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THE POTENTIAL OF JATROPHA CARCUS PLANTING AS RENEWABLE ENERGY CROP UNDER MALAYSIA WEATHER CONDITION

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ABSTRACT

Jatropha carcus was currently been explored as renewable energy crop by extracted the oil from the seeds to produce biodiesel. A study was conducted to determine the potential of jatropha planting under Malaysia weather condition. The jatropha was planted on mineral soil at 2,500 plants/ha by using cutting as the planting material. It was fruiting after 4 months of planting and the preliminary dry seeds yield was 2.66 t/ha and 4.27 t/ha respectively in the first and second year after harvesting. The dry weather had caused serious defoliation of the plant with drastic yield declined after two months of the drought. The oil content of the dry seed and kernel were recorded at 36.5% and 57.0% respectively. The gibberellin hormone (GA3) spraying on Jatropha canopy with 10 ppm concentration at 4 weeks interval and 5 ppm concentration at 2 weeks interval was improved the total fruits production by 77.3% and 92% respectively.

Keywords: *Jatropha carcus*; Yield; Rainfall; Oil extraction; Gibberellin

Jatropha carcus or commonly known as 'Jarak Pagar' in Malaysia is from the family of Euphorbiaceae, where the genus of Jatropha has consists of 165-175 species. Jatropha was originated from South America, where Northeast Brazil and the dry areas of Mexico have been identified as the diversity centre of Jatropha. The temperature of 25-35oC is optimum for Jatropha growth, it can tolerate to the temperature as high as 40oC and below 20oC but caused leaf shedding. Jatropha was claimed to have excellent adaptability on dry, stony, very shallow soils, even between bare rocks and also on very low fertility soil. Jatropha has enormous capability to uptake and utilize the nutrients under low soil fertility condition without significant nutrient deficiency. However, the phosphorous deficiency was reported on the acidic soil. Jatropha is drought tolerance and the established plants have well adaptability to severe dry seasons, however it growth vigorously under humid condition with high rainfall [1].

Jatropha in Malaysia was normally planted as hedges surrounding the garden and farm to protect the crops from animal roaming. Currently, Jatropha has been explored as renewable energy crop by extracted the oil from the seeds to produce biodiesel. The extracted Jatropha oil can be further proces-sed to produce biodiesel by transesterification process. The Jatropha biodiesel (methyl ester) can be blended with diesel in any proportion or used as pure biodiesel (100% without blend) in compress ignition engine success-fully without any problem [2] and no modifi-cation of engine are needed to use the blended diesel with Jatropha biodiesel at 10% and 20% [3]. To maximizing the utilization of Jatropha, the fruit husk could be processed in briquette form as combustion for domestic and industry use, the Jatropha oilcake is a good feedstock for biogas production [2,4] and also as green manure or fertilizer [5].

The potential of biodiesel in Malaysia is huge with the available feedstock from crude palm oil and Jatropha oil. According to Malaysia Biodiesel Association (MBA), there are 10 active biodiesel plants in Malaysia with the total installed capacity of 1.2 million tonnes annually in 2008. About 91 biodiesel licenses have been issued by the Minis-try of Plantation Industries and Commodities in Malaysia [6]. Jatropha oil was found as the cheapest feedstock for biodiesel production and the estimated price of Jatropha biodiesel was 80% cheaper than palm oil biodiesel, 100% cheaper

than soybean biodiesel and 135% cheaper than rapeseed biodiesel. As being a non-edible oil seed feedstock, Jatropha oil has the advantage that not affects the food price and not spurs the conflict of edible oil as food versus fuel [7]. The oil yield of Jatropha was reported the highest among the non-edible oil seeds at 2-3 t/ha as compared to Gastor, Linseed and Mahua which only at 0.5-1.0 t/ha, 0.5-1.0 t/ha and 1.0-4.0 t/ha respec-tively [8].

Meanwhile, the analysis of the chemical and physical properties (viscosity, density, flash point, cloud point, pour point, calorific value, acid value, iodine value, condradson carbon residue and sulfate ash) of Jatropha methyl ester (biodiesel) that produced through transesterification process was comply to ASTM D6751 (Standard Specifi-cation for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels) and EN 14214 (Biodiesel Fuel Testing Europe) specification [9]. The Jatropha biodiesel specification was also comparable with others nonedible biodiesel such Sterculia foetida and crude Ceiba pentandra [10]. Therefore, Jatropha oil is

proven and accepted to be utilized as the feedstock for biodiesel

Jatropha received very encouraging feed-back and attention worldwide on cultivation and downstream processing. However, some findings were contradict with the previous claims and showed that Jatropha require adequate moisture to produce better yield and even with irrigation the yield was still lower than those had reported. Jatropha planting also need long term credit due to their long gestation period, where no less than 3 years even under optimistic performance scenario [11]. As considering of the huge potential and the uncertainty of Jatropha, a study was conducted to determine the feasibility of Jatropha planting as renewable energy crop under Malaysia weather condition.

MATERIAL AND METHODS

This study was carried out at FASSB Jengka 26 Research Station in Pahang, Malaysia under rain fed condition without irrigation. The soil type of this study plot was classified as Bungor Siri (FAO taxonomy: Haplic Nitisols), where their soil texture is fine sandy loam in A horizon and fine sandy clay in B horizon. It is well drained soil with good permeability, however the cation exchange capacity (CEC) is less than 16 cmol (+)/kg clay [12] which can consider as infertile soil. The planting material of Jatropha was using the cuttings from the selected trees which are expected from the similar source. The cuttings were prepared on polybag and transplanted into the study plot after 2 months in nursery stage. The planting distance of Jatropha was 7' x 7' x 7' in triangle pattern with the total planting density of 2,500 plants/ha. The fertilizer input during the immature stage was using NPKMg 15/15/6/4 at 150 g per plant with 2 kg of compost per annum. Where, NPKMg mixture 9.6/4.8/17.6-/2.4 was applied during the mature stage at 550 g per plant with 2 kg of compost per annum. The partial contact and systemic herbicide such as glufosinate-ammonium was used for weed control and cypermethrin was used to control the leaf miner when necessary.

The dry seeds yield was recorded every 1-2 weeks depend on the fruiting pattern and production. The Jatropha oil was extracted by using solvent method to determine the total oil content of the dry seed and kernel. Gibberellin acid hormone (GA3) was sprayed at 10 ppm and 5 ppm concentration in 4 weeks and 2 weeks interval respectively to evaluate their effect on fruit production of Jatropha.

RESULTS AND DISCUSSIONS

Jatropha seed yield performance

The Jatropha was started to fruiting after 4 months of planting and the mature seeds were harvested after 5 months of planting. The immature period of Jatropha by using cutting as the planting material was shorter at 5 months after planting as compared to the direct seeding method which required 8 months. The Jatropha fruit development was about 57 days (2 months) from flower anthesis stage to fruit maturity stage, when the fruits were turned from green to yellow-brown colour. The Jatropha seeds were removed from the fruit husk and sun-dried about 4-5 days to reduce the moisture content for longer storage period.

The initial dry seed yield was low at 10-30 g/tree/month and then increased to 90-190 g/tree/month during the first year harvesting. The maximum dry seed production was able to be achieved as high as 280-300 g/tree/-month in the second year of harvesting when the tree canopy grown bigger. The total dry seed yield

in the first year was 1.07 kg/tree and increased by 59% to 1.70 kg/tree in the second year of harvesting (Table 1). This dry seed yield per plant was higher than that reported in North India, which only produced average of 432 g/plant in their accessions study [13].

The potential dry seed yield of Jatropha was estimated about 2.66 t/ha/year and 4.27 t/ha/year respectively in the first and second year of harvesting (Table 1). The Jatropha yield was widely varies depend on the location, climate, planting density, soil type, plant age and genetic variability. The Jatropha dry seeds yield in the region with 900-1200 mm/year was able to achieve about 5 t/ha/year as compared to low rainfall area in semi-arid region which only yielded 2-3 t/ha/year [14]. In Indonesia, the dry seed yield had recorded as high as 3.0 t/ha even in the first year harvesting. Under the rain fed area with marginal soil in India, the seed yield had be reported at acceptable high level at 3.2-4.1 t/ha/year in the first year after planting [15].

However, some area were reported low yield in the first and second year of harvesting, which only achieved 0.50 t/ha and 1.50 t/ha respectively [16]. The disappointing low dry seed yield was reported at 0.96-1.44 t/ha in India, even with the input of inorganic fertilizer, farm yard manure, irrigation and high density planting [17]. Therefore, the dry seed yield at 2.66-4.27 t/ha/year in this study was considered at the acceptable level among the reported yield of Jatropha.

The Jatropha yield in this study was observed very low at 0-60 g/tree/month in certain periods even during the seconf year harvesting, where the seed yield was expected to be peak. This yield declined in certain period was suspected due to the wintering phenomenon, where Jatropha tree facing drastic defoliation after the drought and caused serious flowers abortion. The dry seed yielding pattern has showed clear relationship with rainfall distribution, where the dry seed yield was dropped drastically at 2 months after the dry weather with the monthly rainfall less than 150 mm (Fig. 1). This correlation was strongly support the hypothesis that the dry weather with low rainfall had caused serious flowers abortion with low fruit set in Jatropha and the effect will only be noticed after 2 months, because the Jatropha fruit development was required about 57 days.

Even though, Jatropha was reported as drought tolerance, however serious dry weather was significantly reduced the leaf area, biomass and relative growth rate of Jatropha [18]. Hence, irrigation for Jatropha is still recommended to achieve consistent and maximum yield. Irrigation for Jatropha at 100% potential evapotranspiration (ETp) showed 89% to 115% increased of total seed yield as compared to the tree that only received 75% ETp and 50% ETp of irriga-tion, respectively [19].

Table 1 The monthly Jatropha seed yield at the 1st and 2nd year after harvesting

Mth	1st year yield		2nd year yield		
	t/ha	t/ha	Mth	t/ha	t/ha
1	0.07	0.03	13	0.69	0.28
2	0.06	0.02	14	0.55	0.22
3	0.04	0.02	15	0	0
4	0.02	0.01	16	0.06	0.02
5	0.22	0.09	17	0.16	0.06
6	0.32	0.13	18	0.76	0.30
7	0.43	0.17	19	0.28	0.11
8	0.48	0.19	20	0.25	0.10
9	0.36	0.14	21	0.21	0.09
10	0.17	0.07	22	0.34	0.13
11	0.35	0.14	23	0.69	0.28
12	0.14	0.06	24	0.28	0.11
Total	2.66	1.07	4.27	1.70	Total

Notes: Mth – months

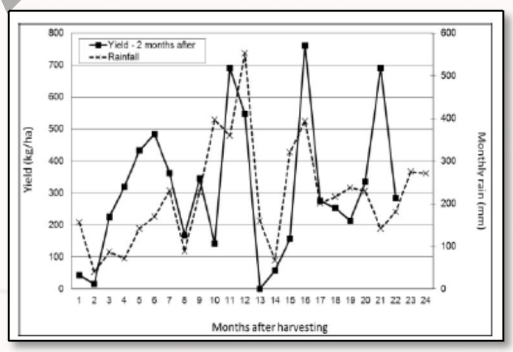

Fig. 1 The effect of rainfall to the dry seed yielding pattern of Jatropha

Jatropha oil content

The analysis of Jatropha oil content in this study was conducted by using solvent method to determine the oil content of the dry seeds and kernel, the result was showed that the Jatropha dry seed was consisted about 36.5% of oil as compared to kernel at 57.0%. The Jatropha accessions study in Florida under subtropical climate zone was show that the Jatropha oil content was vast varied from 19.30% to 35.63% [20]. Meanwhile, the same study in Mozambique under the tropical rainy

climate was reported that the oil content of Jatropha dry seed was about 37-45% [21]. Therefore, the oil content of the local Jatropha variety in this study was considered acceptable and potentially to be used for commercial planting to achieve the desirable oil yield.

Jatropha fruits showed the characteristic of uneven ripening from the same fruit brunch. This caused the Jatropha fruits have to be harvested manually according to their ripening stage, which had cost labour intensive in the operation of harvesting [22]. Therefore, a study was carried out to determine the dry weight, oil extraction and total oil content of Jatropha kernel from the same fruit brunch but with different fruit maturity stages which categorised as fully ripe (brown), ripe (yellow) and unripe (green).

The study showed that the moisture content of the kernel was high in unripe kernel with 34.0%, which slightly higher as compared to fully ripe and ripe kernel at 31.3% and 30.0% respectively. The fully ripe and ripe Jatropha kernel has recorded higher weight by 13% and 16% respectively as compared to unripe kernel. The Jatropha oil extraction was higher in unripe kernel with 60.0% as compared to fully ripe and ripe kernel at 57.0% and 56.0%. However, the fully ripe and ripe kernel showed 5% and 8% higher of total oil content respectively as compared to unripe kernel (Table 2). Therefore, the fully ripe (brown), ripe (yellow) and unripe (green) Jatropha fruits from the same fruit brunch are advisable to be harvest together to improve the harvesting productivity, but with slightly reduce of total oil production by 5-8%.

The oil extraction from the dry seed of Jatropha in different storage period was also been study. The result was showed that the kernel oil content was still able to maintain between 54.6-57.2% when the seeds were storage within 8 months after harvested. However, the Jatropha kernel seem to be deteriorated after 9-11 months of storage, where the kernel oil extraction only achieved between 43.3-45.5% with the reduction more than 10% (Table 3). The growth of fungi such as Penicillium sp. and Aspergillus sp. (storage fungi) on the Jatropha seeds under the tropical climate with high temperate and humidity was the main contributor that caused the degradation of the oil content [21].

Therefore, the Jatropha seeds have to be process within 8 months after harvested to achieve the maximum oil extraction. The Jatropha oil is advisable to store under sealed container without contact with oxygen and light to preserve its quality.

Table 2 The Jatropha kernel weight, kernel oil extraction and total oil content at different fruit ripening stage

colour	Moisture content (%)	Kernel weight (g)	Kernel oil content (%)	Total oil content (g/ kernel)
Brown	31.3	0.71 (113%)	57.0 (95%)	0.40 (105%)
Yellow	30.0	0.73 (116%)	56.0 (93%)	0.41 (108%)
Green	34.0	0.63 (100%)	60.0 (100%)	0.38 (100%)

Note: ( ) - % over Green fruit

Table 3 The oil extraction of Jatropha seeds under different storage period

Storage period (month)	Kernel oil content (%)
3	56.8
4	54.6
5	56.1
6	53.2
7	57.2
8	56.0
9	45.5
10	47.4
11	43.3

Jatropha fruit induction

To improve the Jatropha yield, plant hormonal such as Gibberellin acid (GA3) was sprayed on the canopy to induce the flowering of Jatropha. The early study was showed encouraging result, where the application of GA3 at 10 ppm in 4 weeks interval was able to improve the total fruit production by 43% from 54.0 fruits/tree in untreated trees to 77.3 fruits/tree in GA3 treated trees. Meanwhile, the GA3 application at 5 ppm with 2 weeks interval was showed better result by improved the total fruits production by 92% to 103.9 fruits/tree (Table 4). The GA3 application on Jatropha was significantly increased the total fruit brunches between 41-83% as compared to untreated trees, however the average fruit number per fruit brunch was remaining same at 6.3-6.6 fruits for both treated and untreated tress (Table 4).

Table 4 The effect of GA3 application on total fruit production of Jatropha

GA3 Treatment	Spray interval (week)	Fruit proudction (numbers/ tree)	Total fruiting bunches	Average fruits/ bunch
5 ppm	2	103.9 (192%)	16.1 (183%)	6.6
10 ppm	4	77.3 (143%)	12.4 (141%)	6.3
Untreated	-	54.0 (100%)	8.8 (100%)	6.4

Note: ( ) - % over untreated

CONCLUSION

Jatropha was adaptable under Malaysia weather condition by producing acceptable level of dry seed at 2.66 and 4.27 t/ha/year in the first and second year of harvesting even under the low fertility soil in rain fed area. However, fertilizer input both inorganic and organic were very crucial to sustain the growth and seed production for Jatropha. Irrigation was suggested for Jatropha planting to further improve the seed yield, especially during the dry weather where the yield was drastically drop during this period. Due to lack of price benchmarking and less of consistent market demand of Jatropha oil, Jatropha planting in Malaysia still facing very challenging situation to produce the feedstock for biodiesel industry as compared to palm oil.

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