The Effect of Artificial Rain on Maize and Cassava Yields in Tonle Sap River Basin, Sa Kaeo Province, Thailand

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ABSTRACT

The aim of the research was to analyze the cost of rainmaking services on maize and cassava in the Tonle Sap River Basin in Sa Kaeo Province, Thailand. The results will assist the Bureau of Royal Rainmaking and Agricultural Aviation to decrease rainmaking service expenditure and increase the effectiveness of the service in the future. Data were collected on costs and returns of maize and cassava grown in the 2008/2009 crop year in Watthananakhorn, Klonghad and Ta Phraya districts. Data were collected through interviews with 30 maize and 30 cassava farmers receiving rainmaking services and with the same number of both types of farmers not receiving rainmaking services. Comparisons of maize and cassava farming with and without rainmaking services were then made using regression analysis and ratios of farm cost and rainmaking service cost per unit. The results showed that rainmaking expenditure can be reduced by conducting rainmaking operations only from March to August. The quantity of rainfall affected statistically the maize and cassava yields. The service was less effective at reducing the drought problem in July.

Keywords: Cobb-Douglas production function, cost of rainmaking service, Tonle Sap River Basin

บทคัดย่อ

วัตถุประสงค์ในการศึกษานี้เพื่อวิเคราะห์ค่าใช้จ่ายของการทำฝน ในลุ่มน้ำโตนเลสาป จังหวัดสระแก้ว เพื่อหาแนวทางในการลดค่าใช้จ่าย และเพิ่มประสิทธิผลของการทำฝน ในลุ่มน้ำโตนเลสาป จังหวัดสระแก้ว ทำการเก็บข้อมูลด้านผลได้และต้นทุนการปลูกพืชจากครัวเรือนเกษตรกรในลุ่มน้ำโตนเลสาป ของเกษตรกรผู้ปลูกข้าวโพด และมันสำปะหลัง โดยสัมภาษณ์เกษตรกรพืชละ 30 คน เฉพาะปีการเพาะปลูก 2551/2552 เท่านั้น ในอำเภอวัฒนานคร อำเภอคลองหาด และอำเภอตาพระยา การวิเคราะห์ข้อมูลใช้วิธีวิเคราะห์การถดถอย สัดส่วนและการพรรณนา การวิเคราะห์แบ่งเป็น 5 ส่วนคือ การวิเคราะห์ต้นทุนและผลตอบแทน การวิเคราะห์สมการผลผลิต การประเมินความแตกต่างของผลผลิตและปริมาณฝนตก ประเมินผลการปฏิบัติการฝนหลวงเปรียบเทียบกับฝนตกจริง และสัดส่วนต้นทุนการผลิตของเกษตรกรและต้นทุนปฏิบัติการฝนหลวงต่อหน่วย ผลการวิเคราะห์พบว่าควรเน้นการทำฝนโดยเฉพาะในช่วงเดือน มีนาคม-สิงหาคม ปริมาณฝนตกมีผลต่อผลผลิตอย่างมีนัยสำคัญทางสถิติในกรณีปลูกข้าวโพดและมันสำปะหลัง การทำฝนแล้วไม่มีฝนตกพบในเดือนกรกฎาคมมากที่สุด

คำสำคัญ: ฟังก์ชันการผลิตคอบบ์ดักลาส ต้นทุนปฏิบัติการฝนหลวง ลุ่มน้ำโตนเลสาป

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INTRODUCTION

Thailand is an agricultural country located in Southeast Asia and always faces drought problems during the dry season (February through May). Since 1971, the Royal Rainmaking Project created by King Bhumiphol, the King of Thailand, has endeavored to alleviate these drought problems throughout the country. The Tonle Sap River Basin, which is the major river basin in Sa Kaeo province in eastern Thailand, faces drought problems and has received rainmaking services for several years. This research evaluated the output levels and net incomes of farms growing maize and cassava that were receiving rainmaking services and those not receiving rainmaking services. The results provide input to enable the Bureau of Royal Rainmaking and Agricultural Aviation to improve its services. The purposes of the research were to: analyze the costs of rainmaking services in the Tonle Sap River Basin, Sa Kaeo province; analyze the costs and returns of crop production; and increase the effectiveness of rainmaking services. Data on costs and returns for maize and cassava grown in the 2008/2009 crop year were collected in Watthananakhorn, Klonghad and Ta Phraya districts of Sa Kaeo province. Maize farms in Klonghad district, which received rainmaking services, were compared with maize farms in Watthananakhorn district, which did not receive rainmaking services; while cassava farms in Klonghad district, which received rainmaking services, were compared with cassava farms in Ta Phraya district, which did not receive rainmaking services.

Objectives

The objectives of this study were to:

1) identify farmers' perception regarding water needs and rainmaking services

2) analyze the costs and returns of maize and cassava production

3) analyze factors affecting maize and cassava yields

4) evaluate the cost and effectiveness of rainmaking services

LITERATURE REVIEW

The Cobb-Douglas production function was proposed by Knut Wicksell (1851–1926), and tested against statistical evidence by Charles Cobb and Paul Douglas during the period from 1900 to 1928. Just and Pope (1979) employed a Cobb-Douglas production form and estimated the standard deviation of the output. Doll and Orazem (1984) also applied the Cobb-Douglas production function and suggested independent variables, such as land, labor, and capital.

To date, there has been little research related to the Cobb-Douglas production function or to rainmaking evaluation. However, there has been research related to participation in rainmaking services and on rainmaking measurement using weather radar. Ungsuratana *et al.* (2006) analyzed the need assessment of volunteers participating in the Royal Rainmaking service in Sa Kaeo province. The researchers conducted semi-structured interviews with 44 farmers and found that public water sources and private ponds could not supply sufficient water for farm use all year round. Farmers needed the Royal Rainmaking service from March to May, specifically in April. Royal Rainmakers at the provincial level needed to cooperate in providing services at all cluster levels.

On the other hand, Ungsuratana (2006) introduced measurement indicators for a rainmaking service target area of 80 million rais [12.8 million ha] using weather radar. The area was 50 km in diameter, 240 km in length and had a slope of 15° at a 1,000-10,000 wind rate. The weather radar recorded the presence of cloud and produced data on its intensity. A high intensity tended to produce a large amount of rainfall. To measure the rainfall rate, Ungsuratana (2006) used a grid of 10 × 10 km, which was converted to an amount of rainfall.

Since the introduction of the Cobb-Douglas production function, it has been applied by several

economists, including Maqbool and Bakhsh (2006), who analyzed cotton productivity. Their research was based on primary data collected through a comprehensive questionnaire from 75 cotton growers in Sargodha district. Cotton growers were selected randomly from three villages and in each village, 25 farmers were interviewed to obtain detailed information. This study was designed to investigate the role of farmers' management practices in achieving higher cotton productivity. The factors assessed included education, land preparation, seed, irrigation, plant protection measures, and nitrogen and phosphorus fertilizer levels applied. The effects of these factors on cotton yield were investigated through multiple regression analysis. The Cobb-Douglas type production function was estimated using the ordinary least squares (OLS) method. The R^2 value of 0.49 can be regarded as indicating quite a good fit in view of the cross-sectional data involved in this study. The influential independent variables on cotton yield were education, land preparation, irrigation and fertilizer use.

Based on Doll and Orazem(1984), Mjelde *et al.* (1995) and Maqbool and Bakhsh (2006), the present study also applied the Cobb-Douglas production function; however, labor, use of seed or shoots, chemical fertilizers, chemical pesticides and herbicides, and the quantity of rainfall were included as independent variables. Similar to Maqbool and Bakhsh, cross-sectional data were employed, while Mjelde *et al.* (1995) employed time series data.

METHODOLOGY

Data

The primary data on costs and returns for the 2008/2009 crop year were collected by interviewing farmers selected using a purposive sampling technique. Through interviews with rainmaking service officers, it was found that the district of Klonghad had received rainmaking services and the districts of Watthananakhorn and Ta Phraya had not. Samples of 30 maize farmers in Klonghad district and 30 in Watthananakhorn district and 30 cassava farmers in Klonghad district and 30 in Ta Phraya district were interviewed.

Analysis

The costs and returns for each cash crop were analyzed and the fixed and variable costs were calculated. A comparison of farming with and without rainmaking services was used to explain the output of the rainmaking service. The research also calculated the costs and returns for a combination of farm costs and the rainmaking service cost. The ratio of these costs was used to indicate the efficiency of the rainmaking service. A comparison of the number of rainfall days and rainmaking service days was taken to indicate the effectiveness of the rainmaking service.

Model

The Cobb-Douglas production function was applied to analyze factors affecting maize and cassava yields, with and without rainmaking services. The model was composed of factors affecting the output level, including the quantity of rainfall as a factor of the rainmaking service (Equations 1 and 2):

$$Y_i = a_i X_{i1}^{b_i} X_{i2}^{c_i} X_{i3}^{f_i} X_{i4}^{g_i} X_{i5}^{h_i} e^{U} \quad (1)$$

$$\ln Y_i = \ln a_i + b_i \ln X_{i1} + c_i \ln X_{i2} + f_i \ln X_{i3} + g_i \ln X_{i4} + h_i \ln X_{i5} + U_i \quad (2)$$

where, Y_i = yield (kg ha^{-1})

x_{i1} = seed used (kg ha^{-1})

x_{i2} = chemical fertilizer used (kg ha^{-1})

x_{i3} = chemical pesticides used (kg ha^{-1})

x_{i4} = labor used (workers ha^{-1})

x_{i5} = quantity of rainfall (mm)

i = 1 maize, i = 2 cassava

RESULTS AND DISCUSSION

Maize production

Of the 30 maize farmers with rainmaking services (Klonghad district), 17 (56.67%) claimed that they had adequate water for their maize during

the 2008/2009 crop year. Of those 30 without rainmaking services (Watthananakhorn district), 12 (40%) claimed that they had inadequate water for their maize. A majority of 27 (90%) of the farmers with rainmaking services and an almost three-quarters (70%) of those without rainmaking services had received information on rainmaking operations. The major sources of information were local officers and the radio. All farmers believed that the rainmaking services were still inadequate. Farmers wanted rainmaking services during the period from March to August.

Cassava production

A small proportion (30%) of the cassava farmers receiving rainmaking services (Klonghad district) claimed that they had inadequate water for their cassava during the 2008/2009 crop year. Of those without rainmaking services (Ta Phraya district), 60 percent claimed that they had inadequate water for their cassava. About 90 percent of the cassava farmers with rainmaking services and 73.33 percent of those without such services had received information on rainmaking operations. Their major sources of information were local officers and the radio. Most farmers believed that the rainmaking services were still inadequate. Cassava farmers in both Klonghad and Ta Phraya districts wanted rainmaking services during the period from March to August.

Cost and return analysis

The yield per hectare of cassava was greater with rainmaking services than without. The total cost per kilogram of maize was USD 0.04-0.06 while that of cassava was USD 0.04 per kilogram, and the returns on these crops were positive. Maize farmers received net returns of USD 0.07 per kilogram and cassava farmers received USD 0.01-0.02 per kilogram. Table 1 shows that cassava farms with rainmaking services had higher yields than those without rainmaking services, with yields of 9,966.96 and 9,705.15 kg ha^{-1}, respectively; however, maize farms with rainmaking services had lower yields than those without rainmaking services, with yields of 3,008.90 and 3,271.96 kg ha^{-1}, respectively.

Results of production function

Table 2 presents the regression results. For maize production with rainmaking services, the factors of rainfall and chemical fertilizer had statistically significant effects on maize yield at the .05 and .01 level, respectively, indicating that these factors were positively related to maize yield. For maize production without rainmaking services, the factors of chemical fertilizer, chemical pesticide and herbicide, and labor had statistically significant effects on maize yield at the .01, .05 and .05 level, respectively, indicating that these factors were positively related to maize yield. The rainfall coefficient for maize farming with rainmaking services was 0.496.

For cassava growing in Klonghad district, which received rainmaking services, the rainfall and the root type used had statistically significant effects on cassava yield at the .05 and .01 level, respectively. In Ta Phraya district, which did not receive rainmaking services, the rainfall and chemical pesticide and herbicide had statistically significant effects on cassava yield at the .01 and .1 level, respectively. These results indicated that the rainfall and the amounts of chemical pesticides and herbicides used were positively related to cassava yield. Rainfall was a significant factor for both maize and cassava production in all areas. However, the Cobb-Douglas model has some limitations, since the model does not take into account input interaction effects, which affect somewhat the significance in yield. This study assumed all other factors, besides rainmaking services, were the same. In reality, there are other factors that affect productivity, such as the quality of land, types of chemical pesticides and herbicides or fertilizer used, and farmer practice, but these were not included in the model.

Table 1 Costs and returns of cash crops in the 2008/2009 crop year, in Sa Kaeo province

Item	Maize		Cassava	
	With rainmaking service	Without rainmaking service	With rainmaking service	Without rainmaking service
Variable cost	*224.19*	*145.02*	*299.10*	*308.00*
1. Labor cost				
1.1 Labor cost	31.14	23.00	66.08	79.78
1.2 Machine rent cost	36.91	23.00	64.21	52.39
2. Material cost (seed, fertilizer, etc.)	143.07	99.51	152.42	157.99
3. Opportunity cost of labor and material cost	13.07	8.51	16.39	81.40
Fixed cost	*77.13*	*34.00*	*112.96*	*8.08*
1. Land rent	19.70	19.70	50.00	73.32
2. Depreciation cost of machine	57.43	14.31	62.96	81.40
Cost per hectare	**301.32**	**179.02**	**412.05**	**389.40**
Yield per hectare (kg)	3,008.90	3,272.96	9,966.96	9,705.15
Return per hectare	645.06	487.06	565.55	476.17
Net return per hectare	**343.74**	**308.04**	**153.5**	**86.77**
Yield price (USD kg^{-1})	0.13	0.11	0.06	0.05
Total cost (USD kg^{-1})	0.06	0.04	0.04	0.04
Net return (USD kg^{-1})	**0.07**	**0.07**	**0.02**	**0.01**
Number of farms (units)	30	30	30	30

Note: (USD 1 = 35 baht in Thai currency).
Unless indicated otherwise, all data are in USD ha^{-1}

Comparison of yields with rainmaking service and no rainmaking service

Table 3 presents a comparison of the yield and the rainfall for maize and cassava using the t-test. There were statistically significant differences at the .10 level and .05 level for the rainfall and for maize and cassava yields between the areas with and without rainmaking services, respectively. In the areas with rainmaking services, however, the greater quantities of rainfall might not produce higher levels of yield than those in areas without rainmaking service. Even so, rainmaking services were effective in increasing the rainfall. Nevertheless, it should be pointed out that natural rain cannot be separated from artificial rain (the product of rainmaking), and so the rainfall in this study would be composed of part natural rain and part artificial rain. Rainmaking operations meet with success only if the appropriate conditions for cloud, temperature, and moisture exist; if they do not, no rain will fall. A comparison of the areas with rainmaking services with those without rainmaking services explained the output of the rainmaking service.

Rainmaking service expenditure

The number of days with rain (56 d) accounted for 62.90 percent of the total rainmaking services (Table 4). The rainmaking services in July were less effective than that in any other months; during the 23 d of service, there were only 8 d of rainfall. The rainfall in Sa Kaeo province was 876.60 mm from October 2007 to September 2008 (2008

fiscal budget year). Table 5 shows the cost and ratio of maize and cassava production for the 2008/2009 crop year and the rainmaking cost for the 2008 fiscal year in Sa Kaeo province. In all areas of the province, the material costs (seed, fertilizer, etc.) made up a sizeable component of the ratio (0.37-0.56). The majority of the rainmaking (0.88) was variable cost. The rainmaking cost per millimeter of rain was USD 374.41.

Table 2 Estimated coefficients of crop production of maize and cassava in Sa Kaeo province, 2008/2009 crop year

Independent variable	Maize		Cassava	
	With rainmaking service	Without rainmaking service	With rainmaking service	Without rainmaking service
Constant	1.587	3.432	0.802	6.799
	(0.213)	(0.025)	(0.048)	(0.000)
Chemical fertilizer	0.923	0.496	-	-
	(0.000)***	(0.005)***		
Pesticide and herbicide	-	-0.070	0.004	0.071
		(0.055)**	(0.954)	(0.086)*
Quantity of rainfall	0.496	0.362	0.627	0.251
	(0.048)**	(0.305)	(0.047)**	(0.001)***
Seed, root, or shoot	0.070	0.144	0.547	0.061
	(0.909)	(0.719)	(0.001)***	(0.486)
Labor (person)	-	0.142	-	-
		(0.013)**		
R^2	64.47%	55.83%	40.10%	42.43%
F-value	15.731	4.845	5.357	6.389
n	30	30	30	30

* = p < .1
** = p < .05
*** = p < .01

Table 3 Comparison of rainmaking target area with other areas in Sa Kaeo province, 2008/2009 crop year

	Maize		Cassava	
	With rainmaking service	Without rainmaking service	With rainmaking service	Without rainmaking service
Yield (kg ha^{-1})	3,008.90	3,272.96	9,966.96	9,705.15
t-test	0.274		1.410	
Rainfall (mm)	222.42	199.77	242.82	107.28
t-test	1.949*		2.609**	

** = p < .05
* = p < .10

Table 4 Rainmaking service expenditure in Sa Kaeo province, from October 2007 to September 2008 (USD)

Month and year of service	Number of service days (d)	Variable cost chemical, wage and gas	Fixed cost depreciation of airplanes	Numbers of rainfall days (d)	Rainfall in Sa Kaeo Province (mm)
October 2007	15	20,291.05		15	199.50
May 2008	16	13,439.20		9	147.30
June 2008	7	42,690.13		4	75.10
July 2008	23	79,210.48		8	20.80
August 2008	19	138,858.77		12	136.30
September 2008	9	18,988.44	40,816.33	8	297.60
Total	89	288,394.56	329,210.89	56	876.60
Percentage of rainfall days (%)	62.90				

Source: Bureau of Royal Rainmaking and Agricultural Aviation (2008) and Office of Thai Meteorological Department and Sa Kaeo Meteorological Office (2009).

Table 5 Cost and ratio of maize and cassava production, 2008/2009 crop year and rainmaking cost in the 2008 fiscal year in Sa Kaeo province (USD)

Item	Maize		Cassava	
	With Rainmaking service	Without rainmaking service	With rainmaking service	Without rainmaking service
1. Labor cost	31.14	23.00	66.08	79.78
Ratio	0.10	0.13	0.16	0.20
2. Machine rent cost	36.91	23.00	64.21	52.39
Ratio	0.12	0.13	0.16	0.13
3. Material cost (seed, fertilizer, etc.)	143.07	99.51	152.42	157.99
Ratio	0.47	0.56	0.37	0.41
4. Opportunity cost of labor and material cost	13.07	8.51	16.39	81.40
Ratio	0.04	0.05	0.09	0.21
5. Land rent	19.70	19.70	50.00	73.32
Ratio	0.07	0.11	0.12	0.19
6. Depreciation cost of machine	57.43	14.31	62.96	81.40
Ratio	0.19	0.05	0.15	0.21
Total cost	301.32	179.02	412.05	389.40
Rainmaking cost	329,210.89			
Variable cost	288,394.56			
Ratio	0.88			
Fixed cost	40,816.33			
Ratio	0.12			
Rainfall(mm)	876.60			
Cost per mm	374.41			

CONCLUSION AND RECOMMENDATIONS

The following conclusions can be drawn from the study:

1. Maize farmers needed rainmaking services from March to August. Cassava production in Klonghad district (with the rainmaking service) needed rainmaking services from March to August, while Ta Phraya district (without the rainmaking service) needed rainmaking services from March to June. To reduce rainmaking service expenditure, the Bureau of Royal Rainmaking and Agricultural Aviation could provide services when farmers need them. However, whether there is rainfall depends on clouds and other atmospheric conditions. Local officers and the radio were the major sources of information for farmers and therefore, the Bureau of Royal Rainmaking and Agricultural Aviation should convey their information through these means.

2. Maize and cassava farms gained a positive net return in cost per kilogram for all areas. The yield per hectare in areas with rainmaking services was slightly higher than that without rainmaking services. Besides rainfall, the yield might be dependent on other factors excluded from the study, such as land quality.

3. Based on the Cobb-Douglas production function, the amount of rainfall affected the maize and cassava yield. In addition, it was also found that the quantities of rainfall were significantly different for both maize and cassava farms when the areas with and without rainmaking services were compared. Therefore, the Bureau of Royal Rainmaking and Agricultural Aviation should provide sufficient rainmaking services to these farms.

4. In order to improve the effectiveness of the rainmaking service, the Bureau of Royal Rainmaking and Agricultural Aviation should adjust the service based on the possibility of rain, since there were few days with rain in July after 23 d of rainmaking operations.

Research limitations

The rainmaking service can be successful only if the necessary operational environmental parameters of cloud, temperature and moisture are present; in their absence, no rain will fall. Moreover, it is not possible to exclude natural rain from the artificial rain (rainmaking service). The rainfall in the study would be composed of part natural and part artificial rain.

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