially available fertiliser blends from Thailand in farmers' fields. Farmers observed the impact of fertiliser on their yields and incomes. There is strong interest in accessing fertiliser, however there are other constraints that remain to be addressed.

2.4 Document successful models for supporting cassava smallholders

Working papers have been prepared on the role of value chains in disseminating technologies, including new varieties, fertilisers and improved soil management techniques. These have been discussed with stakeholders at stakeholder meetings at both provincial and national levels (see details of these meetings under Objective 3).

Adoption surveys were conducted with farmers in June 2020 in both Laos and Cambodia. This activity was delayed in light of COVID-19 restrictions. Interviews were also conducted with local government and private sector actors regarding the activities of the project, how activities could be maintained in the absence of a project, and lessons learnt in terms of how the project was conducted. Overall the results show that at the farm level there has been significant changes in knowledge, attitudes, skills and aspirations. However, changed practices have been more mixed.

The survey was also used as an opportunity to discuss the impacts of COVID-19 on households production, marketing and other livelihood activities.

Laos:
The survey was conducted with 20 households per district for the four districts involved in the project (N=80). This included the 10 households per district who hosted demonstrations (N=40) as well as farmers who either attended project activities (training and field days N=9) or had no direct contact with project staff (N=31).

The major impact of the project was related to understanding different pests and diseases, which varieties are susceptible, and the selection of asymptomatic stems as planting material for the subsequent season. 85% of households reported that they had CWBD in the previous season. Those with contact with the project were more than twice as likely to rouge diseased plants and more likely to inspect stems for disease when choosing planting stems. Critically,

[9] See presentation on "**Breaks, Blocks and Edge Effects: A case study of how borders affect value chains**"

only 6% had heard about CMD which was not a focus of the training – but shows an urgent information campaign is need in the new ACIAR project.

Alternatively, the demonstrations of fertiliser proved to be less successful in changing practices. While around 40% of surveyed households indicated an interest in applying fertiliser to their cassava field this year – this reduced to 20% who were interested for delivery of fertiliser that they would have to pay for. The main reason given that they had already spent the income from the previous harvest.
Private sector interviewed expressed a strong desire to continue to link to technical expertise provided by NAFRI and a willingness to engage in rapid multiplication of clean planting material. Addressing the credit issues to enable farmers to access fertiliser was also seen as a priority, but something that needs the involvement of other actors.

Cambodia

Survey and interviews were planned in 2020 to document changes in farmer and private sector actors knowledge, attitudes, skills and aspirations (KASA) associated with the project activities. This activity was also designe to document whether this had actually led to changed practices and what the remaining constraints were. Harvest field days and stakeholder consultations were cancelled due to COVID travel restrictions. The planned follow up survey and KI interviews were carried out in June 2020.

CARDI staff interviewed 12 farmers hosted trials and 15 who had attended field days, plus and additional 12 farmers who had no direct connection, but who had observed the cassava trials within their villages during the 3-year project. Key informant interviews were also conducted with PDAFF staff and other value chain actors.

Some of the main changes observed were farmers desire to change land preparation techniques to used raised beds rather than planting on the flat. This was seen as being favourable for harvesting under hard soil condition and recent availability of harvesting tools fixed to tractor. Raising bed could also reduce weeds and be easy for manual weeding. Changes in machinery owned by contractors may be needed to maintain appropriate density. This reflects the previous high adoption of labour saving herbicide application in contrast to fertiliser application documented during the baseline survey.

The project's vertical planting method could have high rate of surviving plants compared to farmers' common practice of placing horizontal stick below soil surface under last year's long drought experience.

Farmers who had hosted trials were more aware of which varieties that are less susceptible to CMD and the need to plant disease free stems and they also agreed varieties trialled by the project produced higher starch content compared to farmers' mixed varieties. However, farmer access to disease free stems had become almost impossible. Furthermore, the local names (purple ear) was now increasingly used for multiple varieties and traders. While some farmers who hosted trials had changed their fertiliser practices, this tended to be farmers who were already using fertiliser purchasing different fertiliser than a widespread uptake of fertiliser. Most interviewed farmers were convinced an affordable cost for purchasing fertilizers could improve cassava yield.

In 2018-19, staff from local processing factories were invited to join harvest field days. Attempts to link with these value chain actors became more challenging as price increase meant that the Vietnam value chain extended further into Cambodia and out competed the local factories. The SingSong factory in ChetBorei factory has only purchased 1,000 tons of fresh roots in the first 3 months of 2020 – far below the design capacity of 10,000 tons/month. The factory indicated that they have no definite plans for the coming five-year period due to

strong competition, high prices for cassava roots and high electricity costs. Furthermore, the strong competition from Vietnam has meant that the Green Leader factory under development in Snoul District has not started to process and may not finish construction.

Objective 3: Develop capacity for farming systems research and policy analysis and promote policy dialogue on the opportunities for industry development and livelihood enhancement through supported smallholder models.

No.	Activity	Outputs/ milestones	Completion Date	Comments
3.1	Review and document local and national policies with regard to smallholder cassava and identify opportunities for scaling up research outcomes.	Review report	Not completed as there were numerous existing reviews	A review of existing secondary information in both Cambodia and Lao PDR revealed that there are numerous existing reviews of agricultural and rural development policies which are directly relevant to cassava. It was decided that rather than replicate these existing documents in another report, that the project would concentrate on dialogue with stakeholders at local level on local policy settings impacting on cassava value chains. Frequent discussion have been held with stakeholders on this topic.
3.2	Conduct workshops to develop local capacities for on-farm research in cassava, farming systems evaluation, value chain analysis, and evidence-based policy analysis and dialogue.	Training workshops conducted, evaluated, and reported	February 2017	In both Lao PDR and Cambodia, training on sustainable cassava production with national, provincial, district staff, and the private sector have been conducted. Training on household survey implementation have also been conducted with local partner researchers. Training on value-chain analysis was conducted with partners. Training on economic analysis of agronomic data and scenario analysis was conducted.
3.3	Develop technical and policy briefs in local languages outlining the opportunities for improvement of a smallholder-based cassava industry.	Technical and policy briefs disseminat-ed	July 2020	Stakeholder briefs for both Cambodia and Laos are being developed and discussed with stakeholders. These stakeholder briefs cover key project topics including the cassava economy and status in each country, cassava variety use, fertiliser use, stakeholder linkages and pests and disease. Laos: Extension material made and distributed to DAFO, online, other projects. Featured in Ministry Magazine.

3.4	Conduct dialogues between local actors to enable outcomes of research to inform provincial planning and policies aimed at supporting industry development and smallholder livelihoods.	Industry dialogues conducted	December 2019–January 2020 with final workshop and discussion in June 2020	District Stakeholder dialogues were undertaken in Xaybouly in August 2018 and in Bolikhamxay in November 2018. A National Stakeholder dialogue meeting was held in Vientiane, Laos during March 2019. Additional stakeholder discussions were held in 2020 at harvest field days involving farmers, DAFO, traders, processors, NGOs. Project staff contributed into existing dialogues organised by UNDP, CAVAC, GIZ, IFAD, IFC. No parallel national level workshops were initiated to duplicate these existing platforms. Stakeholder discussion occurred during field days with farmers, government, processors and NGOs.

3.1 Review of national policies

A review of existing secondary information in both Cambodia and Lao PDR revealed that there are numerous existing reviews of agricultural and rural development policies which are directly relevant to cassava (for example, as undertaken by the Wold Bank as part of the Lao Agricultural Commercialisation Project). It was decided that rather than replicate these existing documents in another report, that the project would concentrate on dialogue with stakeholders at local level on local policy settings impacting on cassava value chains.

Lao PDR

Cassava in Lao PDR has become one of the national priority crops. However, there are very few direct policies supporting this with limited experience on the government side regarding the cultivation of the crop. The high-profile failure of a starch factory in Vientiane Capital Prefecture has received the attention of MAF. The NAFRI project team has been involved in ongoing research and briefing MAF on problems and potential interventions.

Fertiliser

The GoL has been undergoing a transition in the agricultural strategy that actively encouraged commercialisation to a greater focus on “Green Growth”. This provide some challenges for the project as often then National level thinking was being translated at the district level as discouraging the use of non-organic NPK fertilisers. It also weakened the interest of private sector partners in the fertiliser import and distribution business for working in collaboration with the project. The project partners continue to present the realities of organic cassava production to policy makers and industry.

Varieties and disease

Policy meetings regarding the threats of pest and disease has seen the GoL issue directives banning the import of stems from Thailand due to the high risk of CMD which is now in the main producing regions of Thailand. A more recent regulation has also stopped the movement of stems from the south of Laos to the central and northern parts.

In line with this – value chain actors engaged in the project are now part of efforts in AGB/2018/172 for rapid multiplication within the country.

Export and value adding
The cassava sector has also been captured by the PM Decree restricting the export of raw products. The implementation is much more at the Provincial level with the value chain in Xayabouli impacted. This is assumed to be impart to secure roots for the starch factory in the Province, however roots continue to leak as dried chips as farmers harvest early as possible at a rate beyond the processing capacity.

Cambodia
There are several international agencies working on cassava in Cambodia. The largest is a program run by the UNDP. The aim is to provide evidence for supporting the development of policies by these larger projects. The draft cassava policy was released with an information fact sheet produced by project partners[10].

3.2 Conduct workshops to develop local capacities for on-farm research in cassava, farming systems evaluation, value chain analysis, and evidence-based policy analysis and dialogue

Lao PDR
Training on sustainable cassava production was conducted in Vientiane with national, provincial and district staff which also included some private sector participation. Practical value chain training was conducted in Vientiane with key stakeholders to map value chains in target provinces in Lao PDR. Training on household livelihood surveys and use of electronic tablets for gathering information were conducted with partners in Vientiane in April 2017.

Training material on cassava production has been distributed to DAFO, made available online, and shared with other development projects. It was featured in the MAF magazine in July 2020.

Cambodia
Training on sustainable cassava production was conducted in Kampong Cham with national, provincial, and district staff which also included some private sector participation. Practical value chain training was conducted in Kratie Province with stakeholders to map value chains.
Training on household livelihood surveys and use of electronic tablets for gathering information was conducted with partners in Kratie in July 2017.

3.3 Develop technical and policy briefs in local languages outlining the opportunities for improvement of a smallholder-based cassava industry.

The need for policy briefs was confirmed by the director general of NAFRI during the National Stakeholder meeting in March 2019 when he emphasised that:

> *Policy briefs or policy recommendations are needed which showing the situation of current cassava production and marketing in the global, region and Laos, and provide the policy options on the collaboration between farmers, private sectors and government authorities (farmer groups, trader groups, exporter groups, and others).*

Stakeholder briefs for both Cambodia and Laos are being developed and discussed with stakeholders. These stakeholder briefs cover key project topics including cassava variety use, fertiliser use, stakeholder linkages and pests and disease. Content of the briefs is based on

[10] Information can be accessed at: http://cassavavaluechains.net/cambodia/

the extensive set of discussion papers and other material generated by the project. A number of technical publications (manuals, brochures, fact sheets, posters) have been published in Lao language targeting different audiences (DAFO and farmers).

3.4 Conduct dialogues between local actors to enable outcomes of research to inform provincial planning and policies aimed at supporting industry development and smallholder livelihoods.

In addition to the regional research symposia conducted in Vientiane in January 2018 (in conjunction with the mid-term review) and in North Sumatra in July 2019, project results have been discussed with key stakeholders in local and national stakeholder meetings in both Cambodia and Lao PDR.

Lao PDR

Local stakeholder meetings

Local stakeholder meetings were held on the 14th and 16th of August 2018 in Paklay and Khentao District, Xayabouly province and on the 6th and 8th of November 2018 in Bolikhan and Vieangthong District, Bolikhamxay province:

The topics of discussion involved:

- Overview of cassava production and marketing,
- Review of marketing systems and production value chain research results for provincial, district and household level,
- Review of agronomy research activities and progressive results in 2017
- Farmer adaptation on agronomy technologies, especially, soil fertility improvement with application of suitable fertiliser rates and compound chemical fertilisers, intercropping systems, selection of appropriate varieties and the importance of utilising clean seeds.
- Stakeholder's perceptions, challenges and recommendations of cassava cultivation.

National stakeholder meeting:

The National stakeholder meeting was held on the 6th of March 2019, in Vientiane. The meeting was chaired by Dr. Bounthong Bouahom, DG of NAFRI and included the following presentations and discussions:

- A paper on "Cassava markets, value chains and livelihoods in Asia: implications for Lao PDR" was presented by Dr. Jonathan Newby, Agricultural and Natural Resource Economist, International Coordinator of ACIAR.
- An "Overview of cassava in Lao PDR" was presented by Mr. Chanphasouk Tanthaphone, Director of Economic and Rural Development Research Centre, NAFRI.
- The results from trails and demonstrations were presented by Phanthasinh Khanthavong, Researcher, Corn and Cash Crop Research Centre, NAFRI.
- Results on the cassava value chains in Bolikhamxay and Xayabury Province were presented by Phonepaseuth Souvannavong, Researcher, Economic and Rural Development Research Centre, NAFRI.
- "The cassava value chains in Champasak and Salavan Province" was presented by Santisouk Insysiengmay, Researcher, Economic and Rural Development Research Centre, NAFRI (Policy Think Tank Research).
- The result of the cassava's disease survey was presented by Ms. Pinkham Vongphachanh, Plant Disease Unit, Plant Protection Centre, DoA.

- A paper on “Actions in place, plans and priorities to manage cassava disease in mainland Southeast Asia” was presented by Laothao, Researcher, CIAT.
- “Successful models for scaling sustainable cassava production” was presented by Dr. Jonathan Newby, Agricultural and Natural Resource Economist, International Coordinator of ACIAR.

Additional and less formal stakeholder dialogues occurred during harvest field days. Farmers, traders, processors and government joined field days and discussed the results and other concerns. A few lessons learnt were that timing is important with foreign owned factories – as management are typically absent during the growing season. Secondly, decisions are typically made by management abroad.

Cambodia

Cassava became a crop of interest to several International Organisations (UNDP, FAO, IFAD, IFC) and INGO (CAVAC, GIZ, SwissContact). The project did not seek to replicate a crowded space with additional dialogues, instead provided technical expertise into the existing platforms. All resources and reports were made available and Cambodia made up a large percentage of the Facebook group (416 member from Cambodia) that included high level government, NGOs, Local government and farmers.

UNDP commission the development of the Cambodian Cassava Policy in 2017 which remains ongoing. CIAT lead the component on raising the productivity of the cassava sector in Cambodia and the project passed on all the value chain assessments to FAO who coordinated the input of value chains. A workshop was held with stakeholders to gather inputs and presented at a Workshop in December 2017.

A summary of recommendations put forward were:

1. Establish a **Cambodian Cassava Research and Development Coordination entity**;
2. Promote sustainable and resilient **cassava-based farming systems and livelihoods** avoiding interventions that focus on cassava in isolation of other components of a farming system;
3. Invest in **cassava breeding and coordinate variety evaluation** with industry stakeholders;
4. Develop **viable seed systems and business models** to promote the use of healthy planting material;
5. Develop and promote **robust fertilizer management recommendations** and flexible strategies for different agro-ecological regions of Cambodia;
6. Invest in and coordinate the **monitoring, surveillance and reporting of pest and disease** and promote appropriate management practices;
7. Develop **cassava-based cropping system options** suitable for different agro-economic regions of Cambodia; and
8. Invest in ongoing **development of mechanization technologies** that enable viable contracting models, address rising labour shortages, and enable the implementation of conservation agriculture practices