The Adoption of Improved Cassava Varieties in South and Southeast Asia

Ricardo Labarta[1], Tesfamicheal Wossen[2] and Dung Phuong Le[3]

Abstract

The International Center for Tropical Agriculture (CIAT) collaborated with various research and development partners in nine countries in South and Southeast Asia to document the adoption of different cassava varieties. Cassava experts from Vietnam, Thailand, Cambodia, Laos, Myanmar, The Philippines, Indonesia, China and India got together in country workshops to discuss the use of different cassava varieties and estimated the adoption of these varieties at major production zones and national levels. A variety of disciplines that included breeding, seed production, extension, economics and plant protection contributed to this effort and provided for many countries the first estimates of adoption of this root crop. The more diversity of disciplines and representation of cassava production areas consulted, the more consistent and reliable the estimates we reported. Adoption estimates indicate that out of 4.1 million of hectares of cassava production targeted in the nine countries, 2.7 million (65%) are grown using CIAT related varieties, However, the level of adoption of varieties varies from country to country implying different level of success of different cassava genetic improvement programs in the region.

Introduction

Investments in agricultural research has aimed to boost agricultural productivity and to improve livelihoods around the globe, developing sustainable cropping systems. In the developing world, the CGIAR [4] has played a leading role in developing agricultural technologies together with a variety of national and regional partners. Crop genetic improvement has been for many years the main strategy followed by CGIAR centers and partners that has contributed significantly to increase farm productivity, improve food and nutrition security and increase farm income (Renkow and Byerlee 2010)

Documenting the success of investments in agricultural research has received a large attention among academics and development practitioners and it is increasingly required by funders of these efforts. The CGIAR has also invested large efforts and resources to document their success on technological development and innovations. Tracking the diffusion of these agricultural technologies is one way to provide information of the effectiveness of agricultural research (Walker et al 2014). The International Center for tropical Agriculture (CIAT) and other CGIAR centers have a long tradition in documenting the uptake of improved crop

[1] International Center For Tropical Agriculture (CIAT), Cali, Colombia
[2] International Institute for Tropical Agriculture (IITA), Abuja, Nigeria
[3] International Center for Tropical Agriculture (CIAT), Hanoi, Vietnam
[4] Previously known as the Consultative Group for International Agricultural Research

varieties and improved agronomic practices resulting from their research investments (Evenson & Gollin 2003, Walker & Alwang 2015).

This paper reports on recent efforts led by CIAT to document the diffusion and adoption of improved cassava varieties across the main cassava producing countries in South and Southeast Asia. These efforts were part of the broader initiative funded by the Standing Panel of Impact Assessment of the CGIAR (SPIA) and Michigan State University. By organizing panels of cassava experts in Thailand, Vietnam, Laos, Cambodia, Myanmar, The Philippines, Indonesia, India and China, this study was able to elicit expert opinion about the level of adoption of cassava varieties and to learn about the efforts made in different countries in cassava breading.

Our findings indicate that most of the cassava area in the studied countries is planted with improved cassava varieties (82.7% of total 4.1 million hectares) and around 17% of the total area is still managed under local landraces. CIAT has participated in most of the development of cassava varieties released in Asia and only 17.2% of the total cassava acreage is planted with cassava varieties with no CIAT involvement. There is however a large variability in terms of adoption of improved cassava varieties across countries which can be explained by the different levels of their cassava genetic improvement programs and the orientation of their cassava production.

The Development of Cassava Varieties in Asia

Investments in the development of improved cassava varieties in the Asian continent has been recognized as a successful story. These efforts started with the collaboration that CIAT established with many cassava breeding programs in Asia since 1975. At the beginning a large number of cassava researchers from many Asian countries were trained in CIAT headquarters in Cali, Colombia. But since 1983, with the establishment of CIAT regional office in Bangkok under the leadership of Dr. Kazuo Kawano, CIAT was able to establish a closer and more productive collaboration with the Thai and other national cassava programs (Howeler & Hershey 2002, Mariscal et al. 2002).

The Thai cassava program was the main beneficiary of the collaboration of CIAT in the region, CIAT had a role to facilitate the access to the Latin-American collection of cassava accessions that together with the Thai collection and other regional collections increased the genetic variability needed to establish the regional breeding program. The cassava genetic improvement program started to focus on breeding for high yielding and high starch content, responding to the raising demand coming from the cassava industry.

The breeding efforts resulted in a large number of advance material that has been broadly tested and that resulted in the release of many of today's very well use cassava varieties. Thus Rayong 60 was released in 1987, Rayong 90 in 1991, well the well-known Kasetsar 50 (KU-50) was released in 1992. Later other varieties, like Rayong 5 (1994) and Rayong 72 (1999) became available to Thai cassava growers. Due to the success on the uptake

of this varieties and their impact on cassava yields and starch yields, all these varieties where disseminated rapidly into neighboring countries (Howeler 2006).

In addition of becoming the center of distribution of highly demanded varieties in the southeast region, many of these Thai bred varieties became part of the breeding programs in many other countries in the region and have originated new and productive varieties that are available for cassava growers in many regions. The most recent cases could consider the varieties Huay Bong 60 and Huay Bong 80 in Thailand, and the varieties KM 140, KM 98-5 and KM 419 in Vietnam. The potential for increase the number of improved cassava varieties is huge.

Methodological Approach

For gathering information about the releases and adoption of improved cassava varieties in each country, we followed expert elicitation methods that where developed to recently document the adoption of improved crop varieties in Africa (Labarta 2015, Muthoni & Andrade 2015) that were further refined by Michigan State University during the implementation of the Strengthening the Impact Assessment Capacity of the CGIAR (SIAC) project (Maredia & Reyes 2014).

For each of the 9 countries included in the study, we identified a variety of cassava experts that represented a variety of organizations (national programs, universities, extension services, NGOs, private companies and other research organizations) and that brought to the panel discussion expertise from different disciplines (Breeding, seed systems, agricultural extension, social sciences, etc.). These experts were invited into a central location to participate in a national workshop of one day where a common protocol was implemented.

General Information

Before starting the elicitation procedure, we first documented and updated varietal release history using secondary sources of information as well as personal contacts with knowledgeable persons. In some countries, this information is available. However, in most cases data on varietal release is not well documented (e.g., Laos PDR, Indonesia and Vietnam). The other related problem was the inadequacy of the available information for the study purpose. For example, information related to the genetic pedigree of improved cassava varieties is either not well documented or not available for many of our target countries. As a result, we invited breeders in our expert workshops to update all the necessary information on varietal release and characterization.

For the adoption elicitation, we first looked for possible market level data (such as seed sales) and area under cassava (as disaggregated as possible) from annual agricultural surveys. Unfortunately, market level seed sales data is not available for the cassava sector in all countries. In fact in most of the countries more than 95% of seed distribution is done informally. However, data on cassava area coverage is available for all countries. In rare case such as in

Thailand, area under specific variety has been collected as part of the agricultural annual survey. We used this data as a background information during the elicitation procedure. We did not share this information to our experts until they provided us their own perceived estimates of adoption to avoid bias.

Elicitation Procedure

The cassava area data was obtained from different sources in each country, but in many cases this was available only in the local language. For some countries we were able to get data on harvested area at a much disaggregated level (regional and province level). We also collected data at aggregate level from FAO to compare aggregate area at country level.

The next step is to define the main cassava growing area in each country, which was cross-validated by knowledgeable experts participating in the workshop. Once the participant experts where comfortable with the identified major production areas, we then conducted expert elicitation to estimate adoption rates of improved and local varieties at each defined geographical unit. This was done in three steps. First, each individual expert was asked to provide their own perceived aggregate adoption rates of improved and local varieties for the respective geographical unit.

In the second step, experts were grouped into different groups based on their knowledge of the geographical area under consideration and were given the task of estimating aggregate adoption rates of improved and local varieties in their respective group. The objective of this exercise was to achieve a consensus at each geographical unit. In the final step, we held another round of elicitation-this time all experts together- to achieve consensus on the aggregate adoption rates of improved and local varieties at all geographical units. We then aggregated adoption rates at each geographical unit considering their relative area share to estimate a representative adoption rate at a country level. We opt to use region specific elicitation procedures instead of country level elicitation, since most of participating experts indicated to be more knowledgeable in their own specific region.

Research Findings

Cassava Production Areas

Our study focused on the main cassava producing countries of South and Southeast Asia, but the relative importance of this root crop varies across the countries. Clearly, cassava in Thailand (Table 1.2) and Indonesia (Table 1.4) has a considerable amount of acreage devoted to cassava production (over 1 million ha). There is then a second group of countries where there is over 344,000 hectares under cassava and the cassava production keeps increasing, especially Vietnam and Cambodia (Tables 1.1 & 1.8). India and the Philippines maintain areas producing cassava of around 200,000 ha (Tables 1.3 & 1.8) while countries like Laos and Myanmar are still keeping low levels of acreage under cassava (Tables 1.5 & 1.8)

Table 1.1 Relative importance of cassava production areas in Vietnam

	Red river delta	North midlands mountain areas	North central & central coastal areas	Central highlands	South east	Mekong river delta	Aggregate
Cassava area (ha)	6600	117200	173900	147600	92500	6300	544100
Share (%)	1%	22%	32%	27%	17%	1%	100%

Table 1.2 Relative importance of cassava production areas in Thailand

	North East region	Central region	Northern region	Thailand-Aggregate
Cassava area (ha)	733,972	417,123	234,024	1'385,120
Share (%)	53%	30%	17%	100%

There are also differences across sub-regions in each country. In all countries the main cassava producing region is responsible for between 30% and 60% of the total acreage of the crop. The Northeast area is by far the main producing area in the whole Asia region where 734,000 ha of cassava are being grown annually (Table 1.2). In Laos, although only 45,180 ha of cassava are produced annually, more than 69% of the total production is concentrated in the central region.

Table 1.3 Relative importance of cassava production areas in Philippines

	ARMN	Northern Mindanao	Bicol	Visayas	Calabarzon	Others	Aggregate
Cassava area (ha)	97,486	25,168	22,825	67,362	7,896	14,887	205,287
Share (%)	47%	12%	11%	33%	4%	7%	100%

Note: Visayas include central, eastern and western areas Others include Zamboanga Penin,Socsargen and Cagayan Valley

In five of the countries included in this study, there is a trend to concentrate the cassava production in few regions (less than 3 regions), but countries like Vietnam, Indonesia and the Philippines presents more diverse areas where cassava is being grown. The Philippines with around 10 main producing areas is the more diverse country in terms of cassava production zones.

Table 1.4 Relative importance of cassava production areas in Indonesia

	Lampung	East Java	Central Java	West Java	Other regions	Aggregate
Cassava area (ha)	304487	157091	153201	93921	294593	1003293
Share (%)	30%	16%	15%	10%	29%	100%

Table 1.5 Relative importance of cassava production areas in Laos

	Northern region	Central region	Southern region	Aggregate
Cassava area (ha)	11,425	31,005	2,755	45,185
Share (%)	25%	69%	6%	100%

In India and China we concentrated our efforts to document the adoption of cassava varieties in the main States or Provinces that are growing cassava. In the case of India, 84% of the production of cassava is concentrated in the states of Kerala and Tamil Nadu (Table 1.6). In the case of China, Guanxi, Hainan and Guangdong explains 90% of the total production of cassava in that country (Table 1.7). This regions in both countries may have the size of other countries in Asia and therefore show important levels of production of cassava.

In the case of Cambodia and Myanmar, it was not possible to organize a full workshop to elicit the adoption estimates of the cassava experts. Due to the lack of representation of some countries and adjusting the methodology followed in other countries, the study was able to estimate the overall level of adoption at national level with no sub-national level estimations. As shown in table 1.8 both countries present different levels of production of cassava, being Cambodia a country with a growing area of cassava.

Table 1.6 Relative importance of cassava production areas in India

	Kerala	Tamil Nadu	Aggregate
Cassava area (ha)	71,070	120,000	191,070
Share (%)	34%	50%	84%

Table 1.7 Relative importance of cassava production areas in China

	Guanxi Province	Hainan province	Guangdong province	Aggregate
Cassava area	230,000	37,840	76,160	344,000
Share	60%	10%	20%	90%

Table 1.8 Relative importance of cassava production areas in Cambodia and Myanmar

	Cambodia	Myanmar	Aggregate
Cassava area (ha)	350,000	43,200	393,200
Share (%)	100%	100%	100%

Only national estimates of cassava acreage was feasible for Cambodia and Myanmar

The Adoption of Cassava Varieties

As cassava is not a native crop for Asia, there was no surprise to document that the majority of cassava varieties grown in South and Southeast Asia are genetically improved. As shown in Table 2, around 82.7% of the total of 4.1 million hectares of cassava cultivated in the 9 countries of the study are under improved cassava varieties. The acreage cultivated with local varieties or land races only reaches 17.3% (Table 2).

In three countries, the use of landraces or local varieties is however important. In The Philippines, Indonesia and Laos, almost half of the cassava acreage is grown using local cultivars which is associated with the importance of direct consumption of cassava in these countries. In these countries the genetic improvement programs on cassava have focused in both, breeding for direct consumption and for industrial purposes (Howeler, 2006).

Table 2 Adoption of improved cassava varieties in different Asian countries

	% adoption improved varieties	% adoption local & landraces	% total national acreage represented
Vietnam	94.8%	5.2%	100.0%
Thailand	99.3%	0.7%	100.0%
Philippines	44.9%	55.1%	100.0%
Indonesia	47.4%	52.6%	100.0%
Laos	56.9%	43.1%	100.0%
India	68.7%	15.3%	84.0%
China	98.6%	1.4%	90.0%
Cambodia	100.0%	0.0%	100.0%
Myanmar	100.0%	0.0%	100.0%
Total 9 countries	82.7%	17.3%	97.6%

In the other countries the history of cassava production is more recent and traditionally the direct consumption of cassava varieties has been reduced. But starting with Thailand, and following with Vietnam, Myanmar, China and others, the increasing demand for cassava starch produced a boom of cassava production and for improved varieties that can produce large starch content. In all these countries the level of utilization of improved varieties is above 98% of the total acreage (Table 2).

Most of the rapidly growth in cassava production in these last countries have been associated with the breeding efforts that mainly started in Thailand where the collaboration between the International Center for Tropical Agriculture (CIAT) and Thailand partners originated a strong and productive breeding program (Sarakarn et al. 2001, Howeler & Hershey 2002). From Thailand many countries in Southeast Asia has benefit from these breeding efforts.

Table 3 Top 10 cassava varieties used in South and Southeast Asia

Cassava varieties	Area under the variety (ha)	Countries where is grown
KU 50	1,302,373	Thailand, Vietnam, Cambodia, Laos, Myanmar, Philippines
Rayong 5	387,114	Thailand, Myanmar, Laos, Cambodia, Philippines
UJ 3	257,846	Indonesia
SC 205	175,846	China
UJ 5	163,537	Indonesia
Rayong 90	126,997	Thailand
Rayong 60	93,118	Thailand, Vietnam, Cambodia, Myanmar
KM 140	88,688	Vietnam
Rayong 72	83,361	Thailand, Vietnam, Laos, Cambodia
UPLCa-2	63,825	Philippines

Table 3 summarizes the 10 most used cassavas varieties in the 9 countries included in the study. These 10 top varieties are grown in 66.5% of the total acreage of cassava in the referred countries and constitute 80.4% of the acreage occupied by any improve variety in the region. Although the percentage of local varieties/ landraces are important, there is no single local variety that is grown in large areas in any country (Wossen & Labarta 2015).

By far the variety KU-50, originated by the cross of Rayong 1 and Rayong 90 (with CIAT pedigree), is the most planted variety according to the cassava expert estimation in

various countries consulted. This single variety is currently grown in 1.3 million ha in at least 6 Asian countries and represents 47% of the total acreage under improved varieties in the Asian continent. For many years KU-50 has remained as main cassava variety demanded by the starch industry and most recently is being used in breeding crosses to generate new varieties like Huay Bong 60 and Huay Bong 80 that are increasing rapidly their use in Thailand.

The Thai cassava breeding programs has also boosted the adoption of other cultivars originated in this program that include Rayong 5, Rayong 60, Rayong 72 and Rayong 90. These four varieties are being grown in more than 690,000 ha across various countries (Table 3). By far the investments in cassava genetic improvement has proved to be successful in Asia in terms of the diffusion of the varieties generated, but also due to the large amount of economic benefits hta are estimated to have been generated by the use of these varieties (Robinson and Srinivasan 2013)

Other countries has also made breeding efforts that has resulted in effective development of improved cassava varieties. China, Indonesia and The Philippines where able to release improved varieties that have achieved a large level of uptake among cassava growers in these countries. In Indonesia the varieties UJ-3 and UJ-5 are being planted in more than 400,000 ha while in China the improved variety SC-205 is being planted in around 175,000 hectares. In the case of the Philippines, the collaboration of the cassava program with the Thai program and CIAT resulted in the release of the variety UPL-Ca2 (Mariscal et al. 2002) that is being grown in more than 60,000 ha in this country (Table 3)

Conclusions

The investment on cassava genetic improvement has proven to be effective in the Asian continent. Efforts in establishing functioning and relevant breeding programs have resulted in the development of a set of improved cassava varieties that are currently planted in 83% of the total acreage of the region. There are around 17% of the total area of cassava devoted for local varieties or landraces, mainly devoted for direct consumption. However, this direct utilization for human consumption raises the question whether cassava breeding effort could also be directed for these kind of varieties.

In countries were cassava is mainly targeted to satisfy the growing demand of cassava starch and other industrial purposes, the use of improved varieties have reached almost 100% of the total cassava acreage.

The efforts made by CIAT and its partners are providing the evidence the large pay-offs that the cassava genetic improvement can provide. A single variety KU-50 is currently planted in around 47% of the total acreage of improved cassava varieties and it has been documented that this single variety was able to generate large amount of returns to its development (Robinson and Srinivasan 2013). Other varieties developed by the Thai and other regional breeding programs are also showing the same trend.

One caveat should however be highlighted. Although these study provides the most updated overview of the adoption of cassava varieties in South and Southeast Asia, most of the information comes from cassava experts that were consulted. As has shown by other studies this method could be useful and valid when good secondary information is available, a variety of experts from different disciplines are invited and the information is further verified (Labarta 2015, Walker et al 2014). So it is highly recommended that this analysis can be verified in the near future with more rigorous fieldwork.

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