Cost-Benefit Analysis in *Jatropha Curcas* Plantation of Rural Farmers under Shared Benefits Business with Investor

Khumthorn Nawalertpanya[1], Prapita Thanarak[2*] and Nipon Ketjoy[2]

[1]Department of Alternative Energy Development and Efficiency, Ministry of Energy, Bangkok 10330, Thailand

[2]School of Renewable Energy Technology, Naresuan University, Phitsanulok 65000, Thailand

* Corresponding author. Email address: prapitat@nu.ac.th

Abstract

This research paper focuses on the investigation of a new system of Jatropha plantation for crude oil production under shared benefits business with investor, which could serve a large scale of Jatropha crude oil production in Thailand. The business functions between farmers and investor can be divided in 7 steps. Only 3 steps as plantation, harvesting and delivery to collecting center are managed by farmers, other 4 steps as nursery, transport to factory, crude oil production and shipping to end customers by investor. With agreements to support Jatropha farmers by providing them know-how and raw materials such as seedings, fertilizers or pesticides, etc., they both would reach the highest return. The Jatropha plantation models are analyzed by plantation scales of 1-1,000 rai (1 rai equals to 1,600 m^2), planning technique of 250 seedings/rai, various quantity of fertilizer and pesticide, Jatropha yielding time of 25 years, various seeds prices and seed yields. All costs and incomes of farmers are considered and economically analyzed with helps of economic tools as Net Present Value (NPV) and return on investment (ROI). The results showed that, without helps from investor, Jatropha plantation could be beneficial when plantation scale starts from 5 rai and minimum seeds price at 9 baht/kg, while under shared benefits business at only 6 baht/kg. The shared benefit business makes Jatropha cultivation of 20 rai or over by the lowest seeds price of 3 baht/kg also beneficial.

Keywords: Jatropha Curcas, Cost-Benefit Analysis, Rural Farmer

Introduction

In last decades, the most concerning problems of world populations are the oil depletion and the global warming. Many countries have been encouraging the projects on using new sources of energy, which is more sustainable and environmental neutral in order to promote the CO_2 Reduction. In recent years, biofuel research has been directed mainly to explore plant-based fuels, which is fatty acid methyl esters (FAME) of seed oils and in some cases, animals fats. As previously documented, FAME can be derived from rapeseed, palm, sunflower, soybean, *Jatropha* seed and other plants. The biodiesel from various sources of seeds are considering if it is edible or non edible, this is a controversial issue till now.

Jatropha oil is obtained from the seeds of the succulent plant *Jatropha Curcas*, which is able to grow under various climatic conditions and can accept periods of low water availability and droughts. It is considered as being one of the most promising sources for non fossil fuels. Its chemical composition is optimal for biodiesel applications when used as transesterified fatty acid methyl esters due to its high combustion enthalpy, low iodine number (low content of unsaturated fatty acids which are air sensitive and their oxidation and polymerization products reduce the quality of the fuel), and optimal viscosity. Very large producers of biodiesel are South-East Asia and South America, and also parts of the United States; Malaysia and Indonesia being the leading countries with an annual production of 20 mio. m together. Soybean and palm oil, transferred into the methyl esters, are still the main sources for biodiesel; animal fat is also of considerable importance. There is still a lot of research to be done about the optimization of *Jatropha Curcas* oil for the use as fuel, which includes the evaluation of the optimal growing conditions, the technological processing of the raw seed oil into fuel, and the optimization of the plant itself by selective breeding of high-yield species, and genetic engineering. Even though Jatropha trees can withstand sub-optimal growing conditions and is resistant against plant diseases, it was seen that a high yield of high quality oil can often only be obtained when the growing conditions are good. This study focused on the investigation of a new system of *Jatropha Curcas* plantation for crude oil production under shared benefits business with investor, which could serve a large scale of *Jatropha Curcas* crude oil production in Thailand. The economic tools such as Cost-Benefit-Calculation, Return on Investment, Net Present Value are therefore chosen to help in this analysis.

Technology status and prospects

Kumar, & Sharma (2008). Jatropha curcas is gaining lot of importance for the production of biodiesel. It can be grown in low to high rainfall areas either in the farms as a commercial crop or on the boundaries as a hedge to protect fields from grazing animals and to prevent erosion. The primary conservation benefits to be derived from production of *Jatropha* relate to improved soil restoration and management. The findings of Kumar, & Sharma (2008), have shown that the heavy metal contaminated soil can be restored by using combination of industrial wastes and suitable bio-inoculants strain (Azotobacter). *Jatropha* in addition to protecting crops from livestock; it reduces wind erosion and pressure on timber resources and increases soil moisture retention. Nevertheless, *Jatropha* does mine soil nutrients. *Jatropha* oil projects are expected to provide income and organic fertilizer to increase crop yields, as well as being an ecologically friendly source of alternative energy to rural farmers. The *Jatropha* industry is at a very early stage of development, though there are vigorous efforts to promote it, if successful, will alter the picture considerably. There are areas in the world where interest in the *Jatropha* plant is especially strong, such as Central America where it was originated, and Mali where it is widely grown as a live hedge and a lot of research has been done on biodiesel derived from it. *Jatropha* is one among many oil seeds that can be used to produce biodiesel, soap and fertilizer. The economics of the industry depends significantly on production yields. A determinant key is the costs of oil production and its efficiency knowledge of physical properties and their dependence on moisture content of *Jatropha* seed is essential to improve the design of equipment for harvesting, processing and storage of seeds. Currently, grower is unable to achieve the optimum economic benefits from the plant, especially for its various uses. The markets of different products from *Jatropha* plant have not been properly explored or quantified.

It is time now to examine the potential role that *Jatropha* can play in meeting some of the needs for energy services for rural communities and also creating avenues for greater employment. In India, the government now provides a guaranteed market and price since it has dictated that the fuels must contain 10% biodiesel oil. Therefore, supply and demand for biodiesel in India is much different than in other countries and projected to create entirely new production systems. In Indian context, development of biodiesel would not only serve to reduce the import of petroleum diesel but also in generation of employment and meeting the environmental obligations such as reduction of green house gases. (India can tape the US $ 53-billion global market for carbon trading by promoting biofuels uses and production), carbon sequestration, etc. Further large wasteland could be utilized for the cultivation of non-edible oil producing trees for biodiesel production.

(Achten, et al., 2008) The interest in using *Jatropha curcas L.* (JCL) as a feedstock for the production of biodiesel rapidly growing. The properties of the crop and its oil have persuaded investors, policy makers and clean development mechanism (CDM) project developers to consider JCL as a substitute for fossil fuels to reduce greenhouse gas emissions. Gray literature reports are very optimistic on simultaneous wasteland reclamation capability and oil yields, further fueling the *Jatropha* biodiesel hype. *Jatropha* cultivation, aiming mainly at oil production, block plantation is the best option. How such plantation is best established, is subject to much discussion yet.

According to Heller, plants propagated by seeds are preferred for establishment of long living plantations for oil production. Best available practice at the moment is to use planting material obtained from the best performing trees of the best performing provenance available in the location of interest. Trees with an annual yield above 2 kg dry seeds and seed oil content higher than 30% by weight can be considered as a good source. When the aim of the plantation is oil production, seedlings should be planted wide enough to ensure high seed yields in the mature stage, but close enough to avoid unacceptable loss of photosynthetic capacity in the juvenile stage. Thus, optimum spacing can only be recommended after at least 5 years consecutive growth and yield observations and this is different environmental conditions and using different provenances. Contrary to popular believe, it should be made clear that plantations aiming at oil production will need fertilization (artificial or organic). Fertilizer at least needs to compensate the nutrient removal due to harvest or management practice. Irrigation will depend on the local climatic conditions. The minimum annual average rainfall at which JCL is known to yield a harvestable amount of seeds is 500-600 mm. It is believed that a well managed plantation under good environmental conditions could meet an expectation of dry seed yield about 4-5 t pro hectare. Based on documents of the Global Jatropha curcas evaluation, breeding and propagation program performed by Plant Research International Wageningen with principal investigator R.E.E. Jongschaap, systematic and selective breeding should be carried out in order to develop high and early yielding hybrids with high oil yield in given site conditions. Recently, a method has been developed for identification of superior lines by assessing the phenotypic traits of JCL plants recorded *in situ*. In short, it can be stated that more systematic research and complete reporting is necessary on the input-responsiveness of the production at different levels of inputs, including environment as well as genetic, physical, chemical and management inputs (e.g. Spacing, soil conditions, pruning, fertilizer and irrigation). In addition, studies show that transesterified JCL oil achieves better results than the use of pure JCL oil, straight or in a blend, in unadjusted diesel engines. Changing engine parameters shows considerable improvement of both the performance and the emission of diesel engines operating on neat JCL oil.

However, the choice of using JCL biodiesel (i.e. Methyl ester) or JCL oil depends on the end using demand (e.g. electricity or transport) and the available infrastructure. For project coordinators or investors, it is almost impossible to lay out a coherent and realistic business plan because almost every step in cultivation stage is uncertain, foremost the yield. Based on the available information, it is still difficult to conclude if JCL biodiesel will meet the two essential minimum requirements for biodiesel to be a more sustainable alternative for fossil fuel (i.e. (i) produced from renewable material and (ii) their use has a lower negative environmental impact). JCL is expected to be renewable, but it is not clear at which cost. The impact on the soil seems to be positive, depending on used practice and used soil types, but this contribution to soil restoration might find trade-offs in biodiversity loss. The environmental impacts discussed are lower than the fossil alternative as long as no (semi-)natural ecosystems are removed in favor of JCL and as long as the byproducts of the biodiesel production system are efficiently used.

(Sunil, et al., 2008) A systematic collection of *Jatropha* curcas germplasm has been carried out from four distinct ecogeographic zones of Peninsular India in 2005. This involved recording of passport data, documentation of important plant traits *in-situ*, ecogeographic parameters and assessment of variability. The oil content of 162 collected accessions from different climatic conditions was estimated, which range from 22% to 42%. Results indicates that *Jatropha* seems to perform better in black to brown soils with clay and sandy loam texture having level topography. Inferring from the traits exhibited by the promising accessions, a list of traits to look for in the plus trees has been arrived for use by researchers and explorers. To facilitate easy harvesting of pods, a plant high of 1.5-2.0 m would seem ideal. A collar higher than 60 cm might provide better aeration, facilitating good exchange of gases and aiding in increased photosynthetic activity. A collar thickness of 30-40 cm was found sufficient in giving up to 6 primary branches, which translates into good to very good yields. A petiole length of 10-15 cm seems to optimize the primary function utilization of sunlight and the energy spent on the petiole length. The number of fruits per cluster from 6-10 seems to balance the number of fruits and oil content. Most of the accessions had a pedicel length from 4-5 cm. An oil content of 35-40% coupled with the above traits would translate into very good yields as evidenced by the superior lines.

(De Oliveira, et al., 2009) Two genus of the *Jatropha* family: the Jatropha gossypiifolia (JG) and Jatropha curcas L. (JC) were studied in order to delimitate their potential as raw material for biodiesel production. The oil content of JC and JG, which are 32 mass% and 24 mass% respectively, are higher than those usually reported for soybean, cottonseed and other commercial oil sources, implying that processing the seeds to obtain oil would be economic. High acid value was observed for both JC (8.45 mg KOH/g) and JG (17.34 mg KOH/g), which can be related with the wild origin (different maturation degrees) and seed store conditions. It is important to highlight that the oil content and acid value can be improved by plant breeding and developing a proper farm system.

The JC and JG oils exhibit conventional fatty acid composition (absence of functional groups in the alkyl chain, alkyl chain length between C12 and C18, and unsaturation degree from 40% to 70%, comparable with those reported for some conventional oilseeds like soybean and palm-tree oil. The studied properties (density, kinematic viscosity, water content, flash point or calorific value etc.) of both biofuels are close to those values usually obtained for biodiesel from raw material with conventional fatty acid compositions, such as canola, linseed and sunflower. The high acid values of the crude vegetable oils lead to difficulties in the biodiesel preparation, occurring the formations of soaps and stable emulsions. In the case of JG, this was an obstacle to use only basic catalyst, being imperative the use of a previous acid esterification step. The studied physicochemical properties of the JC and JG biodiesel are in acceptable range for use as biodiesel in diesel engines, showing a promising economic exploitation of these raw materials in semi-arid regions. Indeed, these values match the international specifications. However, further agronomic studies are needed in order to improve the seed production and the crude oil properties.

(Matt, &Tracey, 2007) The opportunities for expanded biodiesel production on national scales are examined as raw volume potential, and as profitable potential from biodiesel exports. The aggregate volume potential of 51 billions liters of biodiesel annually spread out over 119 countries. The top five, Malaysia, Indonesia, Argentina, the United States, and Brazil, collectively account for over 80% of the total. These countries are among the top palm and soybean growers, the two most prevalent oilseed crops in the world. The average feedstock dependence is 28% for soybean oil, 22% for palm oil, 20% for animal fats, 11% for coconut oil, and 5% each for rapeseed, sunflower and olive oils.

However, in part due to relying on different feedstocks, not all of the countries are equally suited to large-scale biodiesel production, as witnessed by the production cost per liter. Biodiesel production costs vary considerably, ranging from $0.29 per liter to over $9.00 per liter. Complicating the results, our study reveals what we term *processing stopover countries*; countries with import raw oilseed crops or unprocessed oils, only to process them domestically for later export. The Netherlands is example of one such country and was identified by the drastic difference in the feedstock distribution of explored processed oils and the distribution of domestic oilseed crops. Identifying all of these countries, however, requires country-specific data not included in the comparative database.

The review above helps researcher to come to an understanding about the plantation's cycle of *Jatropha Curcas*. The best case in regard of 100% yield production should be obtained by following points; 1. Planting spaces of 2.5 m, which requires 250 seedlings per 1 rai 2. Keeping only 6-7 primary branches of each tree 3. Keeping plant height between 1.5 - 2.0 m 4. Using only the family *Jatropha Curcas* not the *Jatropha Gossypifolia* or others. The review also allowed the economic possibility between Thailand and its business part, where the production cost of biodiesel is more expansive than in Thailand.

Methodology

1. *Cycle of Jatropha Curcas plantation for crude oil production*

The cycle of *Jatropha Curcas* plantation under shared business with investor can be schematically described in 7 steps (Nursery, Plantation, Harvesting, Delivery to Collecting Centers, Transport to Factory, Crude Oil Pressing and Shipping to Customer), as presented in the following diagram, as shown in Figure 1

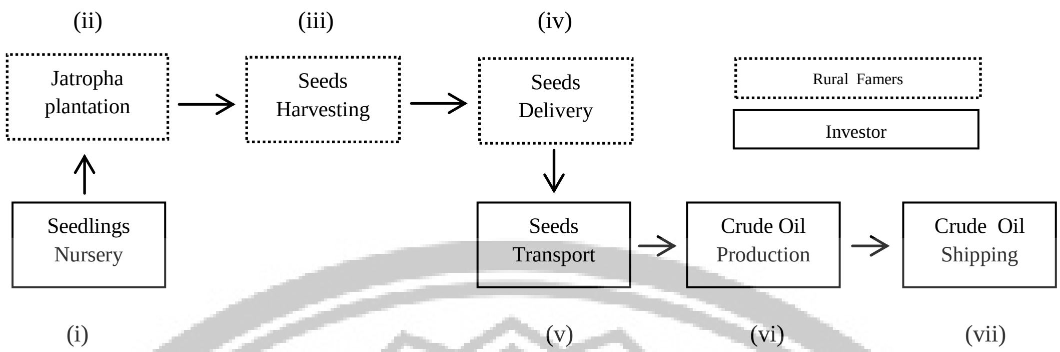

Figure1 The cycle of Jatropha crude oil production under shared business with investor

Step 1 : Nursery The nursery of *Jatropha* seedlings needs almost 3 months of preparation time before the seedlings will be planted in 120 locations owned by the local farmers.

Step 2 : Plantation The farmers receive not only the seedlings, but also the fertilizer during the first year without any costs from the company. The spacing of the young trees by plantation is recommended by 2.5 m due to company's documentation. The total plantation area of *Jatropha* farm under the contract between the farmers and the company is about 960 hectares.

Step 3 : Harvesting *Jatropha* plant usually develops to the first flowering after 5-6 months. The *Jatropha* fruits change its color from green to yellow, and finally to brown. In order to use the seeds for new seedlings, the harvesting time is namely when the fruits color is still yellow, and generally the brown color for oil pressing. The fruits will be shelled before the black seeds will be delivered to the collecting centers.

Step 4 : Delivery to Collecting Centers *Jatropha* seeds will be delivered to the collecting centers, which are located in the close area of the *Jatropha* farms with a distance 8-10 km. At the collecting center, the delivered seeds will be bought at the promising price between the farmers and the company. The farmers are responsible for the delivery cost.

Step 5 : Transport to Factory The bought *Jatropha* seeds will be transported by the trucks to the factory with distances between 600-700 km.

Step 6 : Crude Oil Pressing This step called oil pressing or *Jatropha* crude oil production will be completely operated within the factory, which was planed in full scale with 6 sets of each 4 oil press mills. One oil press mill can approximately produce 72,000 t crude oil per month.

Step 7 : Shipping to Customer This is the last step to be regarded to the cycle of *Jatropha* crude oil production run by the company. The customers are mostly in oversea, mainly in the European countries. Thus, the *Jatropha* crude oil has to be shipped and its price is depending on the quality of the crude oil (moisture content, free fatty acid content etc.)

In this study, the annual Benefit-Cost-Ratio (BCR) will be separately calculated in two sections, namely the farmer section and the company section. The calculation needs base information about costs and benefits, whose values will be calculated into Net Present Value (NPV) by using the mathematic calculations, which have to be taken into account by calculation of the Return on Investment (ROI) in order to find out if the cycle of *Jatropha* crude oil production in Thailand is economically competitive.

2. Farmer Section

By data collecting from 6 farmers who own free lands of 7, 22, 38, 75, 140 and 330 rai and live in Chonburi province, it is planned to use the questionnaires, which contain following information.

$$C_{total,farmer} = C_A + C_B + C_C + C_D + C_E + C_F + C_G + C_H \quad (1)$$

The total cost from each step will be examined and used by the determination of the cost-effectiveness, which are :

A. Cost by land preparation (C_A)

B. Cost by plantation (C_B)

C. Cost by irrigation (C_C)

D. Cost by plants management (C_D)

E. Cost by harvesting (C_E)

F. Cost by seeds transport (C_F)

G. Cost by fertilization (C_G)

H. Other relevant costs (C_H)

The total benefit will be examined and used by the determination of the cost effectiveness, which are :

$$B_{total,farmer} = B_A + B_B + B_C \quad (2)$$

A. Incomes by seeds selling (B_A)

B. Incomes by by-product selling (B_B)

C. Other incomes (B_C)

3. Analysis strategy

This shared benefits business between rural farmers and investor is shown in the Fig.1., and the cycle of Jatropha crude oil production was designed and followed in 7 steps from nursery step to shipping to customer step. Only 3 steps are involved with farmer section, which are plantation step, Harvesting step and delivery to collection center step. By all these 3 steps, all costs and benefits are considered and finally brought into benefit-cost ratio analysis. The costs and benefits in every steps are listed below:

3.1 Cost of seedlings

The Jatropha plantation site is considered in model varieties of 1 Rai, 2 Rai, 5 Rai, 10 Rai, 20 Rai, 50 Rai, 100 Rai, 200 Rai, 500 Rai and 1000 Rai, totally 10 models. The farmers or land owners have opportunity to buy seedlings in good quality from investor at discounted rate of 6 Baht per seedling (from survey). These seedlings will be planted in spacing of 2.5 meter in width and length. This from investor recommended planting distance of 2.5 meter is experienced most appropriate spacing for maximum yield of seeds per year, which relates to 25-30 years of Jatropha plantation's life time. By this distance, the number of Jatropha seedlings are now calculated and listed in following table 1.

For other scales of Jatropha plantation, the multiply factor of 250 seedlings/rai is suggested to be used. For example; farmers A, B, C, D, E and F own free lands of 7, 22, 38, 75, 140 and 330 rai. They all want to do Jatropha plantation and have to know how many seedlings required.

Table 1 Total cost of seedlings by various scales

Plantations' owner	Plantation Dimension [rai]	Number of seedings	Total cost of seedlings [baht]
famer A	7	1,750	10,500
famer B	22	5,500	33,000
famer C	38	9,500	57,000
famer D	75	18,750	112,500
famer E	140	35,000	210,000
famer F	330	82,500	495,000

3.2 Cost of fertilizer

In order to get high yield of seeds by Jatropha plantation, fertilizer is not domain factor compared with other economic plants such as potato or sugar cane, whose annual yield depends directly on fertilizer's quantity. In facts, using of chemical fertilizers by conventional crops is quite high in quantity and spreads in wide area of Thailand. This always makes the soils worse for next plantation after harvesting season. It also means that the farmers have only to invest more money in using chemical fertilizer in order to get the same product in the years after. By Jathropha plantation, it looks quite different. Researchers confirm that Jatropha plantation will not only degrade soil's quality, but also helps farmers to save money from overuse of fertilizer. Jatropha farmers are recommended by planting to use a small amount of 100 g fertilizer per seedling or only 25 kg fertilizer/rai. The first 3 years are very important for the Jatropha tree. They need good care and enough minerals for their growth. In the first year, the fertilizing (N-P-K: 15-15-15) in amount of 50 g per tree should be done monthly. In the second year, the rate of fertilizer's use should be 120 g per tree in every 4 months, and 240 g, 300 g and 360 g by same period till the end of the fifth year. After the fifth year, the among of 360 g fertilizer (N-P-K: 12-12-27) per tree in 4 months-period could be continued till the 25th year. To get more obvious data of fertilizer's using rate, see table 2.

Table 2 Recommended fertilization's technique for Jatropha plantation

Plantation's life time	Fertilizer's using rate [-/tree]	frequency	Annual total amount of fertilizer [-/tree]	Annual rate of fertilization [-/rai]
year 0	100 g	Once by planting	100 g	25 kg
year 1	50 g	12 time/year	600 g	150 kg
year 2	120 g	3 time/year	360 g	90 kg
year 3	240 g	3 time/year	720 g	180 kg
year 4	300 g	3 time/year	900 g	255 kg
year 5	360 g	3 time/year	1.08 kg	270 kg
year 6-25	360 g	3 time/year	1.08 kg	270 kg

Cost of fertilizer will be now calculated in total amount per year, separately in each year through 25 years of life time. For the first year, the amount of **100 g** by year 0 and **twelvefold of 50 g** by year 1 will be added to present as total amount of fertilizer needed for the first year. By year 2 till year 25, threefold amount of fertilizer will be taken into their annual total amount, see table 2. Then, the multiple factor of **250 trees/rai** will be taken into calculation of annual rate of fertilization of Jatropha plantation.

To compare with market price, it's more convenient to convert dimension of **1 kg to 50 kg** or **1 bag of fertilizer.** (1 bag is common unit of 50 kg of fertilizer in Thailand.) The annual rate of fertilization in dimension of **bag/rai** is now adequate for further cost estimation in all 10 Jatropha plantation models. The rate of **3.5 bags/rai** is that estimated amount of fertilizer needed in Jatropha plantation for the first year, and **1.8**, **3.6**, **4.5**, **5.4 bags/rai** for the second, the third, the forth and as of the fifth year. The market price of chemical fertilizer formula 15-15-15 announced from January to October 2010 by the Department of Internal Trade, Ministry of Commerce Thailand is in range of **800-900 baht/bag.** It's average of **850 baht/bag** will be taken to calculate the annual cost of fertilizer. Fertilizer formula 12-12-27 will be applied as of sixth year, which is commonlymore expansive than fertilizer formula 15-15-15 about **100 baht/bag.**

3.3 Cost of labor

This cost of labor cannot be exactly measured or estimated, because one plantation always has different condition from one another. But, according to experience, ***it's assumed that one farmer can do good care of his Jatropha plantation with dimension up to 20 rai.*** The advantage of Jatropha plantation is, Jatropha trees do not need special care like other crops, because they can grow up in very wide range of climate condition and soil quality. They don't need watering system, except only when the soil is too dry or during 1-2 months before fruiting period, they need then watering once a week.

Pruning work is also recommended during growing periods in the first three years. Young Jatropha trees needs much sunlight for fast growth. Pruning helps them not to be too close or shrouded by themselves. By means of pruning, farmers should keep the height of Jatropha trees at an average of 2.0- 2.2 m . This technique helps the farmers not only to get high seeds yield, but also to reduce harvesting work.Good care for Jatropha plantation also includes mowing work, especially during the first years till Jatropha trees have many asters in all directions and gain enough shadow over the ground.

In this analysis, the calculation of labor cost based on Thailand's provincial minimum wage, which has a wide range between 150-190 baht/day, will be therefore calculated with it's **average value of 170 baht/day**, employment rate of **1 labor / 20 rai** and working days in flat-rate of **15 days a month.** Based on this assumption, the cost of labor by doing Jatropha plantation is now with **2550 baht/20 rai, month** to be concerned.

3.4 Cost of transport

After harvesting, Jatropha farmers have to bring their stripped seeds to collecting center. At the collecting center, the seeds will be weighted and measured their moisture. Cost of transport by long distance over 150 km from plantation to collecting center will be reimbursed by investor. It means that farmers' cost of transport will be based on the distance within **150 km**, which will be stepwise estimated at **1000 baht by each 1000 kg of seeds.**

3.5 Benefit by seeds selling

Jatropha seeds are key factor of doing Jatropha plantation with success. Jatropha annual yield under good care starts from **250 kg seeds/rai** by the first year, increases fast in next 3-4 years, gets the highest annual yield of **1750 kg seeds/rai** by the fifth year, and maintains afterwards throughout the whole plantation's life time.

Seeds price is the most interesting topic among Jatropha farmers and investor, which has to be done under shared business concept. Before the plantation begins, the compromising price between **3-10 baht/kg seeds** has to be first agreed by both parties involved in a contract. The annual income rate of the Jatropha plantation is depending on selling price and plantation's life time, which increase from **750 baht/rai** by the first year and seeds price of **3 baht/kg** to **17 500 baht/rai** by the fifth year and seeds price of **10 baht/kg** . It can also be seen that after the fifth year, the seeds yield reaches the maximum yield, the annual income rate seems to be constant till the 25th year. The annual income rate at prices of **3-10 baht/kg seeds** will be in range of **5250-1750 baht/rai.**

4. Total cost

Total cost by various plantation scales different from 1 to 1000 rai uniquely show the character of this *Jatropha Curcas* plantation; they start by year-1 by high level due to cost of seedlings, decrease by year-2 and reaches the minimum level, then increase from year-2 until year-5 due to cost of fertilizers, and perform to continue from year-5 until year-10 due to constant costs of fertilizers and transports.

The total costs of *Jatropha Curcas* plantations are critically decreased, while placing the farmers under shared benefits business which provides them free of charge all needed fertilizers. The costs distribution by doing *Jatropha Curcas* plantation of 50 rai, which includes costs of seedlings, labour, fertilizers and transport. The most contributing factor is fertilizers, which is approximately 50% of total costs, the labour cost is constant over ten years, in the other hand, the cost of transport keeps increasing by the first 5 years and is constant by the last 5 years due to harvesting rate. This shows that the total costs under shared benefits business will be reduced approximately 50%, which makes the shared benefits business interesting in the farmers' point of view.

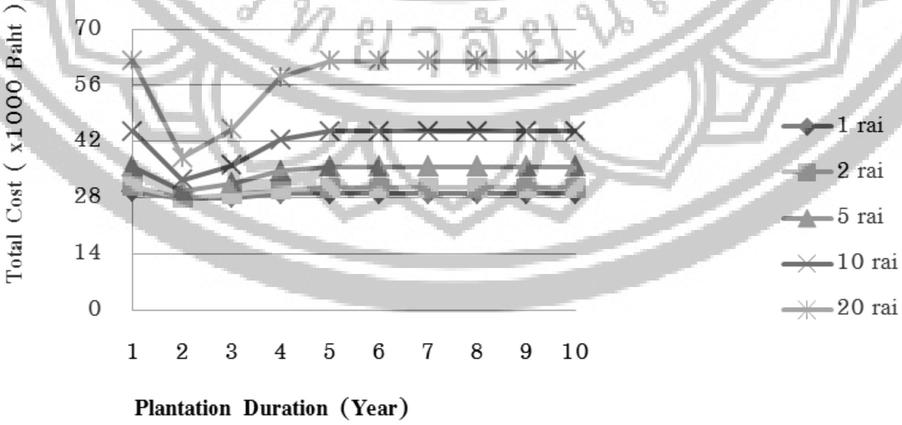

Figure 2 Total cost by various plantation scales different from 1 to 20 rai

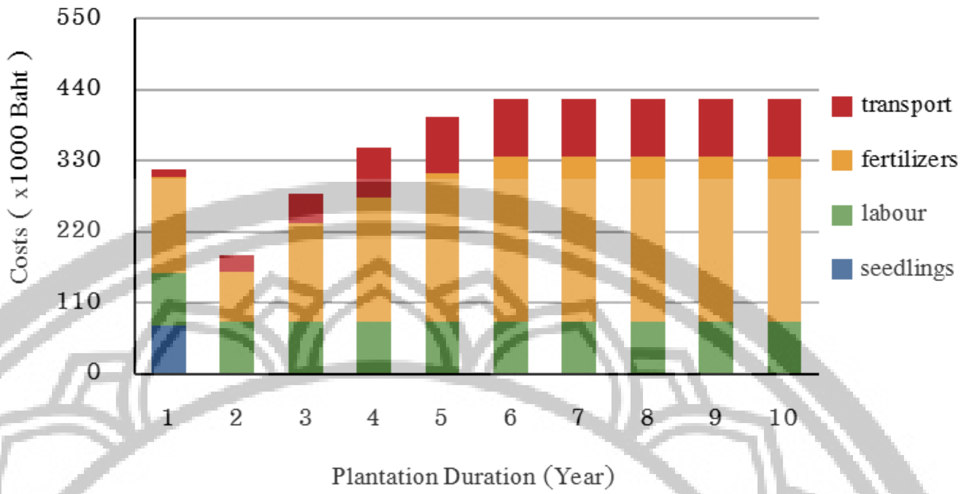

Figure 3 The costs distribution by doing *Jatropha Curcas* plantation of 50 rai

5. Incomes

In this study, only incomes from *Jatropha Curcas* seeds selling is considered, which is strongly depends on harvesting rate. The income is increasing in the first 5 years and then is constant by the last 5 years.

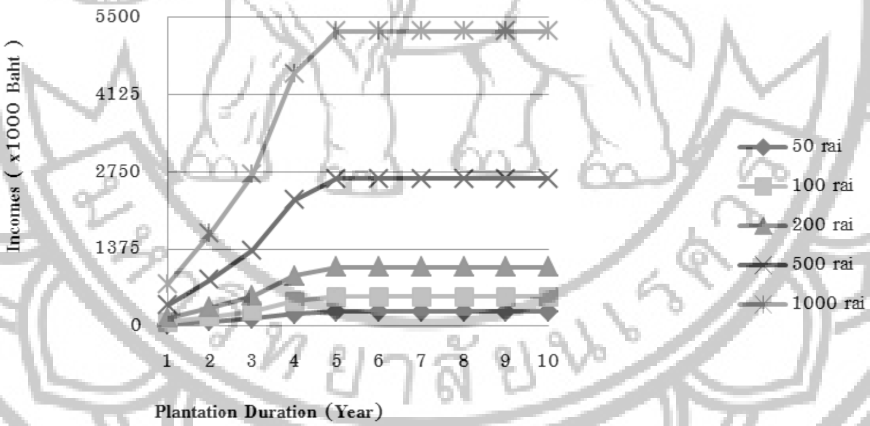

Figure 4 Total income from seeds selling by various plantation scales different from 1 to 1000 rai

6. Benefit-Cost-Analysis

In this economical analysis of *shared benefits business between farmers and investor*, these following conditions have to be regarded;

Table 3 Economical Analysis Conditions

Detail	Condition
plantation's life time	10 years
discount rate	10 %
Benefit-cost-analysis in variations	3, 4, 5, 6, 7, 8, 9 and 10 baht/kg of seeds

Results analysis

1. Net Value

The same trend is observed, while consider the evolution of net value which increases by the first 5 years and is constant over the last 5 years. However, the negative net values can be found by the first year or even the second year by low market prices, this is due to total costs predominated by seedlings cost. At low market price (3 baht/kg), the *Jatropha Curcas* plantation under shared benefits business can not be beneficial, while the area is less than 10 rai. The plantations of 10 rai and 20 rai start to be beneficial at the fourth year and the third year respectively. At very large plantation area such as 100-1000 rai, the beneficial time also starts by the third years. In the comparison with higher market price (6 baht/kg), the plantations of 10 rai and 20 rai starts earlier to be beneficial only at the second year, and even the smaller scale of plantation area (5 rai) could be also beneficial. For very small scale of plantation such as 1-2 rai, the very high market price is required to make it beneficial which is practically difficult.

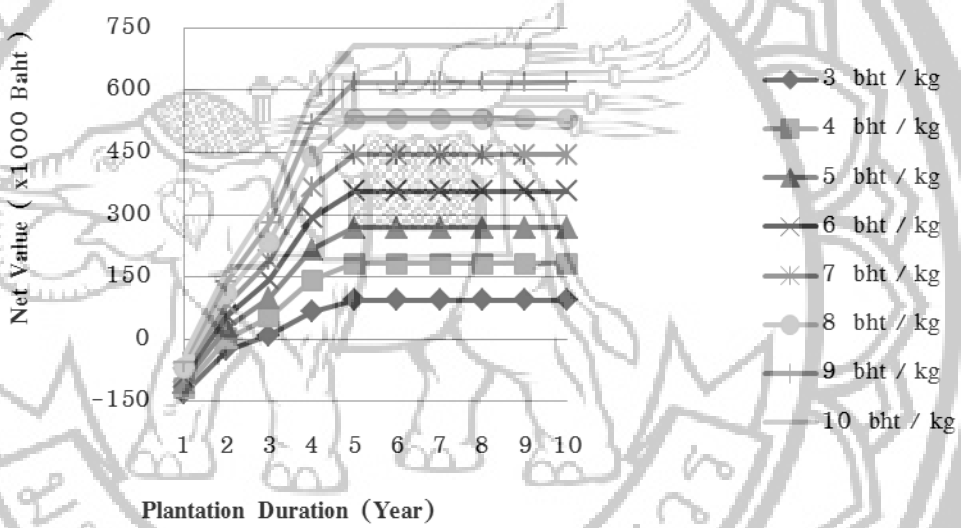

Figure 5 Net value from *Jatropha Curcas* seeds selling by various market prices

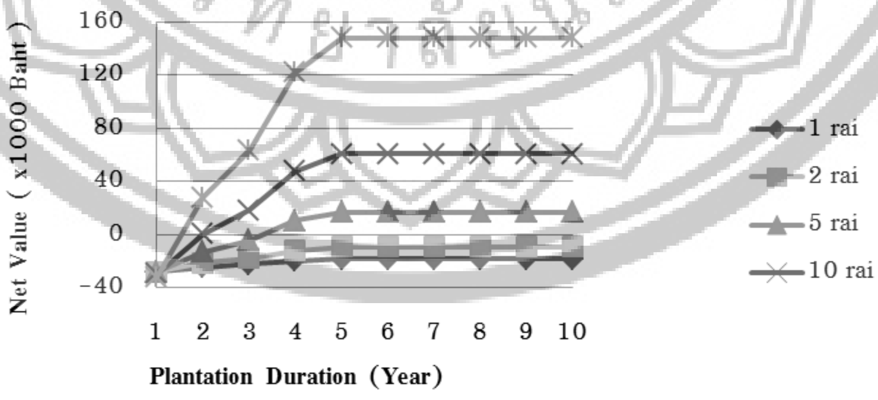

Figure 6 Net value from *Jatropha Curcas* seeds selling at market prices 6 baht/kg

2. Return on Investment

Return on Investment by each year or annual ROI of *Jatropha Curcas* plantation area of 50 rai at the market price of 3 baht/kg starts with negative value of -73% by the first year due to low harvesting rate and high investment cost in seedlings, but after then turns to positive value and keeps increasing from 1% to 86% over the next 9 years. By such conditions, the shared benefits business is quite beneficial.

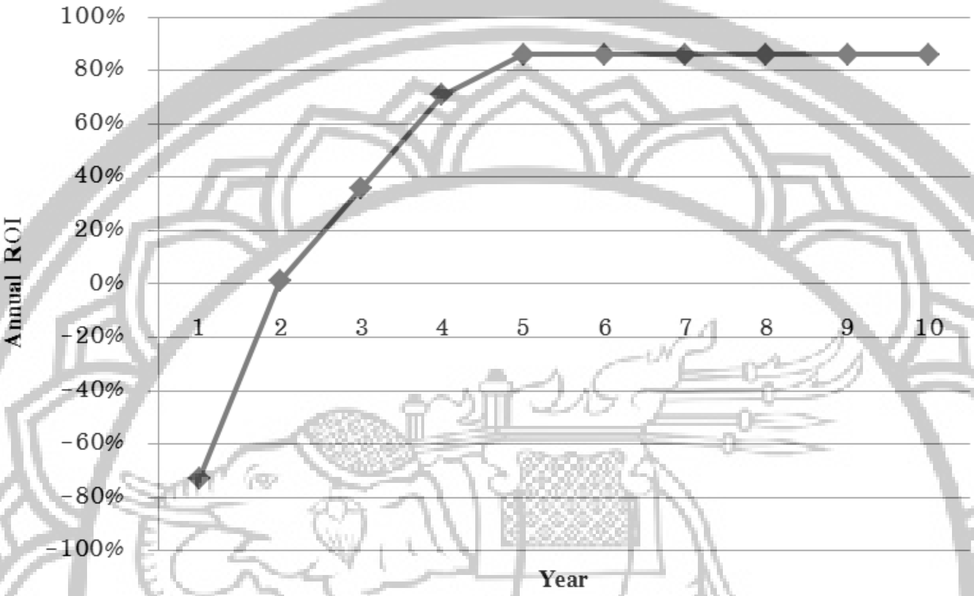

Figure 7 Annual ROI of *Jatropha Curcas* plantation area of 50 rai

3. Risk cases analysis

However the *Jatropha Curcas* trees are very strong against the plants of insects disease, it is to recommended that the farmers should not use any fire or burning method by land preparation in the first step of cultivation and should keep some space in each plantation with 10-15% from total plantation area as unmanaged in order to keep ecological strength against disease remaining in the plantation. In spite of prevention and protection, the plantation might be attacked by any disease, which the yield production could be reduced. The reduced yield production has main effect on total incomes of the farmers.

Conclusions and discussions

In this analysis, the model of *Jatropha Curcas* plantation was created in variation of plantations' scale between 1-1000 rai and the market prices of *Jatropha Curcas seeds* between 1-10 baht/kg. This model helps to predict the total costs, incomes, net value and annual ROI. The model was performed in two different cases; *without shared benefits business* and *under shared benefits business* which is shows beneficial possibilities in conditions of different prices and different plantation scales without shared benefits business (no gratis fertilizers from investor). The very small scales (1 and 2 rai) have no possibilities to have a benefit over 10 years (for the market price between 3-10 baht/kg), when the larger scales of plantation (5 and 10 rai) start to be beneficial after the fourth and second year with ROI of 28-43% and 28-83% by high market prices (7-10 baht/kg). The lower market prices (6 baht/kg) allow medium to large scales of plantation (20-1000 rai) to be beneficial.

	1 baht/kg	2 baht/kg	3 baht/kg	4 baht/kg	5 baht/kg	6 baht/kg	7 baht/kg	8 baht/kg	9 baht/kg	10 baht/kg
1 rai	NO									
2 rai	NO									
5 rai	NO								Year 10-Apr ROI 28%	Year 10-Apr ROI 43%
10 rai	NO						Year 10-Apr ROI 28%	Year 10-Mar ROI 46%	Year 10-Feb ROI 64%	Year 10-Feb ROI 83%
20 rai	NO					Year 10-Mar ROI 28%	Year 10-Feb ROI 49%	Year 10-Feb ROI 70%	Year 10-Feb ROI 91%	Year 10-Feb ROI 113%
50 rai	NO					Year 10-Apr ROI 24%	Year 10-Feb ROI 44%	Year 10-Feb ROI 65%	Year 10-Feb ROI 85%	Year 10-Feb ROI 106%
100 rai	NO					Year 10-Mar ROI 28%	Year 10-Feb ROI 49%	Year 10-Feb ROI 70%	Year 10-Feb ROI 91%	Year 10-Feb ROI 113%
200 rai	NO									
500 rai	NO									
1000 rai	NO									

Figure 8 Beneficial chart of Jatropha Curcas plantation with ROI index without shared benefits business (no gratis fertilizers)

The next cases corresponding to *Jatropha Curcas* plantation under shared benefits business (with gratis fertilizers from investor) is more incentive by the farmers' side to invest. The range of beneficial possibilities is extended, especially in the direction of lower prices (3-5 baht/kg). The very small scales (1 and 2 rai) still have no possibilities to have a benefit over 10 years (for the market price between 3-10 baht/kg), when the larger scales of plantation (5 and 10 rai) start to be beneficial after the third and second year with ROI of 47-145% and 57-293% from even low to high market prices (4-10 baht/kg). Even very low market prices (3 baht/kg) can allow medium to large scales of plantation (20-1000 rai) to be very beneficial.

	1 baht/kg	2 baht/kg	3 baht/kg	4 baht/kg	5 baht/kg	6 baht/kg	7 baht/kg	8 baht/kg	9 baht/kg	10 baht/kg
1 rai	NO									
2 rai	NO									
5 rai	NO					Year 10-Apr ROI 47%	Year 10-Apr ROI 71%	Year 10-Mar ROI 96%	Year 10-Mar ROI 120%	Year 10-Mar ROI 145%
10 rai	NO			Year 10-Apr ROI 57%	Year 10-Mar ROI 97%	Year 10-Feb ROI 136%	Year 10-Feb ROI 175%	Year 10-Feb ROI 215%	Year 10-Feb ROI 254%	Year 10-Feb ROI 293%
20 rai	NO		Year 10-Mar ROI 69%	Year 10-Feb ROI 126%	Year 10-Feb ROI 182%	Year 10-Feb ROI 239%	Year 10-Feb ROI 295%	Year 10-Feb ROI 352%	Year 10-Feb ROI 408%	Year 10-Feb ROI 465%
50 rai	NO		Year 10-Mar ROI 56%	Year 10-Jan ROI 108%	Year 10-Feb ROI 160%	Year 10-Feb ROI 212%	Year 10-Feb ROI 264%	Year 10-Feb ROI 315%	Year 10-Feb ROI 367%	Year 10-Feb ROI 419%
100 rai	NO		Year 10-Mar ROI 69%	Year 10-Feb ROI 126%	Year 10-Feb ROI 182%	Year 10-Feb ROI 239%	Year 10-Feb ROI 295%	Year 10-Feb ROI 352%	Year 10-Feb ROI 408%	Year 10-Feb ROI 465%
200 rai	NO									
500 rai	NO									
1000 rai	NO									

Figure 9 Beneficial chart of Jatropha Curcas plantation with ROI index **under** shared benefits business (with gratis fertilizers)

The very small scales of plantation (1 and 2 rai) are possible to be beneficial only in case of self laboring, which dramatically extends the range of beneficial possibilities all over every scales of plantation area and market prices. The plantations of 5 rai and 10 rai start to be beneficial since the first year with ROI of 100-900% from very low to high market price (2-10 baht/kg).

	1 baht/kg	2 baht/kg	3 baht/kg	4 baht/kg	5 baht/kg	6 baht/kg	7 baht/kg	8 baht/kg	9 baht/kg	10 baht/kg
1 rai	NO	Year 10-Feb ROI 75%	Year 10-Feb ROI 163%	Year 10-Feb ROI 250%	Year 10-Feb ROI 338%	Year 10-Feb ROI 425%	Year 10-Feb ROI 513%	Year 10-Feb ROI 600%	Year 10-Feb ROI 688%	Year 10-Feb ROI 775%
1 rai	NO	Year 10-Feb ROI 100%	Year 10-Feb ROI 200%	Year 10-Feb ROI 300%	Year 10-Feb ROI 400%	Year 10-Feb ROI 500%	Year 10-Feb ROI 600%	Year 10-Feb ROI 700%	Year 10-Feb ROI 800%	Year 10-Jan ROI 900%
5 rai	NO					Year 10-Feb ROI 500%	Year 10-Feb ROI 600%	Year 10-Jan ROI 700%	Year 10-Jan ROI 800%	Year 10-Jan ROI 900%
10 rai	NO			Year 10-Feb ROI 300%	Year 10-Feb ROI 400%	Year 10-Feb ROI 500%	Year 10-Feb ROI 600%	Year 10-Jan ROI 700%		
20 rai	NO		Year 10-Feb ROI 200%							
50 rai	NO	Year 10-Apr ROI 24%	Year 10-Feb ROI 86%	Year 10-Feb ROI 147%	Year 10-Feb ROI 209%	Year 10-Feb ROI 271%	Year 10-Feb ROI 333%	Year 10-Feb ROI 395%	Year 10-Feb ROI 457%	Year 10-Feb ROI 518%
100 rai	NO									
200 rai	NO	Year 10-Apr ROI 18%	Year 10-Mar ROI 77%	Year 10-Feb ROI 136%	Year 10-Feb ROI 195%	Year 10-Feb ROI 254%	Year 10-Feb ROI 313%	Year 10-Feb ROI 372%	Year 10-Feb ROI 431%	Year 10-Feb ROI 490%
500 rai	NO		Year 10-Mar ROI 72%	Year 10-Feb ROI 130%	Year 10-Feb ROI 187%	Year 10-Feb ROI 245%	Year 10-Feb ROI 302%	Year 10-Feb ROI 360%	Year 10-Feb ROI 417%	Year 10-Feb ROI 475%
1000 rai	NO		Year 10-Mar ROI 71%	Year 10-Feb ROI 128%	Year 10-Feb ROI 185%	Year 10-Feb ROI 242%	Year 10-Feb ROI 299%	Year 10-Feb ROI 356%	Year 10-Feb ROI 413%	Year 10-Feb ROI 469%

Figure 10 Beneficial chart of Jatropha Curcas plantation with ROI index **under** shared benefits business (with gratis fertilizers) **at no charge** of 1 labour (self laboring)

Figure 11 also shows beneficial possibilities in conditions of different prices and different plantation scales with shared benefits business (with gratis fertilizers from investor) **in due consideration of risk analysis** of natural disaster from plants/insects disease, which causes yield reduction presented in 10%, 20% and 50%. By this effect, the return on investment comes obviously later than by best case without any natural disaster. The farmers can despite that continue their *Jatropha Curcas* plantation with benefits depending on the market price and the level of yield reduction similar Ashwani Kumar et al. (Kumar, & Sharma, 2008) said that the economics of industry depends significantly on production yields. Nevertheless, the study on life cycle assessment of *Jatropha Curcas* plantation for biodiesel production will indicate an environment impact similar Sate Sampattagul, et al. (Sate Sampattagul, et al., 2011) studied the life cycle assessment of palm oil biodiesel production in Thailand.

	1 baht/kg	2 baht/kg	3 baht/kg	4 baht/kg	5 baht/kg	6 baht/kg	7 baht/kg	8 baht/kg	9 baht/kg	10 baht/kg
Best case	NO	Year 4-10 ROI 24%	Year 2-10 ROI 86%	Year 2-10 ROI 147%	Year 2-10 ROI 209%	Year 2-10 ROI 271%	Year 2-10 ROI 333%	Year 2-10 ROI 395%	Year 2-10 ROI 457%	Year 2-10 ROI 518%
10% Reduction	NO	Year 4-10 ROI 11%	Year 3-10 ROI 67%	Year 2-10 ROI 123%	Year 2-10 ROI 178%	Year 2-10 ROI 234%	Year 2-10 ROI 290%	Year 2-10 ROI 345%	Year 2-10 ROI 401%	Year 2-10 ROI 457%
20% Reduction	NO		Year 3-10 ROI 48%	Year 2-10 ROI 98%	Year 2-10 ROI 147%	Year 2-10 ROI 197%	Year 2-10 ROI 246%	Year 2-10 ROI 296%	Year 2-10 ROI 435%	Year 2-10 ROI 395%
50% Reduction	NO			Year 4-10 ROI 24%	Year 3-10 ROI 55%	Year 2-10 ROI 86%	Year 2-10 ROI 116%	Year 2-10 ROI 147%	Year 2-10 ROI 178%	Year 2-10 ROI 209%

Figure 11 *Beneficial chart by* ***50 rai in due consideration of risk analysis under*** *shared benefits business (with gratis fertilizers)****at no charge*** *of 1 labour (self laboring)*

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