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Results of Cassava Demonstration Trials in Ayeyarwady Region in 2018[1]

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Summary

Cassava is one of the most important upland crops in Myanmar especially in the Ayeyarwady region. The crop has been both a mechanism for livelihood improvement at the household level, and a key contributor to the regional economy. Beyond the food and feed value, cassava is also important for a range of industrial purposes when it is converted into modified starch, sweeteners and ethanol, etc. As a result, cassava is in high demand locally and for potential export - especially to China, Thailand and Bangladesh.

Cassava has a high yield potential and can be grown under a wide range of upland conditions. It grows reasonably well in low fertility soil and in areas with low or unpredictable rainfall - conditions which limit the growth of many other food and feed crops. As a relatively undemanding crop in terms of inputs, cassava can be considered an excellent pro-poor crop compared to other upland crops.

Ayeyarwady region has a long history of cassava production. Two important cassava growing districts, Pathein and Hinthada were purposively selected as locations for the demonstration trials in 2018. The demonstration trials were conducted in three townships: Hinthada township and Lemyethna township in Hinthada district and Kyonpyaw township in Pathein district.

Farmers traditionally plant cassava on mounds at variable spacings. Within the trial, ridging methods were introduced and cassava stakes were planted vertically in rows. The advantages of ridge method are that farmers can save time as ridges can be made by tractors and it is easy to apply fertilizer and control weeds.

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[1] This series ***Cassava Program Discussion Papers*** presents results of the Australian Centre for International Agricultural Research (ACIAR) supported projects ASEM /2014/053 *Developing cassava production and marketing systems to enhance smallholder livelihoods in Cambodia and Lao PDR* and AGB/2012/078 *Developing value-chain linkages to improve smallholder cassava production systems in Vietnam and Indonesia*

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Cassava has been grown on less fertile soils usually with little or no balanced fertilizer application. Continuous cultivation of cassava on inherently low fertility soils in Ayeyarwady region, without application of any fertilizers (organic and inorganic), has resulted in low yields and soil degradation. However cassava yields can be markedly increased by the application of correct formulations of fertiliser at the correct time and rates.

Lack of suitable high-yielding varieties for specific agro-ecological conditions and a shortage of healthy and good quality planting materials are constraints for increasing cassava production. In addition if the planting area has been affected by pests and diseases, these may be transmitted through infected planting materials, resulting in poor growth and low yields.

Three cassava demonstrations were conducted in the 2018/2019 growing season:
1) Planting methods demonstration;
2) Balanced fertilizer application demonstration trials; and
3) Multiplication of good planting materials

In order to demonstrate the performance of suitable planting methods, balanced fertilizer applications, and good planting material multiplication, a cassava field day was held in Hinthada township on 23 January 2019.

While improved cassava varieties and good agronomic practices are needed for sustainable cassava production and its processing, their adoption depends on the level of awareness of current farmers and local processors of its wider industrial significance and the economic benefits from improved cassava production. The results of the demonstration trials, the discussions and recommendations are presented in this report.

Introduction

In Myanmar, rainfed cropping systems are the most common agricultural system, but where irrigation facilities are available, farmers irrigate their crops. Generally paddy-paddy or paddy-pulses-paddy patterns dominate in the irrigated and rainfed lowland areas. In the upland areas, farmers grow crops such as banana, cassava, maize, peanuts, and upland rice.

Cassava can grow on a wide range of soils and it reasonably grows well under rainfed upland conditions where other crops (such as rice) cannot be productive. Once the crop is established, it becomes a drought tolerant, and hence a water efficient crop. As a relatively undemanding crop in terms of inputs (such as fertilizers, water, and labour), cassava can be considered an excellent pro-poor crop compared to other key crops.

Cassava production in Ayeyarwady region has been both a mechanism for livelihood improvement at the household level, and a key contributor to the regional economy. Many resource poor farmers prefer to grow cassava rather than other crops as cassava production systems are relatively simple compared to other cash crops.

Cassava yields in Myanmar are much lower than the theoretic potential yield levels. In recent years, the planted area of cassava has markedly increased due to market demand in Yangon and Mandalay. However over the past decade average yield of cassava has declined especially where continuous cassava cultivation is practiced without the application of sufficient inputs. With the adoption of high-yielding varieties and good agronomic practices, greater production and higher levels of profits can be achieved which can significantly improve the economic resilience of smallholders in the Ayeyarwady region as well as other parts of the country. However at present only a handful of farmers understand how cassava should be grown in a sustainable manner to optimize yield and maximize profits. Additionally concerns related to the cassava sector include price fluctuations, market stability, soil nutrient depletion, and waste-water pollution from local starch processing.

Many farmers see cassava as an easy crop, that requires few inputs and minimal care. Only a handful of farmers understand how cassava should be grown in a sustainable manner to maximize yield and income.
In this regard, several limitations have been identified for achieving optimal cassava yields.

1. *Lack of suitable high-yielding cassava varieties and shortage of quality planting materials*

It was observed that farmers currently grow popular cassava varieties which may not be the best adapted variety for the specific soil and climate conditions. A key constraint is thus the inability to access suitable high-yielding varieties for specific agro-ecological zones.

Another key constraint related to cassava production is the shortage of healthy and good-quality planting materials. With a significantly lower multiplication rate relative to most other food crops such as rice and maize, farmers are only able to receive between

5 and 10 stem cuttings from a single cassava plant. Although multiplication rates are generally low there is a relation between the rate of multiplication and the cassava variety along with the adopted growing practices.

If the planting area has been affected by pests and diseases, these may be transmitted through infected planting material, resulting in poor growth and low yields. Therefore, two important things must be considered to get healthy and high-quality planting materials.

a) Disease and pest free (healthy) planting material
b) Good quality planting material

Earlier demonstration trials have shown significantly higher cassava yields as a result of planting clean high-yielding cassava varieties (such as KU50 and Rayong 72) in the Ayeyarwady region.

2. *Reduced soil fertility and soil erosion*

We observed that soil fertility management in cassava production systems is not well understood in Myanmar especially at the farmer level. Management of soil fertility is important for increasing cassava yields, especially since it has traditionally been grown on less fertile soils with little or no balanced fertilizer application. Continuous cultivation of cassava on infertile soils in the Ayeyarwady region, without application of any fertilizers (organic or inorganic), have resulted in low yields and soil nutrient depletion.

Similar to other cassava growing countries , some farmers in Myanmar grow cassava on gently sloping lands. Although soil erosion is key contributor to nutrient loss, at present farmers have limited alternatives. Hence cost-effective erosion control measures such as balanced fertilization, intercropping, vegetative barriers, and control hedgerows should be encouraged.

In the Ayeyarwady region, a reasonable cassava yield can be achieved with minimum inputs, and farmers can expect high yields from fields with medium- to high-level soil fertility and adequate soil moisture.

3. *Emerging cassava pests and diseases*

Unlike other parts of SE Asia, cassava in Myanmar has been largely pest and disease free, although this status appears to be changing in recent years. However there have been no official reports of serious outbreaks emerging from cassava pests and diseases in Myanmar.

In general farmers consider pests and diseases not to be a serious problem for their cassava fields. Regardless, there were some farmers that voiced their concerns in relation to cassava damage and reduced yields resulting from various insects and diseases. Some farmers lost cassava stems that were to be used as planting materials in 2017/18 due to mealybug infestations. The mealybug species were papaya mealybugs (*Phenacoccus marginatus*), striped mealybug (*Ferrisia virgata*) and pink mealybug (*Phenacoccus manihoti*). The cassava pink mealybug has also been known to cause major problems in Cambodia, Laos, Thailand and Vietnam. While the biological control of the cassava mealybug through the parasitoid wasp *Anagyrus lopezi* has been rolled out in parts of the SE Asia, the spread and efficacy of this control measure needs to be evaluated. A number of other insects, including mites and whiteflies as well as a number of diseases caused by phytoplasma, bacteria, and fungi are a concern for cassava in Myanmar. Perhaps the most serious threat of all is the Cassava Witches Broom (CWB) diseases. The witches-broom disease has invaded many cassava growing townships particularly Kyonpyaw and Lemyethna. Several of these pests and diseases, if unchecked, are likely to cause major yield loss and negatively impact the livelihoods of many poor farming communities in the Ayeyarwady region.

4. *Lack of systematic planning and technical assistance to the cassava sector*

Cassava production, processing and marketing in Myanmar are done with little planning or technical assistance. Fresh cassava roots are often in oversupply causing large post-harvest losses and/or sold below market price due to delays related to inadequate transportation and marketing. In Ayeyarwady region, there are many small processing factories with inefficient and/or outdated technology. There are no medium or large scale commercial processors with adequate capacity for the fresh roots harvested by farmers in the production areas. Moreover, there are only two traders operating in the area with capacities large enough to sell cassava starch to Yangon and other cities effectively.

5. *Research and extension systems*

Similar to other Mekong countries greater emphasis in Myanmar is also placed on staple rice production for both research and extension services. Many rice research stations and demonstration farms are established at optimal locations and use high levels of inputs.

This lack of support is a serious constraint for the development of the cassava sub-sector in the country. Investment in cassava research and extension systems should be improved to ensure sustainable intensification of cassava production systems in Myanmar. Training activities and knowledge sharing are essential for building the capacity of national research and extension systems.

Objective

This study aims to learn the opportunities and constraints for sustainable intensification of cassava production systems in the Ayeyarwady region. The objectives of specific demonstration activities are explained below in the cassava demonstration trials section. This report can also be used as a reference for training agricultural researchers and extensionists, influential farmers in current target region, as well as local processors, and private companies. In addition the trial results and information can also be used for developing and designing appropriate training programs on cassava production systems across the country in the future. This technical report will be followed by an action plan with recommendations on how to proceed, with a specific timeline and an estimate budget for year 2019/2020.

Selection of study area

The Ayeyarwady region has a long history of cassava production. Besides cassava, farmers grow other crops in these areas including rice, maize, black gram, mung bean, peanut, banana, turmeric, chilli, tomato, vegetables and fruit trees.

The target Ayeyarwady region was chosen based upon its importance as a key cassava growing area by smallholder farmers in Myanmar. Two important cassava growing districts, Pathein and Hinthada were purposively selected as study areas for the project.

The selection of districts for the target project area was completed after consultations with regional Department of Agriculture (DOA) officers and village leaders in both districts. From the two districts, three townships were selected for the cassava research study: Hinthada township and Lemyethna township in Hinthada district and Kyonpyaw township in Pathein district (Figure 1). Higher dependence upon cassava is particularly found amongst farmers in the uplands of Kyonpyaw township, Lemyethna township and Hinthada township.

Primary data was collected to obtain information about cassava cultivation practices, processing, marketing and post-harvest handling using both semi-structured interviews and questionnaires. Secondary data was also collected in the selected areas on rainfall, soil type, the history of cassava production, marketing, processing and any other relevant data to the study. The status of cassava production in Ayeyarwady region (production, cultivated areas, and yields) in 2017/2018 is shown in Table 1. The three townships were also assessed with a specific focus on cassava processing during the cassava processors' survey which was conducted in 2018 (See Processor survey report).

Figure 1: Locations of study townships in Ayeyarwady region, Myanmar

Geographical location, climate and demographic information

The country of Myanmar lies between 92° 10' and 101° 11' East longitude and 9° 58' and 28° 31' North latitude. The Ayeyarwady region is Myanmar's most populated area with an estimated population of 6.32 million. This region shares borders with Rakhine, Bago, and Yangon and has the highest percentage of people living in rural areas (88%) relative to urban areas (12%). Ayeyarwady region consists of 26 townships covering a total area of 35,964 km^2 (Figure 1)

Ayeyarwady region has diverse topography, climate and natural vegetation. It has tropical climate and the monsoon winds bring rains that are crucial to the agricultural sector in the Ayeyarwady delta. Generally there are three seasons; the hot season between mid February and mid May, the rainy season from mid May to mid October, and cold and dry season between mid October and mid February. Temperatures generally rise above 33 degree Celsius during the hot season and averages about 21 degrees Celsius during the cold season. The mean annual precipitation is about 3,000 mm with 82% average relative humidity. However the amount of annual rainfall as well as the maximum and minimum temperatures vary across the region.

Current cassava production

Cassava has been grown in the Ayeyarwady region for several decades. It was initially grown by farmers in small areas as a food crop for home consumption. From being a neglected food crop, more recently cassava has been regarded as an important cash crop for smallholder farmers.

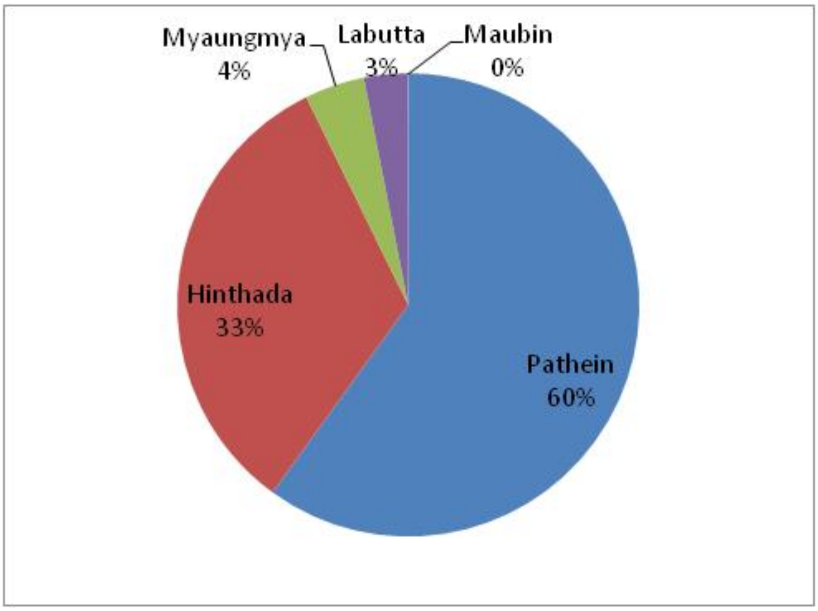

Figure 2. Share of cassava production (%) by districts of Ayeyarwady region in 2017/2018

At least 30,000 smallholder farmers grow cassava in Myanmar particularly in the Ayeyarwady delta region. Current cassava production area (12,320 ha), total production (182,444 t) and average root yield (14.8 t/ha) are low in Ayeyarwady region (DOA, 2019). Figure 2 indicates that Pathein district and Hinthada district are the main production districts in the region. The total production in the top three townships from Hinthada district and Pathein district (i.e. Kyonpyaw township, Lemyethna township and Hinthada township) accounts for about 83% of the total production within the Ayeyarwady region.

Table 1 provides details of cassava growing areas, fresh root yields and root production in the districts of Ayeyarwady region in 2017/2018.

Table 1. Cassava sown area, root yield and production in the districts of Ayeyarwady region in 2017/2018

	District /Township	Sown/Harvested area (ha)	Root Yield (ton/ha)	Production (ton)
1	**Pathein District**	**7,647/7,040**	**15.56**	**109,511**
	Pathein	52	11.73	610
	Kangyidaunt	40	12.03	481
	Tharpaung	258	13.97	3605
	Ngaputaw	372	14.51	5396
	Kyonpyaw	6,702/6,093	15.78	96177
	Yegyi	79	16.70	1319
	Kyaunggon	146	13.17	1923
2	**Hinthada District**	**4,294**	**13.88**	**59,619**
	Hinthada	1,521	13.70	20,843
	Zalun	2.5	13.20	33
	Lemyethna	2,514	13.95	35,058
	Myanaung	14	14.50	203
	Kyangin	11	14.09	155
	Ingapu	231.5	14.37	3,327
3	**Myaungmya District**	**516**	**14.81**	**7,642**
	Myaungmya	516	14.81	7,642
4	**Labutta District**	**464**	**12.06**	**5,598**
	Labutta	464	12.06	5,598
5	**Maubin District**	**6**	**12.33**	**74**
	Maubin	6	12.33	74
	Total	***12,927/12,320***	***14.81***	***182,444***

Cassava demonstration trials in 2018/2019

As indicated above, cassava has been grown in the Ayeyarwady region for several decades, although the cultivation methods have involved insufficient inputs, resulting in declining yields for many farmers over the past decade. The secondary data from DOA, MOALI (regional average 14.8 t/ha in 2017/2018) and cassava processor survey (average root yield of processor 10.4 t/ha) also confirms low yields of fresh cassava roots in the Ayeyarwady region. These yields are significantly lower than their potential. Cassava yields may vary greatly depending on the type of varieties planted, planting methods adopted, seasonal rainfall, inherent soil fertility and level of fertilizer application, weed control, and other forms of crop management. However, given the agro-ecological and climatic conditions in the Ayeyarwady region, there is significant potential for high cassava yields through appropriate agronomic practices.

From discussions with farmers and local DOA extension officers, three types of cassava demonstrations were conducted at two locations (1. Sharkhe Village, Hinthada ; and 2. Konenyaungsai Village, Kyonpyaw) in the 2018/2019 growing season. These demonstrations involved 1) Planting methods; 2) Balanced fertilizer application demonstration trials; and 3) Multiplication of good planting materials. The objectives of each of the three cassava demonstrations were as follows:

1) Planting methods: to demonstrate cassava planting methods to that result in improved cassava production.
2) Balanced fertilizer application: to demonstrate the response of cassava plants to the application of various combinations of fertilizers (N, P and K) to identify optimal fertilizer rates that produce higher cassava yields and maximize profits.
3) Multiplication of good planning materials: to demonstrate the multiplication of planting materials for obtaining increased number of good planting materials to disseminate suitable high-yielding cassava varieties amongst smallholder farmers.

Cassava field day

After meeting with the DOA team, local authorities and participating farmers, a cassava field day was held on Wednesday the 23rd of January 2019 at Sharkhe village (Picture 1). The field day was organized by Daw Nilar Aung and the team from Hinthada DOA extension. The main aim of the field day was to expose all participating members to the three types of demonstration trails that had been developed. Over 70 participants attended the field day. Dr Rod Lefroy (Reviewer of Mid-Term Cassava Value Chain Projects) and Mr Naing Oke (Industrial Engineer) were among the participants and were involved in visiting cassava fields and processing facilities in the project target areas.

The field day programs were preceded by an explanation of the objectives of the demonstrations, possible outcomes, and a request to stay involved in the project activities. DOA staff and local farmers were also involved in harvesting some cassava from the demonstration trials. Local farmers in particular seemed to be excited by the potential of new varieties and better fertilizer application. It was also a great opportunity for DOA extension officers to learn methods for identifying new cassava varieties, planting methods, fertilizer response, and measuring cassava yields and starch content (%) after harvesting them.

Picture 1: Farmers, processors and DOA officials discussing at Field day in Hinthada district

There was active discussions between the participants (which involved both male and female participants) regarding evaluations of the demonstration trial results(Picture 2 & 3).

Picture 2: Evaluating cassava demonstration trials with local farmers and processors

Participants also discussed the current situation of cassava production and its utilization in the Ayeyarwaddy region (opportunities and challenges) as well as their preferences and priorities for future cassava research for development activities. The regional DOA, cassava farmers, miller and trader association and local processors expressed their interest in extending the demonstration trials to the new villages and to receive further technical assistance. The village authorities have supported the logistic arrangements and local processors have agreed to provide their lands for cassava demonstration activities in the future.

Farmers in the local area are involved in growing cassava through traditional cultivation methods using available local varieties. Participating farmers realised that their cassava yields had declined primarily as a result of insufficient agricultural inputs such as improved varieties and adequate fertilizers. The detailed results of cassava demonstrations are presented below in the results and discussions section.

Picture 3: NPK fertilizer demonstration trial in Hinthada township

Results and discussions

Cassava varieties

Myanmar farmers plant locally available cassava varieties, but they are not aware of varieties that are most suitable for their specific agro-ecological conditions. “Sweet varieties” are grown mainly for direct household consumption, and the “bitter varieties” for industrial purposes. Generally, varieties that are consumed by people have low dry matter and starch contents as well as low hydrogen cyanide (HCN) concentrations. It seems that most of these varieties were introduced from Thailand in the past few decades.
The popular cassava varieties grown in the Ayeyarwady region for starch production were Malaysia, Bangkok and Japan. These cassava varieties can have high yields and high starch content. Most farmers used their own cassava stems as planting materials which they usually retain for up to two months prior to planting.

Since 2009, Department for Agricultural Research (DAR) has introduced cassava varieties (Thailand, Vietnam and Laos) from Laos and kept them at the DAR germplasm in Yezin, Nay Pyi Taw. Some varieties have been tested on-farmer fields in the Ayeyarwady region. Previous variety demonstration trials showed that industrial varieties

Rayong 9 and KU50 produced higher yields with higher starch content compared to the two local varieties (Japan and Bangkok). However, Bangkok and Japan varieties gave higher root yields than NEP and NARC-61. In addition, NEP and NARC-61 have low HCN content and are hence better for consumption by humans and animals as a feed source.

On-farm demonstration trials for planting methods

Cassava is generally planted between March and June with most farmers planting in May and June in Hinthada and Pathein districts. There is a range of cultivation methods currently practiced by farmers most of which they have learned from one another.. Farmers in Ayeyarwady traditionally plant cassava on mounds. The distance between mounds vary from 1.5 to 3 meters but is generally about 2 meters. Farmers normally use two stakes per mound while some plant one stake per mound with either slant (incline) or using vertical planting methods. As a result the density may be lower than optimum density resulting in higher yields.

During the demonstration trial the ridge method was introduced and cassava stakes were vertically planted in rows at a density of 10,000 per ha. The advantage of adopting the ridge method are 1. farmers can save time as ridges can be made by tractors, and 2. it is easier to apply fertilizers and control weeds.

Table 2. Information of planting method demonstration trials in Hinthada township (2018/2019)

Name	Village	Sown date	Harvesting date	Plant Age (in months)
U Sein Tin (ST)	Shar Khe	5/12/2018	1/23/2019	8
U Myint Soe (MS)	Shar Khe	6/9/2018	1/26/2019	7
Daw Yin Nu (YN)	Shar Khe	6/10/2018	2/1/2019	7
U Kan Thein (KT)	Palin 2	6/12/2018	2/1/2019	7
U Aung Moe (AM)	Kyon Win	6/13/2018	2/17/2019	8

Table 3. Results of planting method demonstration trials in Hinthada township (2018/2019)

Planting Method	Fresh Root Yield (t/ha)						Starch content (%)					
	ST	MS	YN	KT	AM	Ave	ST	MS	YN	KT	AM	Ave
Ridge	29	30	18	22	29	26	31.1	31.1	34.0	31.1	33.2	32.1
Mound	26	28	11	21	28	23	31.1	31.1	31.1	31.1	33.2	31.5

Details (name of participant, location, sowing and harvesting dates, and the age of plant at the harvest period) related to the on-farm demonstration trails conducted in Hinthada and Kyonpyaw townships are shown in Table 2. Cassava from the five on-farm trials were harvested and measured for fresh root yield and starch content %. The results of the demonstration trials are presented in Table 3. Although the root yields varied across the five farmer plots for the same method, there were variations in root yields between the ridge method and mound method in all demonstration trials. Figure 3 shows that in all five trials the ridge method produced higher yields (average root yield 26 t/ha), while the traditional mound method produced lower yields (average root yield 23 t/ha). However there were significant differences between the two methods in terms of the start content (%).Table 4 shows the results of the two planting methods in relation to their costs of production and net income in Hinthada township (2018/2019). According to results, the mound method, although associated with higher costs, also resulted in higher yields per hectare and hence higher profits. However the ridge method allowed for easier cultivation and required less labour compared to the traditional mound method.

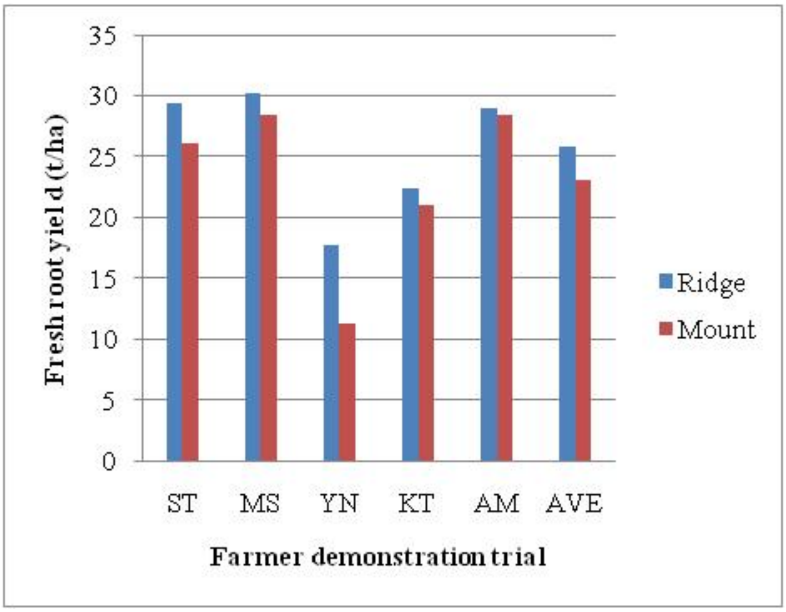

Figure 3. Comparing the root yields of five farmers between ridge method and mound method in Hinthada township (2018/2019)

Table 4. Effect of different planting methods on yield and starch content as well as production cost and net income in Hinthada township (2018/2019)

Planting Method	Fresh Root Yield (t/ha)	Starch Content (%)	Gross Income (kyat/ha)	Production Cost (kyat/ha)	Net Income (kyat/ha)
Ridge	26	32.1	3,309,000	692,000	2,617,000
Mound	23	31.5	2,961,000	807,000	2,154,000

On-farm demonstration trials for balanced fertilizer application

The recent field survey indicated that most farmers in the Ayeyarwady region (90% of interviewed farmers) used fertilizers for their crops mainly for lowland rice. However

farmers generally grow cassava with little or no balanced fertilizers (high amount of Urea with no P and K). While Urea was commonly used in cassava cultivation, there are farmers that do not apply any fertilisers. Some farmers use their owned farmyard manure as a source of organic fertilizers, and a few farmers use compound fertilizers (15N-15P_2O_5-15 K_2O and 10N-10P_2O_5-5 K_2O). Fertilizers are generally applied at the time of planting by top dressing. Depending on the farmer's preferences, sometimes urea is mixed with compound fertilizers before application.
Fertilizer demonstrations were conducted on farmer fields in Hinthada and Kyonpyaw townships. There were a total of six treatments (2018/2019).

The fertilizer treatments:

1. Balanced NPK High rate (100kg of Urea+50kg of TSP+100kg of KCl/ac)
2. Balanced NPK Low rate (50kg of Urea+25kg of TSP+50kg of KCl/ac)
3. Balanced NPK Low rate plus Manure (50kg of Urea+25kg of TSP+50kg of KCl + FYM 2t/ac)
4. NP Low rate without K (50kg of Urea+25kg of TSP /ac)
5. Farmers' practice (75kg of Urea per ac)
6. Control (No fertilizer application)

Urea (46% N), TSP (46% P_2O_5) and KCl (60% K_2O) fertilizers were used for the NPK demonstration trials. However, to get better fertilizer use efficiency, Urea and KCl fertilizers were applied twice: half at the time of planting and another half at 4-5 weeks after weeding. TSP fertilizer and manure FYM were applied only at the time of planting. The trials were harvested and measured for fresh root yield and starch content %.

Table 5. Results of the fertilizer demonstration trials in 2018/2019

Treatment	Fresh Root Yield (t/ha)						Starch content (%)						Starch Yield (t/ha)
	ST	MS	YN	KT	AM	Ave	ST	MS	YN	KT	AM	Ave	Ave
1	30	27	30	21	37	29^{a}	31	31	35	31	31	32^{a}	8.9^{a}
2	20	22	27	22	45	27^{ab}	31	31	31	31	31	31^{a}	8.4^{a}
3	23	22	26	27	40	28^{ab}	33	29	31	31	31	31^{a}	8.6^{a}
4	22	16	19	21	46	25^{ab}	31	31	31	31	29	31^{a}	7.2^{ab}
5	27	15	20	23	25	22^{b}	29	31	29	29	27	29^{b}	5.8^{b}
6	13	7	4	6	20	10^{c}	31	29	27	27	27	28^{b}	2.6^{c}

Note: In the same column, the means followed by different small letters are significantly different.

Results of five demonstration trials show that fertilizers (ie. mineral fertilizers and FYM) greatly increase root yields and root starch content. The results of the fertilizer demonstration trials are shown in Table 5. Highest root yields and starch content were obtained when Urea+50kg of TSP+100kg of KCl (46 kg of N, 23 kg of P_2O_5, 60 kg of K_2O) were applied at rate of 100kg of per hectare. Balanced NPK High rate significantly increased the fresh root yield compared to that of current farmers' practice. The response of cassava to fertilizers varied across demonstration farms, and increasing the rate of NPK fertilizers did not always increase the root yields (see the results of KT and AM trials). Combination with mineral fertilizers and FYM improved the yields and starch content. However, only urea application produced markedly less starch yield than other mineral fertilizer applications (Figure 4).

The results show that deficiency of particular essential minerals (i.e. N, P, K) reduce both quantity and quality of cassava roots, and balanced fertilizer application is one of the most effective ways to increase fresh root and starch yields; and hence net incomes. Organic materials such as FYM can also play an important role as a soil conditioner to improve soil moisture, add necessary major and minor nutrients and other physical properties to the soil that are necessary for producing improved yields. The optimum fertilization rates for specific locations is unclear as the response of cassava to fertilization depends upon the specific cassava variety, soil chemical and physical characteristics, micro-climatic conditions, and other crop management practices such as weeding. Regardless, it is clear from the results presented in Table 6 that fertilizer application, despite the associated costs, results in higher rates of return.

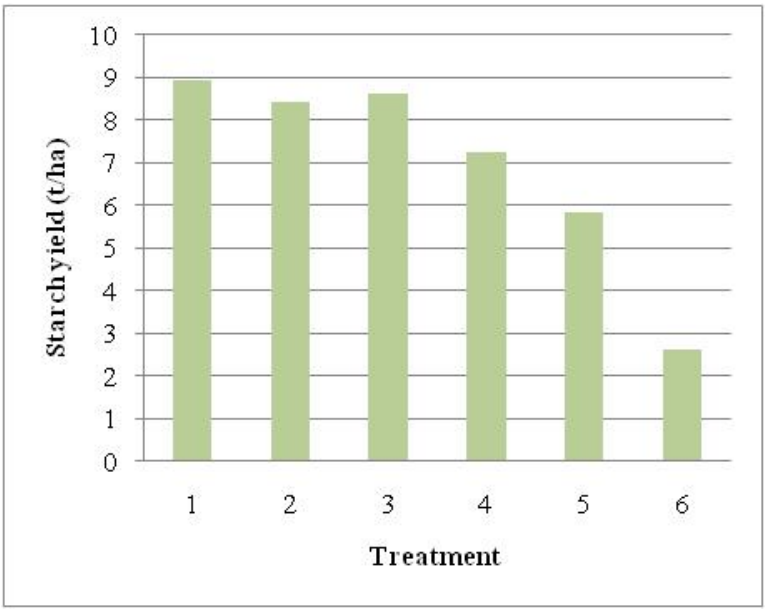

Figure 4. The effect of different fertilizer rates on the cassava starch yields

Table 6. Effect of different rates of fertilizer application on root yield, production cost and net income

Treatment	Yield (t/ha)	Gross income (kyat/ha)	Production cost (kyat/ha)	Net income (kyat/ha)
NPK High rate	29	3,694,179	747,000	2,947,179
NPK Low rate	27	3,482,121	601,000	2,881,121
NPK Low rate plus FYM	28	3,571,571	733,000	2,838,571
NP Low rate without K	25	3,213,257	540,000	2,673,257

Farmers' practice	22	2,794,025	545,000	2,249,025
No fertilizer	10	1,260,524	455,000	805,524

Note: 1 ha = 2.47 ac; Fertilizer prices: Urea = 24,000 kyat per 50 kg bag, TSP = 20,000 kyat per 50 kg bag, KCl = 24,500 kyat per 50 kg bag, FYM = 26,400 kyat per ton

On-farm demonstration plots for multiplication of good planting materials

Japan and Bangkok varieties were used for the demonstration of cassava multiplication as both are popular varieties in the Ayeyarwady region. The multiplication plots were selected and harvested for planting materials for the purpose of demonstrating the results but also to distribute quality stems to interested farmers in neighbouring villages in the project townships. The information of multiplication plots are shown in Table 7. The demonstration plots showed that Bangkok variety produced higher yields with higher starch content relative to the Japan variety.

Table 7. Results of cassava multiplication demonstration plots in Hinthada township (2018/2019)

Variety	Root Yield (t/ha)	Starch Content (%)	*Stem Yield (stem/ha)	**Gross Income (kyat/ha)	Production Cost (kyat/ha)	Net Income (kyat/ha)
Bangkok	33	31.1	20,000	4,182,000	749,000	3,433,000
Japan	19	31.1	18,000	3,305,000	749,000	2,556,000

*estimated number of stems per ha **excluding potential income from stems

Costs of cassava production and profit margin

Economic considerations are a critical part of most management decision for farmers, and it is crucial to consider the costs and returns of an operation to assess economic viability. The income from cassava cultivation depends on the method of cultivation practiced, productivity, and the prevailing prices in the market. When cassava is grown on ridges, the number of plants per unit area, and sometimes yield per plant, are higher than for a crop raised on mounds. This results in a plant population of 10,000 per hectare. In a sole cropping system where ridges are used, the plant population may go up to 12,500 per hectare. Productivity or yield varies according to the intensity of cultivation. Generally, cassava cultivation is not very intensive in Myanmar producing an average yield of 10 tonnes/ha . Though productivity per hectare is generally higher in the Ayeyarwady region (15 t/ha), the cost of cultivation is also relatively higher.

In the 2018 growing season total production costs for the traditional mound method (807,500 kyat per ha) were higher than introduced ridge method (692,250 kyat per ha), a difference of 115,250 kyat. However, the average total production cost of cassava production in Ayeyarwady region was about 750,000 – 850,000 kyat per ha excluding the cost of planting materials. The net cost per unit produced (kyat/t) and estimated net incomes from different cassava cultivation methods in Hinthada and Kyonpyaw townships are presented in Table 8.

A cassava cultivation provides a promising source of income for smallholder farmers in Myanmar it requires considerable amounts of investment to produce good yields.

With labour as the most expensive input in cassava cultivation there is a need to identify labour efficient methods for cassava cultivation including the introduction of labour saving technologies\. Fertilisers also contribute to significant input costs for smallholder farmers. The profit margins farmers can generate are strongly influenced by the price fluctuation, which varies from day to day and sometimes even within a single day. The average prices for fresh roots have increased over the years, but within each year, there has been large variations in prices. Fresh root price was 110-150 kyats/viss in 2017 and 120-160 kyats/viss in 2018. Due to low prices some farmers appear to have cut back on inputs further to reduce their production costs. Given this scenario, it is unlikely that smallholder farmers who generally practice traditional non-intensive low input cultivation methods will adopt improved farming practices. However, the fresh root price appears to be increasing (180-220 kyats/viss and dry starch price at 800-1,000 kyats/viss) in the 2019 harvesting season (January-March).

Research should also be undertaken on the use of optimal resources and rates of fertilizers to reduce dependence on expensive fertilizers. This would have the advantage of lowering production costs, while addressing issues related to maintaining soil health. The return on investment of different combinations and rates of fertilizers are calculated in Table 9. While the results show promise in terms of higher profits from increasing fertiliser usage, as discussed earlier, profit margins are strongly influenced by the market prices of cassava.

Table 8. Gross incomes and profit margins of cassava production by traditional mound method and ridge method

Item	**Mound method**	**Ridge method**
Planting materials	n.a	n.a
Land preparation (kyat/ac)	48,000	40,000
Planting (kyat/ac)	12,000	16,500
Weeding (kyat/ac)	72,000	46,200
Earthen up (kyat/ac)	96,000	79,200
Fertilizers (kyat/ac)	95,000	95,000
Harvesting	n.a	n.a
Total production cost (kyat/ac)	323,000	276,900
Total production cost (kyat/ha)	***807,500***	***692,250***
Fresh root yield (t/ha)	25.75	23.04
Cost /t (kyat/t)	31,359	30,045
Root price (kyat/t)	128,520	128,520
Gross income (kyat/ha)	***3,309,390***	***2,961,100***
Net income (kyat/ha)	2,617,000	2,154,000

Note: Fertilizer rate: Urea75kg + TSP50kg + KCl 100 kg per ac

Table 9. Return on investment of fertilizers (Calculated from fertilizer demonstration trials in 2018/2019)

Price of fresh roots = 128,520 kyat/t					
Fertilizer treatment	fertilizer cost (kyat)	yield (t/ha) 2018/19	gross sales (kyat)	Kyat increase from fertilizer	return on investment
NPK High rate	288,990	29	3,694,179	2,433,655	7.4
NPK Low rate	144,495	27	3,482,121	2,221,597	14.4
NPK Low rate + FYM	274,911	28	3,571,571	2,311,047	7.4
NP Low rate without K	83,980	25	3,213,257	1,952,733	22.3
Farmers' practice	88,920	22	2,794,025	1,533,501	16.2
Control (No fertilizer)	0	10	1,260,524	0	

Conclusion

Cassava is an important crop particularly in the Ayeyarwady region of Myanmar. A rising demand for cassava both locally and for export coupled with its relatively low input production methods make for an excellent pro-poor crop. Moreover, there is significant potential in the region for improving yields through the adoption of new varieties and appropriate cultivation methods. Sustainable intensification of cassava thus has the potential to increase incomes and improve the livelihoods of rural farmers.

Continued traditional methods of production and the resulting low cassava yields reveal limited information in terms of appropriate cultivation practices as well as a lack of access to improved varieties and inputs. A key goal of the current project was thus to expose cassava industry stakeholders including local farmers, processors, cassava traders as well as DOA extension officers, to new cassava varieties and improved cultivation practices.

Improved cassava varieties and planting methods using ridges were demonstrated through field trials. The use of ridges in relation to the traditional method of creating mounds had advantages in terms of reduced labour as they could be constructed using tractors, but also allowed for easier cultivation in terms of fertiliser application and weed control. However based upon the results of the trials, yields appear to be relatively lower when using ridges in place of mounds. Field demonstrations were also conducted for multiplication of good planting materials which is crucial given the significantly low multiplication rate of cassava relative to most other food crops.

Field trials on the effect of different rates of fertiliser application on root yield revealed variable yields associated with different mixes and rates of fertiliser application. Highest root yields and starch content were obtained when Urea+50kg of TSP+100kg of KCl (46 kg of N, 23 kg of P_2O_5, 60 kg of K_2O) were applied at the rate of 100kg of per hectare. Additionally balanced NPK at a high rate also significantly increased the fresh root yield compared to that of current farmers' practice. However increasing the rate of NPK fertilisers did not always increase root yields.

Ultimately, stable prices at reasonable levels are an important factor in determining whether specific intensive cultivation practices should be adopted, as returns corresponding to cost and effort are fundamental for sustainable production. In the event of low cassava prices it is unlikely that smallholder farmers who generally practice traditional non-intensive low input cultivation methods will adopt improved farming practices. Hence further research is required in the context of optimal input use. For example the response of cassava to fertilization depends upon the specific cassava variety, soil chemical and physical characteristics, micro-climatic conditions, and other crop management practices such as weeding. More research is required to enable appropriate recommendations in terms of appropriate input use given cassava prices.

A key achievement of the project was the opportunity it provided for the various cassava industry actors to connect and engage in active dialogue. Based upon the responses from the current project activities there appears to be significant interest amongst actors along the cassava value chain to work together in promoting an improved cassava industry. The activities of the project, in particular the demonstration trials and field days, not only provided the different actors with important information regarding improved cultivation practices, but also a valuable opportunity to engage with one another and share ideas and viewpoints. The improved communication through such exchanges are crucial for identifying preferences and priorities of the different actors but more importantly finding solutions for moving forward.