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Analysis of the cassava yield variation at Cambodia-Thailand border

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Abstract

Cassava (*Manihot esculenta* Crantz) is one of the most important upland crops in Cambodia. However, there is still a shortage of information and research about its yield variations and the causal factors, which is important to know if our goal is to increase the cassava production in Cambodia. The objectives of this study were to highlight the yield variation and causal factors in agro-practices of cassava production in Battambang and Pailin provinces. In these two provinces, 109 cassava farmers were randomly selected from a list of households provided by each village chief. The results showed that the cassava yield ranged from 10 to 34 tons per hectare with the mean yield ranging from 29.41% to 82.35% of the maximum yield, while the corresponding yield gap ranged from 6 to 24 tons per hectare. The variables of the agro-practices, such as the weed control and the usage of herbicides and liquid fertilizers are the significant factors of the cassava yield. They account for 83% of the total yield variability among the sample farmers. The main constraints to cassava production are drought, weed density, pests, and diseases. The farmers had, in general, a low education; 41% of them had only a primary school education diploma. So, it was difficult for them to understand information on new techniques, the weather factors, the pest mitigation, and appropriate agro-practices. The knowledge of all those factors could improve the yield and narrow the cassava yield gap. Therefore, it is undeniable that the yield gap varies substantially in Cambodia.

Keywords: Agro-practices, analysis, Cambodia-Thailand, cassava, yield variation.

Introduction

Besides rice, which is the major agricultural product in Cambodia, the farmers are also attracted to cassava production. Cassava has now become an important cash crop for resource-poor farmers in Cambodia (Sopheap et al. 2008). For the last 5 years, the cassava production area in Cambodia has expanded significantly from less than 515 thousand hectares in 2014 to more than 650 thousand hectares in 2018 (MAFF 2017). Cassava is an essential tropical crop and can be suitable to grow with an average temperature of 25-29 ^{0}C (Onwueme and Sinha 1999) and annual rainfall greater than 500 mm (MAFF 2015). In 2014, the average yield of cassava in Cambodia was 25 tons per hectare, which was the second-highest yield after Laos in Southeast Asia (FAOSTAT 2017). The increase in production has come from the expansion of the planting areas, although the average yield had decreased to 22.55 tons per hectare in 2017 (AFSIS 2017). In an optimal growing environment, the yield of cassava could reach 90 tons per hectare (El-Sharkawy 2004). However, the cassava experiment under Cambodian conditions obtained the highest yield at 36 tons per hectare (Sopheap et al. 2008).

Improving crop management practices including high-yielding varieties, good quality planting materials, sufficient moisture, proper plant spacing, and pest and disease management are needed to close the cassava yield gap. However, farmers often based their practice more on myths instead of facts, like thinking that cassava does not need fertilizers or pesticides, so they grow cassava with minimal or even no fertilizer application. Another study conducted in Thailand showed that the yield decline is due to continuous cassava production in the same unfertilized plot over an 8-year period, which is similar to the result of other experiments in Southeast Asia (Howeler and Cadavid 1983). A study by Sopheap et al (2012) in Cambodia showed a large yield variation ranging from 12.7 to 37.2 tons per hectare, with the main constraints in increasing the yield being the soil nutrient deficit, short crop duration, and the weed competition.

Surveys of farming practices, supplemented by measurements of soil properties and crop performance, have the potential to provide a valuable means of assessing yield constraints in farmers' fields (Calvino and Sandras 2002; Inthavong et al. 2011). Neumann et al (2010) pointed out that minimizing the yield gap requires an understanding of nature and the constraints of the regions. Therefore, separated assessment is needed to increase the yield in a specific region. At the same time, information on yield variations, coefficients, and causal factors are indispensable for increasing the cassava production in Cambodia.

The objective of the study is to highlight the yield variation and causal factors in relation to the aspects of agro-practices of the cassava production: varieties, fertilizers, herbicides, pesticides, weed control, and knowledge (Education and farmer experience). The study is also an importance tool that highlights the prevalence of a yield gap; that information is not readily available in many regions of Cambodia, due to a lack of data in the agro-practices of cassava production.

Methods

Study area

This study was conducted in two provinces of Cambodia, Battambang and Pailin which are located near the Cambodia-Thailand border. They have more than 50,000 hectares of cassava fields per province and are among the top 10 provinces that planted the most cassava in Cambodia, according to the Ministry of Forestry and Fisheries, Cambodia (MAFF 2017). The study area is situated in one particular agro-ecological zone which has many enterprises for the storage, processing, and export of cassava, mainly to Thailand. The major source of household income in the study area is from cassava, maize, mungbean, soybean, and fruit trees. These provinces both have a long history of cassava production and are currently the largest cassava growing areas in Cambodia.

Sampling method

A multi-stage sampling method developed by Yamane formula (created in 1967 and 1973) was used to select 109 cassava farmer samples with a sampling fraction of at least 10% of the population of cassava farming (standard error of 10%). These respondents were chosen randomly from a list collected from the village chiefs across 3 districts of those 2 provinces as shown in Table 1 and Figure 1. The cassava farmers who collaborated with this study had to indicate a willingness to be interviewed and allow a study of their crop. The first survey was conducted between February and March 2019 in Battambang province and the second one was from June to July 2019 in Pailin province.

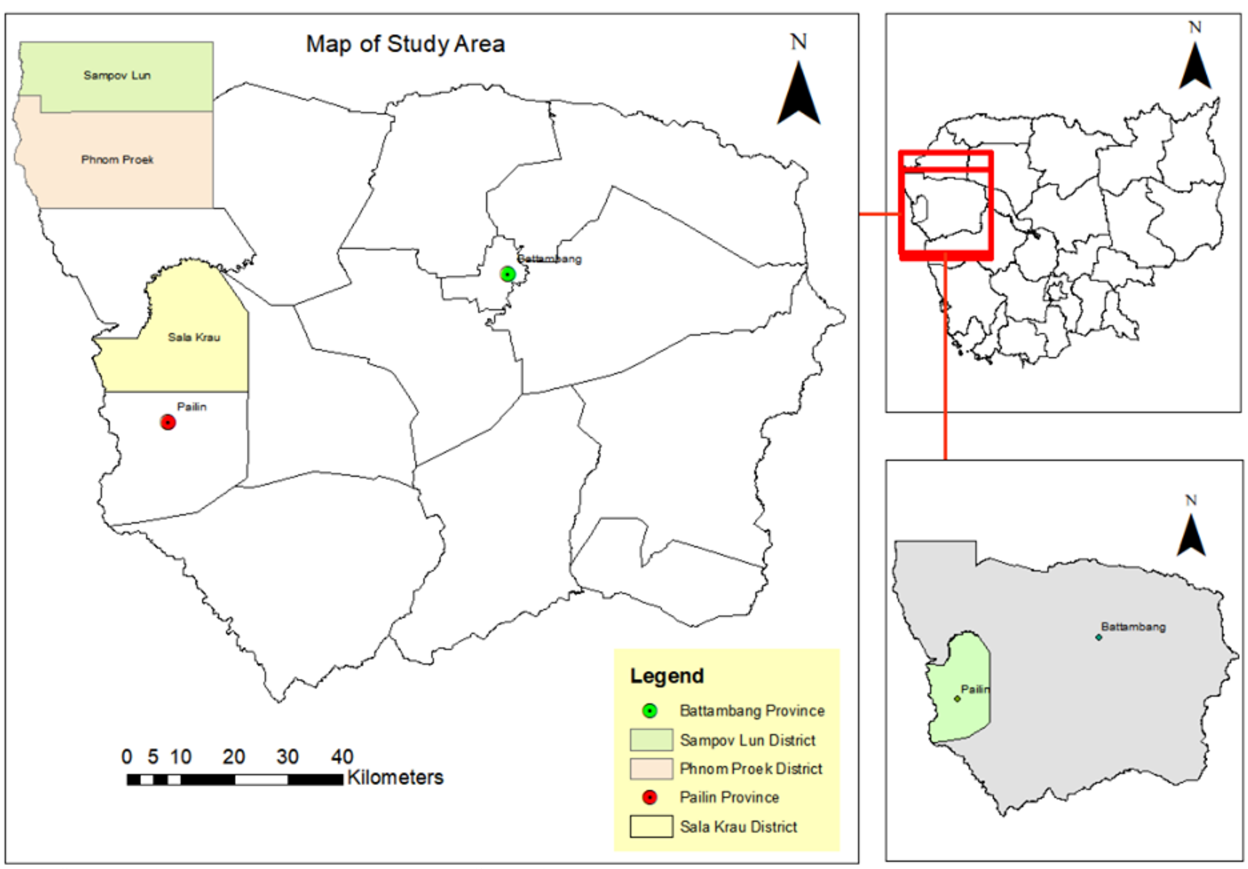

Fig. 1: Study area in Battambang and Pailin provinces, Cambodia.

Table 1. Number of household samples in each target village.

Provinces	Districts	Communes	Villages	Households	Households	
					Cultivated	Selection
Battambang	Sompovlun	Serei Mean Chey	OuKandal	455	308	28
	PhnomPhrek	PhnomPhrek	PhnomPhrek	901	350	32
Pailin	Salakrav	Salakrav	Phnomkuy	386	295	27
		OuAndoung	Ouchetbram	290	241	22
Total				1,637	1,194	109

Data collection

Both qualitative and quantitative methods of data analysis were applied in this study to understand the actions of cassava farming. Primary data was collected to get information about cassava production, the agro-practices, the varieties, pests and diseases, and the history of cassava production. This was achieved by using both semi-structured and guided questionnaire interviews with the members of the households who were part of sample. Secondary data gathered information about temperature, humidity level, rainfall, and any other data relevant to the study.

Data analysis

The data collected from the questionnaire surveys were coded and analyzed using SPSS Version 20 statistical program to generate cross-tabulation of variables and calculate descriptive statistics. The correlation and regression analysis were also conducted to examine how agro-practices significantly affect cassava yield and whether the farmer's knowledge level, represented by education level and farm experience, has an influence on the cassava yield. Microsoft Excel was used for frequencies, charts, and tables to show visible findings of agro-practices and causal factors.

Results

Education of head households

The level of education is one of the factors that affect agricultural productivity (Asadullah and Rahman 2005). Likewise, the major finding in a previous study showed that as the level of education increases, the productivity increases as well. The farmers with a secondary school education got the highest returns on agricultural productivity (Oduro et al. 2014). The results of our findings, as in Figure 2, showed that a large number of cassava farmers in our samples have a low level of education: 41.29% of them have a primary school education and 16.5% are illiterate. Only 3% of them completed college education.

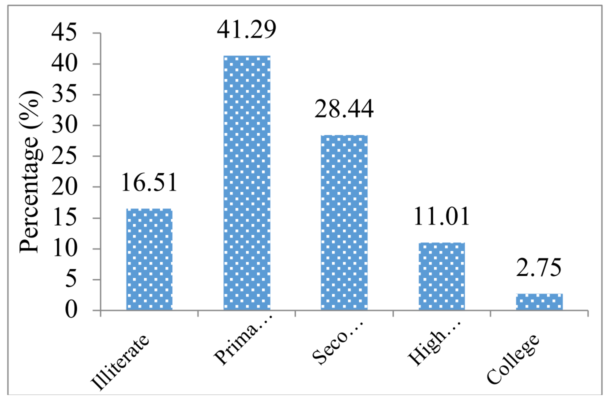

Fig. 2: Education level of head of households' cassava farmers in both provinces.

Characteristics of the Agro-practices
Land use

The sample farmers have an average farming area of 7.63 hectares, which is divided into 58.03% of cassava cultivation, 30% of maize, 6.11% of rice, and 5.86% of fruit trees such as mango, longan, and cashew nuts (See the detail in Fig. 3). This indicates that cassava is the most important crop. It provides a major income to farmers in this study area.

Of the land planted with cassava, 43.66% was previously used to plant maize. Most farmers grew cassava as a mono-crop. Only a few farmers were growing cassava as a mixed crop. Our findings showed that only 28.77% of cassava is processed locally and the rest is sent to Thai traders who export the cassava to the Chinese market. Therefore, the crop prices seem to influence the usage of the land (crop change from maize to cassava) in the study area.

At the same time, 63.3% of the farmers in this study area had more than 5 years of experience in cassava cultivation and they practice a crop rotation between maize and cassava from year to year. The crop rotation is a good way to improve soil properties such as soil aggregate, soil fertilizer, and help to minimize pests and diseases (Yuniwati et al. 2020). These processes contribute to the development of soil structure (Ball et al. 2005).

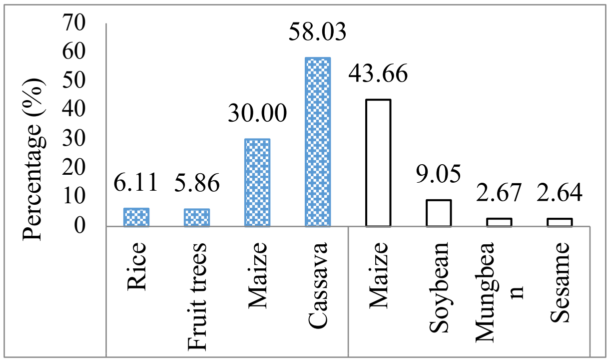

Fig. 3: Land used and crop rotation for cassava farming in the both provinces.

Cassava varieties

In Battambang province, the most popular variety is Rayong 9 while variety 89 is the most popular in Pailin province. More than 43.12% of the farmers planted Rayong 9 variety and 17.43% planted the variety 89. Moreover, 8.26% of the farmers planted an unknown variety as shown in Figure 4. Among these cassava varieties, Rayong 9, Huay Bong 60, and KU 50 are from Thailand. Kromumyun variety is from Vietnam, while the 89 and KorlTorl varieties are from unknown sources, but the owner of a silo mentioned that those varieties come from Thailand. Rayong 9, KorlTorl, Huay Bong 60, and KU 50 have high yield potential and high starch content and variety 89 has a very high yield potential.

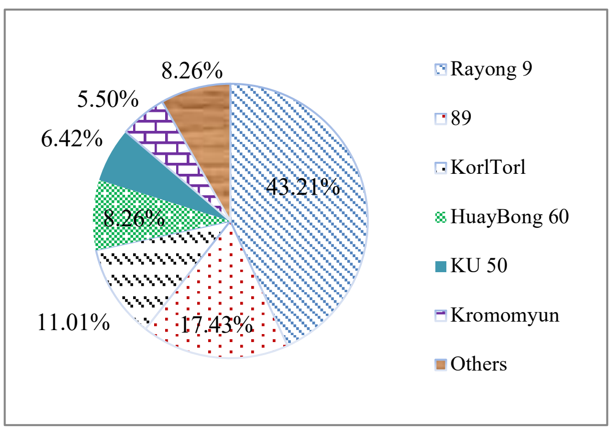

Fig. 4: Varieties of cassava in the study area.

Fertilizer usage

In the study areas, there is great misunderstanding among the farmers. In some cases, the information about cassava production is based more on myths than on facts. Some of those farmers often grow cassava with minimal or no fertilizer at all. Also, they would apply fertilizer, not for the cassava plant, but to improve the soil property only. They apply NPK (15-15-15) fertilizers or Bio-fertilizer only one time or 50 kg per hectare when they raise beds before planting stems.

Table 2 showed that 58.33% of the cassava farmers in Battambang province used fertilizer in their farming, while in Pailin province, that figure is only 28.57%. Likewise, liquid fertilizer (called Chy Tuek or Hormone in the local language) is widely used. Cassava farmers who were interviewed believe that this application improves the cassava yield. One month after planting, the farmers always spray liquid fertilizer on the cassava leaves for the first time. The second time of spraying is conducted 2 to 4 weeks after the first time. The rainfall will have an influence on the frequency of spraying. In Battambang 85% of the farmers sprayed the liquid fertilizer while in Palin, only 4.08% of the farmers did not spray as shown in Table 2. The majority of the cassava farmers used the liquid fertilizers (85% - 95.92%) and the dry fertilizers (58.33% - 28.57%).

Continuous cropping, recycling, and reusing of nutrients from organic sources may not be sufficient to sustain crop yields. A study on the effect of fertilizer application on continuous cropping of cassava from 2004 to 2007 in Indonesia revealed that without fertilizer application, cassava yield decreased from more than 20 tons per ha in the first year to less than 10 tons per ha in the third year, after which the yield remained constant at about 9 tons per ha (Yuniwati et al. 2012).

Weed control

Weed control is a very important factor that can improve the yield. A very good weed control could increase the yield by 7 to 8% according to a previous study (Clair et al. 2000). In the study area, the cassava farmers conduct two types of weed control. For the first method, the weed is removed by hand when the cassava is 1 month old and then when trimming is done at 7-8 months old or 2-3 months before harvesting. The second method is by using herbicides. Table 3 shows that the "hand weeding" control in Battambang province was done once and it represented 53.33% of their work time for the cassava farming. In Pailin province, the" hand weeding" was done 1 to 3 times and it represented 96% of their work time. So, we can understand the reason why the cassava farmers in these 2 provinces prefer to use herbicides for weed control.

The herbicides used are produced in Thailand: 48% of Glyphosates and 28% of Paraquate which are mostly used in the study area to control the weeds. However, because the study area is close to the Thai border, the cassava farmers mostly bought herbicides or chemical pesticides from Thailand.

Table 2: Both types of fertilizer application of household samples in the study area.

Both Types of fertilizer application	Battambang		Pailin	
	Frequency	Percentage	Frequency	Percentage
Dry fertilizer				
Not used	25	41.67	35	71.43
Bio-fertilizer	13	21.67	11	22.45
Chemical	17	28.33	1	2.04
Both	5	8.33	2	4.08
Total	**60**	**100**	**49**	**100**
Liquid fertilizer				
Not used	9	15.00	2	4.08
1 Time	42	70.00	46	93.88
2 Times	9	15.00	1	2.04
Total	**60**	**100**	**49**	**100**

Table 3: The ways of controlling weed by cassava farmers in study area.

Ways of controlling weed	Battambang		Pailin	
	Frequency	Percentage	Frequency	Percentage
By hand				
Not used	4	6.67	0	0
1 Time	35	58.33	15	30.61
2 Times	6	10.00	13	26.53
3 Times	13	21.67	19	38.78
4 Times	2	3.33	2	4.08
Total	**60**	**100**	**49**	**100**
By herbicide				
2 Times	9	15.00	11	22.45
3 Times	20	33.33	36	73.47
4 Times	18	30.00	2	4.08
5 Times	9	15.00	0	0
6 Times	4	6.67	0	0
Total	**60**	**100**	**49**	**100**

Pesticide usage

Figure 5 show that 50% of cassava farmers in Battambang have used insecticides while only 24.48% did in Pailin. The majority of invasive insect species are mites and mealybugs in the study area. This situation agrees with the study of MAFF (2015) and Ignazio et al (2016), which shows that the main pests in South East Asia are the cassava mealybugs, cassava mites, and whiteflies.

In Battambang province, the highest percentage of the farmers who used insecticides 2 times is 21.66% while in Pailin province; it is 10.20% of the farmers who have used insecticides 1 and 2 times (Fig. 5).

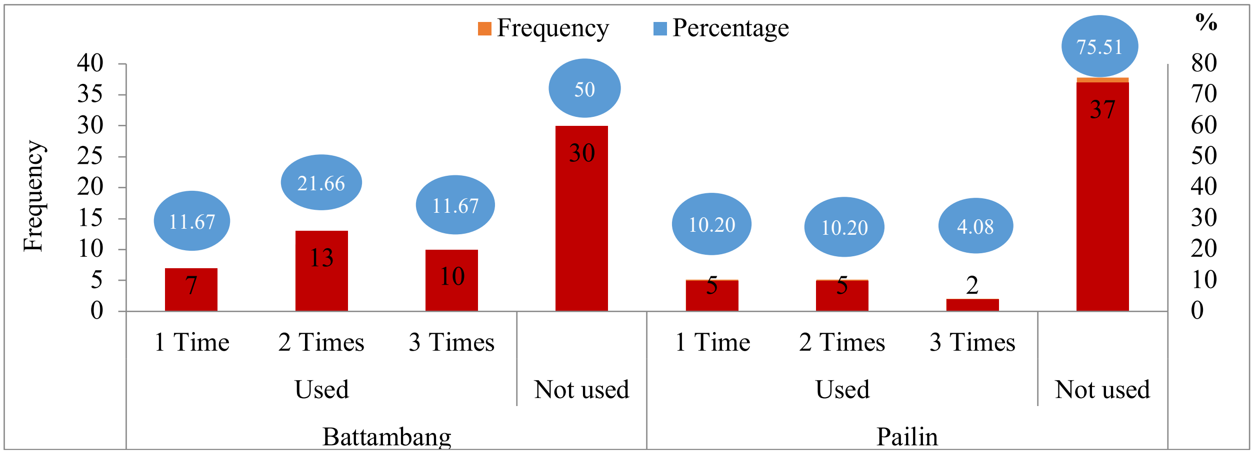

Fig. 5: Frequency and percentage of pesticides usage for cassava farmers.

Cassava yield gap

In the study area, the yield of fresh root cassava showed a great variation, ranging from 10 to 34 tons per hectare, with an average of 22 tons per hectare. The yield gap between the maximum and the average yield was 12 tons per hectare, while the gap between the average and the minimum yield was 12 tons per hectare. The fields with a low to moderate level of yield accounted for 63% of the fields surveyed in this study. Therefore a total gap between the maximum and minimum yield is 24 tons per hectare. These data are similar to the study of Sopheap et al (2012) which showed a large difference in the yield of cassava in Kampong Cham province where the highest yield was 37.26 tons per hectare and the lowest yield was only 12.8 tons per hectare.

In the study area of Battambang and Pailin provinces, the group with the highest frequency experienced moderately low yields with frequency declining towards both the higher and the lower ends. However, the yield groups of moderately high, moderate, and moderately low represented the smallest variations among groups (Table 4). The mean yield of the moderately high to the low yield group ranged from 82.35% to 29.41% of the highest yield recorded, while the corresponding yield gap ranged from 6 to 24 tons per hectare. The maximum yield of 34 tons per hectare was considered to be representative of the maximum potential farm yield.

Figure 6 indicates the difference of yield in those communes. For example, in PhnomPhrek the percentage of "moderately low " and "low'' yields is large, while in Salakrav, the percentage of "High" and "Moderately high"is also large. However, the percentage of average yield per hectare is low for SereiMeanChey PhnomPhrek commune in Battambang Province and OuAndoung Salakrav in Pailin Province. The low average yields in these communes seem to be caused by drought, weed competition, pests, disease, and inappropriate agro-practice of the cassava production.

Factors affecting cassava yield

To find the factors affecting cassava yield, we calculated the correlation coefficient between cassava yield per hectare and the variables representing the farmer's attributes and his agro-practice. As shown in Table 5, the frequency of liquid fertilizer application has a high and significant correlation with the cassava yield (r=0.60, P<0.01), the usage of herbicides represented a negligible correlation (r=0.27, P<0.01), and the weed controlling has the highest and significant correlation (r=0.90, P<0.01). So the agro-practices might influence the cassava yield in the study area, but we cannot call it an unequivocal proof.

Table 4: Distribution of yield group and yield gap for fresh root cassava.

Yield group	Mean (ton/ha)	Range (ton/ha)	No. of fields	% of maximum yield	Yield gap range (ton/ha)
High	34	> 30.99	18	100.00	-
Moderately high	28	26.00-30.99	22	82.35	6
Moderate	22	20.00-25.99	25	64.70	12
Moderately low	17	14.00-19.99	26	50.00	17
Low	10	<14.00	18	29.41	24

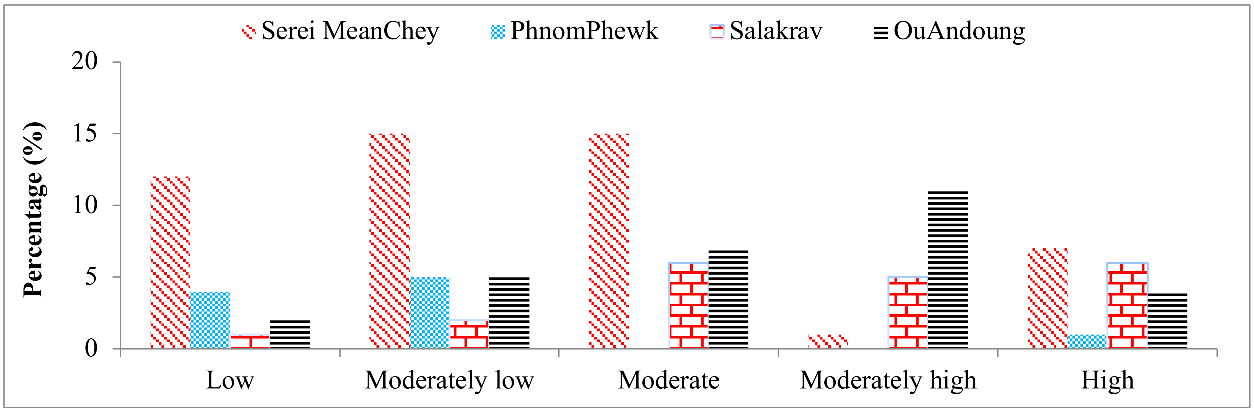

Fig. 6: Percentage of mean yields per hectare in each commune.

Table 5: Correlations between yield and agro-practice factors influencing the yield.

Variables	1	2	3	4	5	6	7	8	9	10
[1]Yield/H	1									
[2]Farm size	-.002	1								
[3]Farm Experience	-.104	-.030	1							
[4]Education	.031	.263**	.080	1						
[5]Chemical	.045	.055	-.013	-.011	1					
[6]Bio Fertilizer	-.163	.035	-.023	.004	-.280**	1				
[7]Liquid Fertilizers	.600**	.162	-.174	.148	-.096	-.020	1			
[8]Pesticides	-.027	.089	.007	-.013	.301**	.123	-.210*	1		
[9]Herbicides	.275**	.016	-.041	-.089	.026	.031	.056	.378**	1	
[10]Weed Controlling	.908**	.047	-.134	.059	.048	-.159	.588**	-.017	.177	1

**: Correlation is significant at the 0.01 level (2-tailed). *: Correlation is significant at the 0.05 level (2-tailed).

The planting season is a more appropriate term to use here. It was not included in the computation of correlation because the data did not allow a meaningful analysis, as most of the farmers planted cassava from February to March and only a small number of farmers planted in May. Planting interval is also not included in the analysis because all the sample farmers planted 3-4 stems per meter. So, these factors were not the cause of the yield variation in the present study.

To control the effect of confounding factors, a regression analysis was also conducted. We first estimated a model using all the independent variables, and then we removed the variables with VIF values larger than 10 in models 1 and 2 to avoid multicollinearity. The variables that we removed are all those indicating the cassava variety such as (Rayong 9, 89, KorTorl, HauyBoung 60, and unknown).

Model 1: The analysis was carried out to determine if cassava is affected by the knowledge of the farmers (education level and farm experience) as well as the agro-practices such as varieties, agro-chemical usage and weed control (See Table 6, Model 1). The results indicated that weed control, herbicides, and liquid fertilizers were significant factors affecting the yield. Among these agro-practices, weed control by hand has the largest positive effect on cassava yield. If cassava farmers increase the frequency of hand weed control by one, the cassava yield will increase by 6.6 tons per hectare. This is a factor of most importance for the agro-practice in cassava farming, in the study area.

The second factor affecting yield is the usage of liquid fertilizers. If the farmers increase the frequency of spraying liquid fertilizers by one, the yield will increase by 2.35 tons per hectare. For the herbicides, there will be an increase of 1.19 tons per hectare if the farmers increase the frequency of application by one. All variables together accounted for 83% of the total yield variability (R^2 = 0.83) as shown in Table 6.

Table 6: The coefficients analysis of the determinants of cassava yield.

Variable	Model 1		Model 2		Model 3		Definition
	Coefficients	t-value	Coefficients	t-value	Coefficients	t-value	
(Constant)	6.885	5.326	7.281	6.990	22.061	10.689	-
Farm Size	-.128	-1.353	-.136	-1.511	-.004	-.018	Planted area of cassava (ha)
Farm Experience	.043	.662	-	-	-.169	-1.071	Years of cassava farming
[1]Gender	.195	.192	-	-	3.786	1.549	Gender of head household
[2]Education	-.075	-.215	-	-	.610	.717	Level of Education
KU50	-1.192	-.887	-1.284	-.973	-	-	Dummy variable (Types of variety)
Kromomyun	-.230	-.145	-.287	-.184	-	-	
Chemical Fertilizers	.631	.637	.630	.644	-	-	Categorical variable (1= Used, 0= Don't use)
Bio-Fertilizers	-.345	-.441	-.346	-.450	-	-	
Liquid Fertilizers	2.359**	2.350	2.265**	2.321	-	-	Liquid fertilizers usage (Frequency)
Pesticides	-.681	-.844	-.696	-.874	-	-	Pest controlling by pesticides (Frequency)
Herbicides	1.190 **	3.174	1.208**	3.308	-	-	Weed controlling by herbicides (Frequency)
Weed Controlling	6.609**	15.959	6.603**	16.194	-	-	Weed controlling by hand (Frequency)
Adjusted R^2		0.83		0.84		-0.002	-

**. Statistically significant at 1% level; Sample (N) = 109 cassava farmers. [1](Male=1, Female=2); [2](Score: 1= Illiterate, 2= Primary school, 3= Secondary school, 4= High school, 5= College.

Model 2: Includes only the variables representing agro-practices and farm size. The data showed that the adjusted R^2 does not change much from the model 1 (If the knowledge of the farmers affects cassava yield by a large degree, the adjusted R^2 of model 2 must be much smaller than that of model 1) this means that agro-practices are the most important factors to determine the cassava yield, while the attributes of farmers including their knowledge does not have a significant influence on cassava yield.

Model 3: The knowledge of the farmers might affect agro-practices that they adopt and hence can have an indirect effect on cassava yield. To examine this possibility, Model 3, which includes only the farm size and the attributes of the farmers, was also estimated. But the estimation result showed that the variables such as education level and farming experience do not have significant association with cassava yield. This result implies that education and farming experience do not have a significant correlation with agro-practices that affect cassava yield (Table 6).

Constraints of cassava farmers before planting

According to data analysis, only 49.54% of the farmers had no problem with the previous planting, while 50.46% have encountered some problems as shown in the left pie chart of Figure 7. Problems mentioned by the farmers include lack of rain (15.60%), a lack of cut stem (9.17%), the high cost of the cut stem (4.59%), lack of capital (8.26%), and lack of labor (12.84%), as shown in the right pie chart of Figure 7.

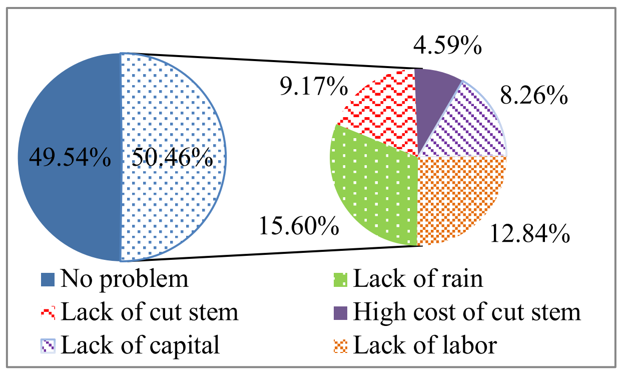

Fig. 7: Representation of the percentage of constraints before cassava planting.

Constraints of cassava farmers during cassava growing

Forty-six percent (45.87%) of the respondents answered that they faced problems during the growing period; the other 54.13% said that they had encountered some problems as shown in the left pie chart in Figure 8.

Those problems, as shown in the right pie chart of Figure 8 were associated with pests and diseases (16.52%), weed competition (10.09%), increased drought (12.84%), lack of capital (5.50%) and a lack of labor (9.17%).

Hence, pests and diseases represented around 16% and a big percentage of problems in the study area. The farmers showed the invasive pests such as mealybugs, cassava mites and Cassava witches broom (CWB) diseases in their plantation. According to another study, CWB has affected 64% of the fields in several prime cassava-growing areas, and was especially problematic in Cambodia where 78% of the cassava fields were impacted by CWB (Ignazio et al. 2016).

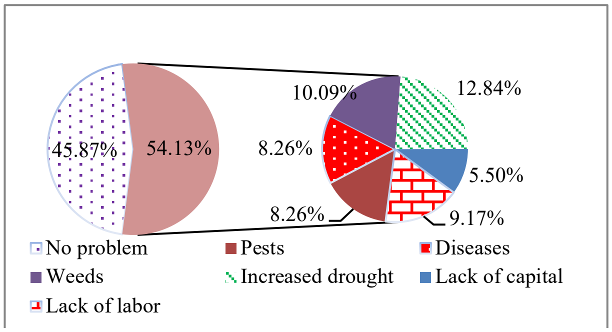

Fig. 8: Representation of the percentage of constraints during cassava farming.

Discussion

The farmers had, in general, a low education; 41% of them had only a primary school education diploma. So, it was difficult for them to understand information on new techniques, the weather factors, the pest mitigation, and appropriate agro-practices. The knowledge of all those factors could improve the yield and narrow the cassava yield gap. A major effect of education on agriculture is the cognitive effect, whereby a farmer acquires basic literacy and numeric ability to read the instructions on fertilizer, pesticides, and herbicides containers and to calculate the number of multiple inputs correctly to enhance productivity (Appleton and Balihuta 1996).

The farmers use different cassava varieties because they want to achieve higher yields. According to our interview, they don't know which variety is suitable for their specific agro-ecological condition. Our survey also revealed that for planting a new crop, most farmers used cassava stems which they bought or kept from their previous cultivation, for their convenience. Unfortunately, this technique provides an easy way for the diseases to spread to the next season especially when cassava stems affected by viruses are kept. Presently, no cassava breeding program has been either established or carried out in Cambodia and only the testing of some varieties from cassava breeding centers of Thailand, Vietnam, and China have been done in Cambodia (MAFF 2015). It is undeniable that the cassava farmers have a difficulty to find or to get healthy and high-quality planting material.

The rainfall conditions and good management in agro-practices have effects on the yield of cassava production in the study area. The study Luar et al (2018) revealed that the optimal nutrient management is the key to closing wide yield gaps and to attain a sustainable intensification in the cassava production. Continuous cropping of cassava without balancing the fertilizer application can lead to soil nutrient depletion and yield decline over time. Our findings showed that cassava farmers did not use fertilizer based on cassava needs. The concept of the 4R Nutrient Stewardship is a framework for promoting the right application of nutrients sources (or products) at the right rate, right time, and right place (IFA 2009). 4R Nutrient Stewardship Framework as a means of linking science to practice, and supporting effective communications with all stakeholders (Johnston and Bruulsema 2014). Thus, the judicious use of chemical fertilizers is essential to maintain soil fertility. Fertilizer usage is closely associated with the growth phases of cassava. Apply N, P, and K fertilizer 2 to 4 weeks after planting to ensure that the crop has enough nutrients to support its early growth (IPNI 2012). On the soils that are moderately deficient in P and K, a general recommendation is to use a fertilizer with an N: P: K ratio of roughly 1:1:2, e.g. 40-80 kg N, 40-80 kg P, and 80 -160 kg K per hectare (MAFF 2015).

Based on our interviews, the cassava farmers often used fertilizers, pesticides and herbicides based on their experience and the suggestion of other cassava farmers or agrochemical sellers rather than the manufacturer's recommendations or agricultural experts, and the farmers would often mix pesticide with chemical fertilizer spay. If the farmers followed the experts' recommendations, they would benefit from it and would not need to spend extra money and time with herbicide spraying.

Conclusions

The results of this study have shown substantial disparities in cassava yields at the Cambodia-Thai border region. The maximum yield obtained, 34 tons per hectare, was considered to be representative of the maximum potential yield under the rainfall conditions in this region with proper agro-practice. However, large gaps relative to the maximum yield were found for most fields, and fields with a low to moderate level of yield accounted for 63% of the fields surveyed in this study. The regression analysis revealed that weed control by hand, application of liquid fertilizers and herbicides significantly affect the cassava yield. Another possible constraint to higher yield is the usage of cassava stems from a previous crop to plant their new crop, because of the risk of carrying diseases from a previous cassava generation. The knowledge of all those factors could improve the yield and narrow the cassava yield gap. Climate change (drought or rainfall) would also affect cassava yield, as many of the farmers surveyed mentioned the climate as a problem in their cassava cultivation. But this study could not examine whether or not and to what extent the climatic factors affect the cassava production. Further research is needed to investigate the effects of the climate factor.

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