# Integrated Research on *Jatropha curcas* Plantation Management

Penjit Srinophakun[*1,2], Anna Saimaneerat[1], Isara Sooksathan[1], Niphon Visarathanon[1], Savitree Malaipan[1], Kosol Charernsom[1], Wiboon Chongrattanameteekul[1]

[1]*KU-biodiesel Project, Center of Excellent for Jatropha, Kasetsart University, Bangkok, Thailand*
[2]*Center of Excellent for Petroleum, Petrochemicals, and Advanced Materials, Department of Chemical Engineering, Faculty of Engineering, Kasetsart University, Bangkok, Thailand*
**Corresponding author. Tel: +66 2 9428555, Fax: +66 2 5614621, E-mail: penjit2004@yahoo.com*

**Abstract:** This paper will present the interactive research of expert team on *Jatropha curcas* plantation management to obtain high productivity in terms of dry seed weight per cultivation area. Set of experiments were designed and performed on randomize central block design and triplicate data were collected. The spacing was the important factor along with the cutting management program for long time cultivation. Therefore, the 3 different spacing (2x2, 2x3 and 3x3) were tested. The results show that 2x3 and 3x3 m spacing gave high yield of 129.2 and 127.1 kg/rai for the first cultivation year. In addition, types of insect and pest were surveyed in the Jatropha plantations and the ranking of the most found insect and pest was proposed. Mealy bug, Aphids and coccus were the most found insects in the Jatropha plantation. In the mean time, leaf spot, fungus infection, was the most sever in many areas in Thailand. Then the harmless chemical and biological treatments were tested to control those insects. The harmless chemical such as sodium lauryl sulphate and consumable products (tooth paste, shampoo etc) were used. In case of biological control, the natural predator, green lace wing, of the first top three insects was introduced and tested in the field. On the other hand, the number of insect pollinator was recorded at the Jatropha plantation responding to the Sun direction and time of the day. Interestingly, pollen germination also depends on the Sun direction. On the other hand, Box-Behnken design was used to optimize the transesterification of Jatropha oil to obtain the high fatty acid methyl ester (FAME) percentage. The results show that at the mole ratio of methanol and oil of 9:1, catalyze of 1.5%, reaction time of 72 min and temperature of 60 $^{o}$C was the optimum condition and 99.0% of FAME was obtained. For the seed cake utilization, different rates of the seed cake (1,600, 800, 400 kg/rai) were applied to the cultivation of Chinese kale, tomato and potato. It was understandable that the mix of chemical fertilizer and Jatropha seed cake (1,600 kg/rai) gave the highest plant performance and no phorbol ester residue left in the cultivation soil and harvested vegetable.

***Keywords:*** *Jatropha curcas, Plantation management, Jatropha insect and pest, Jatropha polinator*

## 1. Introduction

*Jatropha curcas* Linn. is perennial shrub belongs to Euphorbiaceae family same as rubber tree and cassava [1]. Originally, *Jatropha curcas* was native tree in South America and was induced to Thailand about 200 years ago by Portuguese who produced soap from Jatropha oil. Generally, Jatropha tree is 3-5 meter tall, smooth grey bark, having latex and heart green leaf. The flowers are small in size, white color and much more male flowers than female ones. Flowering occurs at the branch terminal. The fruit is green at the beginning and then turns to yellow and dark brown at the ripen stage. The fruit composes of 2-3 seeds. The seed is black, oval shape and one white point at the top. Oil content in the seed is about 30-40% [2, 3]. However, without the seed coat the oil content increases to 50-54%. Oil is non-edible, high unsaturated fatty acid with the same heating value as other vegetable oil. Jatropha can grow in many types of soil including marginal land which is not suitable land for food crop cultivation. This reduces the conflict of food/feed/fuel issue in some countries. Nevertheless, many products can be produced from Jatropha residues such as fertilizer from the seed cake (this work), pesticides and medical bio-active compounds from Jatropha extract [4, 5].

Jatropha curcas has great potential as energy crop as above mentioned. However, low yield seed is the burden and challenging for the researchers to overcome. Therefore, there have been many findings conducting to improve yield of Jatropha. As a wild crop the knowledge of Jatopha plantation management is little known and slowly developed. To accelerate the

research investigation under limited human resources and budget, the integrated research at the plantation level is desired. This paper shows how different discipline approaches to one goal of Jatropha yield improvement.

## 2. Methodology

This content will be divided to 5 sections according to the discipline and experimental set up. The five sections are agronomy, plant pathology, entomology, engineering and seed cake utilization.

### *2.1. Agronomy*

To obtain the objective of Jatropha high yield, the optimum spacing and level of fertilizer was investigated. This experiment has been taken at 2 plantations. The first plantation aimed to conduct the investigation of the spacing (2x2; 2x3; 3x3 m) and the second plantation was to observe the effect of fertilizer (high, medium, low and none inputs) to the Jatropha performance. Note that high input means chemical (15-15-15 and 50 kg/rai) and organic fertilizer (500 kg/rai), medium means only chemical fertilizer (50 kg/rai), low means only organic fertilizer (500 kg/rai) and none is no fertilizer. Note that 6.5 rais equal 1 hectare. There is only 1 variety, TH1 (plant form seed) reported in this paper. The collected data are the seed yield, number of fruit, weight of 100 seed, plant height, and canopy width during one year cultivation time.

### *2.2. Plant pathology*

The survey has been conducted across the Kingdom of Thailand to collect the specimen such as leaf or stem or confected part of Jatropha tree. The severity of pest was ranking and the specimens were then taken from the plantation to the laboratory for the biological assay. The symptom finally was identified.

### *2.3. Entomology*

There are three investigations in this area namely insect, nature predator of Jatropha insects and pollinator. Each investigation was separately carried on by different researcher. For the insect, mealy bug, was controlled by household chemical and natural predator (green lace wing). In fact, green lace wing is effective natural predator not only for mealy bug but also aphids and coccus. This paper did the mass cultivation of green lace wings and their eggs were packed in the capsules and tested in the Jatropha plantation. Concerning the pollinator, the percentage of pollinator visiting to 1,500 flowers was recorded during the dry and wet season at different time of the day. Then the pollen was collected from the Jatropha canopy and germinated in the laboratory to check germination percentage.

### *2.4. Engineering (biodiesel production)*

After the Jatropha seeds were collected from the field, the shells have been cracked by machine and oil was expelled using the oil expeller. The expelled oil was filtered to remove the solid residue and oil was used for biodiesel production using transestification technique and KOH was used as catalyst. The condition of biodiesel production namely mole ratio of methanol to oil (3-9), catalyst concentration (0.5-1.5%), reaction time (60-120 min) and reaction temperature (30-60 $^{o}$C) was optimized by experimental Box-Behnken design. Then percentage of fatty acid methyl ester (%FAME) was analyzed by gas chromatography.

### *2.5. Seed cake Utilization*

As known that one liter of Jatropha oil comes from about 4 kg of seed which will give about 3 kg of the seed cake. The objective of this section was to utilize the seed cake as fresh fertilizer to the vegetable cultivation. The experiment was conducted and applied to three types of vegetables namely Chinese kale, tomato and potato which represented the fresh consumed vegetables, fruit plants and root plants. Three level of seed cake was applied to those plants as high (1,600 kg/rai: 6.5 rais = 1 ha), medium (800 kg/rai) and low rates (400 kg/rai). Nevertheless, sole chemical fertilizer (recommended rate), sole organic fertilizer and half mixed of the seed cake (three doses) and chemical fertilizer or organic fertilizer were applied. Twelve treatments in total were carried out including the control (without fertilizer). The growth of plants was recorded. However, in this paper only the results of Chinese kale were reported. Samples were taken from the leaf and cultivation soil to check the phorbol ester residue. HPLC and LC-MS/MS were used to analyze phorbol ester content using TPA as external standard.

## 3. Result and Discussion

The results and discussion are divided into 5 parts according to the methodology as following.

### *3.1. Agronomy*

As can be seen in Table 1, 2x2 and 2x3 spacing gave the high seed yield of 129.2 and 127.1 kg/rai respectively. Number of fruit and 100 seed weight responded directly to the seed yield. Even though the plant height is the same but the canopy width clearly relates to the spacing. The larger spacing of 3x3 comparing to the narrower ones gives the wider canopy width.

*Table 1. Effect of spacing on Jatropha performance of TH1 variety.*

| Spacing | Seed yield (kg/rai) | number Fruit/rai | 100 seed weight (g) | Plant height (m) | Canopy width (m) |
|---|---|---|---|---|---|
| 2x2 | 129.2 | 55,804 | 86.3a | 2.7 | 1.6b |
| 2x3 | 127.1 | 56,698 | 84.4b | 2.7 | 1.9a |
| 3x3 | 97.9 | 44,498 | 84.2b | 2.7 | 2.0a |
| F-test (a) | ns | ns | ** | ns | ** |
| LSD (0.05a) | - | - | 0.6 | - | 2.7 |

*Table 2. Effect of fertilizer on Jatropha performance of TH1 variety.*

| Input | Seed yield (kg/rai) | number Fruit/rai | 100 seed weight (g) | Plant height (m) | Canopy width (m) |
|---|---|---|---|---|---|
| High | 182.3a | 80,455a | 85.5 | 276.0a | 187.5a |
| Medium | 132.1b | 58,826b | 85.1 | 276.5a | 188.6a |
| Low | 98.6c | 43,530c | 85.2 | 264.1ab | 183.6a |
| None | 59.1d | 26,524d | 84.1 | 256.6b | 163.5b |
| F-test (b) | ** | ** | ns | * | * |
| LSD (0.05b) | 29.5 | 12892 | - | 13.3 | 17.8 |
| Spacing x fertilizer | ns | ns | ns | ns | ns |
| CV (%) | 25.3 | 24.9 | 3.6 | 5.0 | 9.9 |

### *3.2. Plant pathogen*

The specimens (Fig 1.1) from the plantation were assayed for the microbial type. Leaf spot was the top ranking severity in the plantation as shown in Table 3. Fungal infection was the

most found particularly at the moderate temperature and high humidity. Fig. 1 shows the fascicles of conidiospores and conidium of *Pseudocercospora* sp. causing leaf spot.

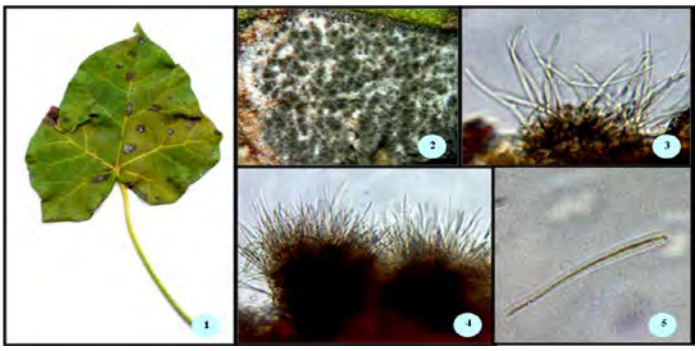

*Fig.1. Leaf spot infected by Pseudocercospora sp. 1) disease symptom on leaf; 2) fungal fruiting structure under stero-microscope; 3, 4) fascicles of conidiophores; 5) conidium*

*Table 3. Diseases and severity in the Jatropha plantation.*

| Diseases | Severity |
|---|---|
| Leaf spot (*Pseudocercospora* sp.) | ++++ |
| Leaf spot (*Pestalotiopsis* sp.) | ++ |
| Leaf spot (*Phoma* sp.) | ++ |
| Leaf spot (*Alternaria brassicicola*) | + |

### *3.3. Entomology*

There are three different investigation in entomology namely Jatropha insect, natural predator and pollinator.

#### *3.3.1. Jatropha Insect*

From the field survey, it was obvious that mealy bug was the most found insect in many areas of Thailand. The second and third populations of insect found were aphids and coccus. Fig. 2 shows the mealy bug before and after the treatment of sodium lauryl sulfate (SLS). As can be seen in Fig.2b SLS dissolve wax on the mealy bug's body.

*a* *b*

*Fig. 2. Mealy bug on the Jatropha tree a) before b) after treating with SLS*

#### *3.3.2. Natural predator*

The survey of prime natural predators of Jatropha insect particularly mealy bug, aphids and coccus has been done intensively. Green lace wing was found to be the effective natural predator of those insects. This natural predator has potential for mass production. Therefore, it was selected for further study. Table 4 shows the longevity and number of egg collecting from the laboratory. Comparing of different starting egg numbers of 50, 100 and 200 eggs, starting with 50 eggs give the highest ratio of egg/longevity and reasonable daily egg number. As the result this number is used for finding the suitable food composition for egg production (Table

5). Bee pollen and honey food mixed was selected as it gave the highest ratio of egg/longevity and daily egg obtained.

*Table 4. Number of eggs of Plesichrysa ramburi and its adult longevity from various number of starting adults at 27 °C and 70% RH.*

| No of starting | Ratio of egg/longevity | Mean longevity (day) | Daily obtained egg |
|---|---|---|---|
| 50 | 2,080a | 22.33c | 94.12 |
| 100 | 3,590b | 20.67b | 180.40 |
| 200 | 4,565c | 14.67a | 323.78 |
| CV (%) | 2.98 | 3.11 | - |

*Table 5. Number of eggs obtained from 50 starting aduls in different food composition.*

| Food composition | Ratio of egg/longevity | Mean longevity (day) | Daily obtained egg |
|---|---|---|---|
| Yeast & honey | 1,708 | 14.00 | 122.00 |
| Bee pollen & honey | 1,891 | 13.67 | 138.37 |
| CV (%) | 5.25 | 14.95 | - |

After eggs were mass produced in the laboratory, 300 eggs were packed in the plastic tube and tested at the field sites for 1, 2 and 3 weeks including the control (no egg pack). Unfortunately, during the experiment, there were not many insects as expected. Therefore, we could not observe the different numbers of the predator and insects before and after treatment. This field experiment is needed to re-perform later.

### *3.3.3. Pollinator*

The number of pollinator during the dry and wet seasons was recorded as shown in Fig 3. As can be seen in Fig 3, it is noticeable that the female flower is more preferable as the number of pollinator visiting is higher than male flower particularly in the morning. Fig 4 shows the percentage of pollen germination at different direction and time of the day. In the morning the high percentage of pollen germination is found in the direction exposing to the Sun. Correspondingly, in the late afternoon the higher percentage of pollen germination is found in the Southern west where the Sun is.

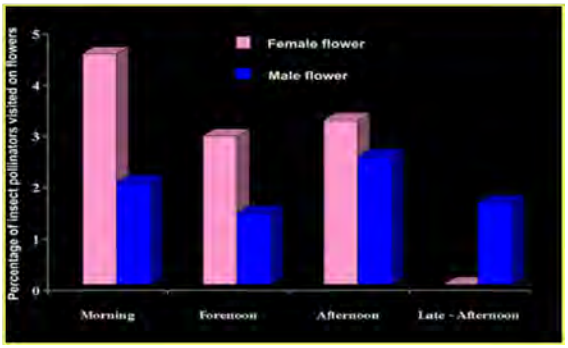


*Fig. 3. The percentage of pollinator visiting female (first) and male flower (second) in the morning, late morning, afternoon and late afternoon*

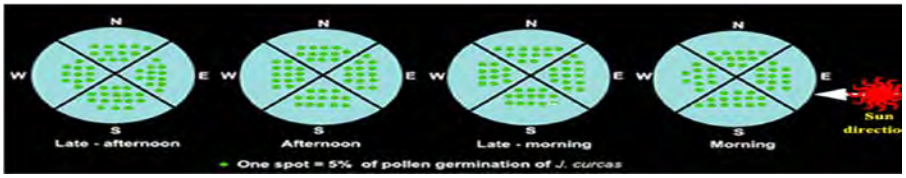


*Fig. 4. The percentage of pollen germination according to the direction*

### *3.4. Engineering*

From the Box-Behnken design of experiment with three levels, 35 experiment runs were designed. The data was analyzed using Minitab software to construct the contour as in Fig 5. As can be seen in Fig 5, the effect of reaction temperature and time has more influence on % fatty acid methyl ester (FAME) (Fig 5a). While the effect of mole ratio of methanol to oil, and %KOH has greater effect than reaction temperature (Fig 5b & 5c). The optimum condition for transesterification from Jatropha oil suggested by the model was 9:1 mole ratio, 1.5% KOH, 72 min reaction time and 60 $^{o}$C reaction temperature and 99.0% FAME was obtained at this optimum condition.

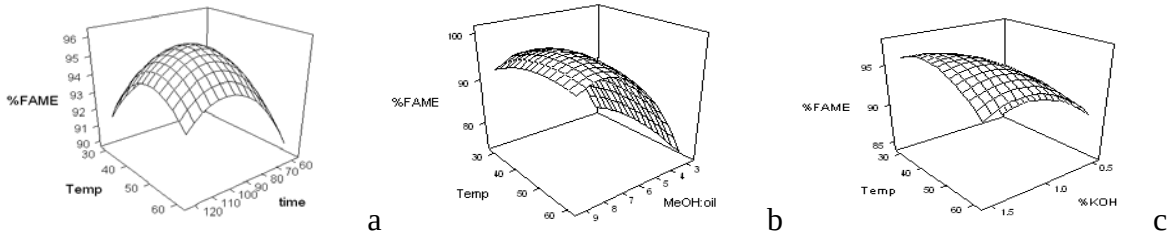


*Fig. 5. Surface plot of %FAME and a)reaction temperature and time b) reaction temperature and mole ratio c) reaction temperature and %KOH (catalyst).*

### *3.5. Seed cake utilization*

Table 6 shows the growth performance of Chinese kale of twelve fertilizer treatments. Pure chemical fertilizer and half dose of chemical fertilizer plus high rate of Jatropha seed cake give the highest Chinese kale yield of 9.87 and 9.08 t/ha. Note that 4 kg of Jatropha seed will give approximately 1 kg of oil and 3 kg of seed cake. From the phorbol ester analysis, the residue of phorbol ester both in the Chinese kale and cultivation soil was not found.

*Table 6. Average growth characteristic of Chinese kale (a, b, c show statistical significant).*

| Treatment | Leaf length (cm) | Leaf width (cm) | Plant height (cm) | Canopy height (cm) | Canopy width (cm) | Total yield (t/ha) |
|---|---|---|---|---|---|---|
| Without fertilizer | 10.87c | 8.70b | 7.39b | 19.83c | 13.27cd | 4.12c |
| CF | 14.83a | 12.26a | 15.83a | 29.27a | 21.27a | 9.87a |
| OF | 11.18c | 8.58b | 7.73b | 20.47c | 17.00bc | 2.02e |
| SF (400 kg/rai: H) | 9.75c | 7.05b | 7.26b | 18.37c | 13.57cd | 1.77e |
| SF (800 kg/rai: M) | 9.63c | 7.04b | 7.83 b | 17.60c | 12.33d | 4.08c |
| SF (1,600 kg/rai: L) | 11.35bc | 9.63ab | 9.06b | 22.91bc | 14.42cd | 3.77cd |
| 0.5CF + SF (H) | 12.10abc | 10.03ab | 10.13b | 20.90c | 14.23cd | 7.07b |
| 0.5CF + SF (M) | 9.76c | 8.00b | 8.33b | 19.07c | 12.60cd | 4.55c |
| 0.5CF + SF (L) | 14.23ab | 12.40a | 10.57b | 27.87ab | 19.67ab | 9.08a |
| 0.5OF + SF (H) | 10.43ac | 7.63b | 8.05b | 20.77c | 15.40cd | 2.60de |
| 0.5OF + SF (M) | 12.07abc | 8.267b | 9.60b | 23.27bc | 15.23cd | 4.12c |
| 0.5OF + SF (L) | 11.50bc | 9.16b | 8.85b | 23.30bc | 15.20cd | 3.99c |

Please note that CF is the chemical fertilizer, OF is organic fertilizer and SF is Jatropha seed cake fertilizer,

## 4. Conclusion

This paper shows the multidisciplinary research work of Jatropha in the plantation level. The results of this preliminary investigation are the important basic knowledge to increase the Jatropha yield. The actual work has been done intensively in the plantation level to make sure that the developed technology is practical and useful for the future users. It is clear that Jatropha yield improvement is the challenge and it needs the integrated research of agriculture, engineering and science.

## 5. Acknowledgement

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