GROWTH RESPONSES OF VARIETIES OF *JATROPHA CURCAS* SEEDLINGS TO VARYING NPK FERTILIZER RATES

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ABSTRACT

The cultivation of the non-edible oil-bearing crop Jatropha curcas L. in Malaysia was initiated due to its potential as a source of cheap biodiesel feedstock and short gestation period. However, the drive for Jatropha curcas cultivation has been relatively slow. Past fertilizer experiments on the species focused on plants in the field under different environmental conditions. This study was conducted to gauge the response of potted Jatropha curcas varieties to NPK fertilizer rate under a covered net house during the early establishment phase. The experiments were conducted in an RCBD using two months old seedlings of four varieties and four NPK fertilizer rates in 3 replicates. Local variety had the lowest height increment while India variety had the lowest diameter increment whether with and without fertilizer treatment. With fertilizer treatment, India variety had the best height increment while Indonesia variety had the best diameter increment. ANOVA was significantly different for mean height increment and mean diameter increment between varieties ($p<0.001$ and between NPK fertilizer rate ($p<0.001$) respectively. An application of 5 to 10g of NPK fertilizer per Jatropha plant was sufficient to induce the best growth response in J. curcas seedlings.

Keywords: *Jatropha curcas*, NPK fertilizer, variety, growth response

INTRODUCTION

Global energy crisis is expected to worsen as the global non-renewable petroleum stock declines amid increasing energy consumption as indicated by increased global oil prices. Renewable biofuels which include bioethanol, biomethanol, biodiesel and biohydrogen (Yusuf et al., 2011) are set to be the future sources of energy. Brazil, USA, Germany, Austria, Australia, Italy are utilizing biofuels for transportation (Dorao et al., 2006; Haas et al., 2006) setting the trend for green fuel consumption. Biofuels produced from biomass are in fluid or gaseous state, are environmentally friendly, sustainable, and biodegradable (Yusuf et al., 2011). Biodiesel described as monoalkyl esters of vegetal or animal fats have similar characteristics to diesel but does not contain Sulphur and aromatic. Biodiesel has approximately 10% built in oxygen that burns completely and improves ignition quality (Singh and Dipti, 2010). Biodiesel can be used in the blended form or pure form (Singh and Dipti, 2010), but will require minor modification to the fuel system (Pradeep et al., 2007). Malaysia has a 7% biodiesel mandate that stimulate local demand and consumption of biodiesel (Commodity Basis, 2017), and its interest to reduce greenhouse gases (GHG) emissions (Mojifur et al., 2012). Malaysia is the third largest producer of global palm oil at approximately 20M t/year but only 15% is consumed within the country. Palm oil prices in Malaysia is dependent on international supply and demand (Commodity Basis, 2017) and is expensive for biodiesel production. Therefore, non-edible oil-bearing plants like *Jatropha* are being explored to produce viable biodiesel feedstock. *Jatropha* was relatively an unknown plant until it was acknowledge as a biofuel crop in Malaysia in 2005 (Mansor and Sivapragasam, 2008).

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Jatropha curcas L. also known as Physic nut or Jarak Pagar (Malaysia) (Mojifur et al., 2012) is a non-edible oil crop that belongs to the Euphorbiaceae family (Boswell, 2003). It is native to Central America but widely planted throughout the arid, semi-arid and tropical regions globally for the production of biodiesel (Boswell, 2003; Omar et al., 2014). It was cited as the cheapest source of biodiesel feedstock (Mojifur et al., 2012), and has shorter gestation period of 2 years compared to 3 years in oil palm (Mansor and Sivapragasam, 2008). *Jatropha curcas* is one of the most commonly used oils for producing biodiesel (Foidl et al., 1996; Chhetri et al., 2008). *Jatropha* was promoted due to its hardiness, the ability to grow on marginal lands and thus not compete for land with food crops. It grows easily, rapidly, propagated without difficulty, reasonably high-yielding and has an economic life span of about 30 years (Arjun et al., 2008; Mansor and Sivapragasam, 2008). *Jatropha* grows well below 1400m from sea level, and optimum rainfall between 900 to 1200 mm. However, the species is tolerant to drought, requiring a minimum rainfall of 250 mm (Bosswell, 2003). It was reported that *Jatropha* oil contents is influenced by altitude where it is grown, performing better under lower elevations (Pant et al., 2006). Furthermore, it is non-edible and thus not browsed by animals and considered a good alternative to the more costly edible oil crops (Arjun et al., 2008). In Malaysia, *Jatropha* oil can fetch RM2000 tons/ha of *Jatropha* oil about 20% less than palm oil (RM2750) (Mansor and Sivapragasam, 2008). *Jatropha* has multiple uses including medicinal uses and as natural pesticide (Chhetri et al., 2007), and the potential of developing by-product such as biofertilizers and biogas (Zulkefly et al., 2013). The risks of *Jatropha* cultivation is related to its long gestation period (2 years), and becomes very labor intensive at the harvesting stage. *Jatropha* oil yield is 1.2 tons/ha about three times less than oil palm (3.6 tons/ha) under the same production cost of RM3300/ha (Mansor and Sivapragasam, 2008).

Jatropha curcas oil yield is about 1590 kg oil/ha (Gui et al., 2008), the seed can yield 30 to 50% of oil whilst the kernel yields 45 to 60% oil (Pramanik, 2003; Gui et al., 2008). In India, Jatropha yields 50-60% of oil fraction producing 2 to 3 tons of oil/ha/year in India (Mukunda, 1999). *Jatropha* oil consist of about 14% free FA and 80% unsaturated FA with palmitic and stearic acid as the major saturated FA. The conversion of *Jatropha* oil to fatty acid methyl ester (FAME) achieved 97% for jatropha. The overall FA content in *Jatropha* biodiesel was 45.79% oleic acid (18:1), 32.27% linoleic acid (18:2), 13.37% palmitic acid (16:0) and 5.43% stearic acid (18:0) which is comparable to Gubitz et al. (1999) report (Chhetri et al. 2008). The FA profile of *J. curcas* was reportedly appropriate for biodiesel and met the major specification of Biodiesel standards of European Standard Organization and the USA (Mohibbe et al. 2005). A biodiesel blend containing 50% *Jatropha* oil is suitable for diesel engines such as transportation and farm machinery without huge operational difficulties (Sheehan, 1998; Ofari and Lee, 2011), although long-term effects on engine performance will be required (Pramanik, 2003). *Jatropha* oil is also an excellent substitute for kerosene (Ofari and Lee, 2011).

In Malaysia, research and development of *Jatropha* initiated by the Malaysian Rubber Board lead to its cultivation by small holders and private holdings but only to a small extent (Mojifur et al. 2012; Bionas, 2017). Its cultivation has yet to gain impetus compared to oil palm which has 30 years of cultivation, improvement and commercial industry. Research and development efforts from propagation, cultivation, harvesting and post-harvesting of *Jatropha* is essential to propel the industry to greater heights. The prospect of *Jatropha* for biodiesel production in Malaysia was purportedly positive due to the availability of land and good climatic condition, with existing partnership on Jatropha production between government agencies and the private sector (Mojifur et al., 2012). *Jatropha* oil production is considered economically feasible under large scale operation (Ofari and Lee, 2011). Furthermore, the Malaysian government supports the production and use of biodiesel by providing subsidies and farmer support programs for *Jatropha* cultivation (Mojifur et al., 2012). Consumer spending on diesel engine is steadily growing and could be encouraged by reduced annual road tax for diesel engines by 10% to 34% in 2007 (Raymond , 2010; Malaysia Automative Association, 2009). However, the biggest challenge to the *Jatropha* industry is low productivity which could be associated with low-yielding germplasms, cultivation and cultural practices and the utilization of marginal lands (Zulkefly et al., 2003).

Studies on fertilizer application and nutritional requirement of *Jatropha* was primarily reported from Nigeria (Ige et al., 2011; Ngwu, 2016), India (Mohapatra and Panda 2011) and Brazil (Omar et al., 2014). The fertilizer experiments of these studies were conducted in the plantation under varying environmental conditions with respect to the different countries. These research focused on plants that were already at the production stage with higher nutrient requirements. This study was conducted to gauge the response of potted *Jatropha curcas* seedlings to different NPK fertilizer rates in the nursery and provide some guidelines for maintaining *J. curcas* in the nursery. Plants maintained in the nursery can be easily accessed and utilized for vegetative propagation and research purposes. Early growth response of *Jatropha* seedlings to fertilizer input could affect its survival, development and yield in the plantation.

MATERIALS AND METHODS

Experiment I was conducted in in a 2 x 5 factorial Complete Randomized Design (CRD) layout using two *J. curcas* varieties namely Indonesia (Ina) variety and India (Ind) variety, and 5 NPK (15:15:15) fertilizer rates at 0g (A, Control), 5g (B), 10g (C), 15g (D) and 20g (E) per plant respectively. The combination of variety and fertilizer rates consists of 10 combinations in 3 replicates respectively. Experiment II was conducted 2 x 4 factorial CRD layout using 2 *J. curcas* varieties namely local Sabah variety (L) and Thailand (T) variety; and 4 NPK (15:15:15) fertilizer rates at 0g (A, Control), 5g (B), 10g (C), and 15g (D) per plant respectively after the results of Experiment I. The combination of variety and fertilizer rates consist of 8 combinations in 3 replicates respectively. For both experiments, each variety x fertilizer rate combination represented a single plot which comprised of 6 seedlings. Two month-old seedlings were sown in a mixture of topsoil and sand (3:1 ratio) in 10” x 15” polybags (volume 77.2 L). Fertilizer was applied on once a month interval. The data was collected once a month for four months. Based on results of the first experiment, fertilizer rate 20g (E) was omitted in the second experiment. The results were presented as descriptive analysis, ANOVA and correlation analysis for each experiment. Then data from the two experiments were merged for analysis.

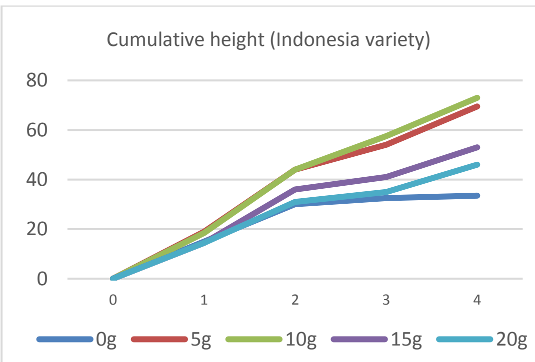
RESULTS

In the first experiment, overall India variety gave better performance for mean height, diameter and number of leaf after four months (Table 1) than Indonesia variety. An application of 10g/plant NPK fertilizer had the best growth responses for both variety and all parameters. The control treatment or without fertilizer plots had the least growth response for the *Jatropha* plants. ANOVA showed that the growth response were very significantly different among the different fertilizer rate ($p<0.001$) and among the different variety and fertilizer rate interaction ($p<0.001$) for height, diameter and number of leaf of the *J. curcas* seedlings. ANOVA showed that diameter and number of leaf of *J. curcas* seedlings was very significantly different among the two varieties ($p<0.001$) but not significant for height ($p=0.066$). Figure 2 shows that mean height increment for Indonesia variety was variable than India variety and mean diameter increment had similar trends in both variety. Height increment had the highest correlation with increment of leaf ($r=0.927$, $p<0.01$) and moderate correlation with diameter increment (r-0.502, $p<0.05$). Correlation between diameter increment and leaf number increment was low ($r=0.379$, $p<0.05$).

In the second experiment, Sabah variety had better diameter growth response while Thailand variety had better height growth response (Table 2). An application of 5g NPK had the best growth responses for mean height and mean diameter for the local variety. Without fertilizer application, growth responses for both varieties were poor (Figure 2). *Jatropha* seedlings had similar growth responses until 1 month after NPK application. ANOVA showed significant differences for mean height increment and mean diameter increment between varieties ($p<0.0001$) and between fertilizer treatments ($p<0.0001$). The effects of combined variety*fertilizer treatment was not significant for all growth responses ($p>0.05$). Height increment is positively correlated with diameter increment of the *Jatropha* seedlings ($r=0.708$, $p<0.01$).

Table 1: The mean height, diameter and number of leaf *Jatropha curcas* seedlings of Indonesia and India variety applied with different NPK rates (Experiment I)

	Experiment I (Height, cm)					
		0g	5g	10g	15g	20g
1	Indonesia	33.50	69.50	73.00	53.00	45.5
2	India	8.50	76.00	77.50	73.50	70
	Experiment I (Diameter, mm)					
		0g	5g	10g	15g	20g
1	Indonesia	16.50	20.00	20.00	16.50	13
2	India	7.00	15.50	16.00	12.50	11.5
	Experiment I (number of leaf)					
		0g	5g	10g	15g	20g
1	Indonesia	20	41	43	39	35
2	India	9	45	52	48	50



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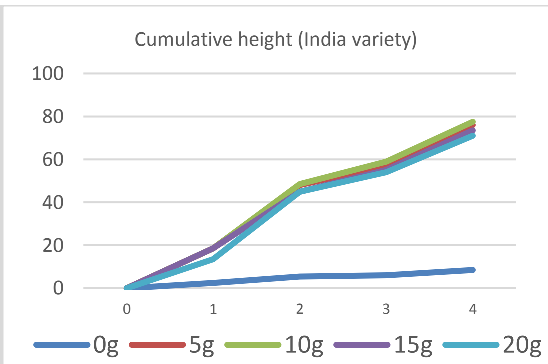

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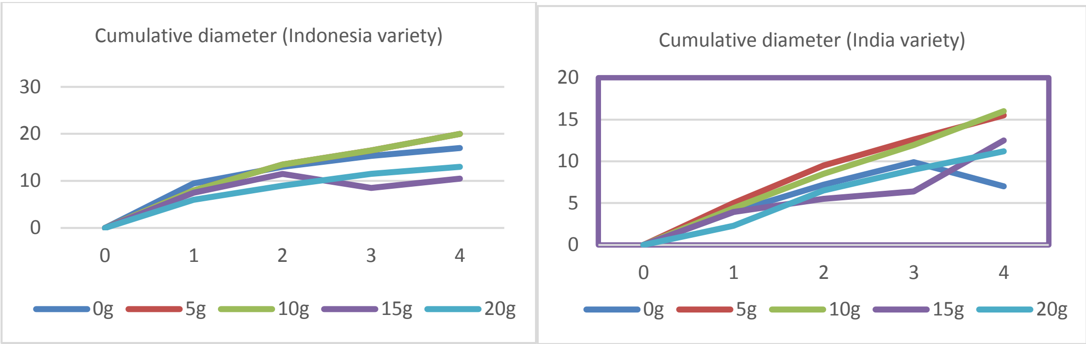

Figure 1: The mean cumulative height and diameter of *Jatropha curcas* seedlings of Indonesia (A, C) and India (B, D) variety applied with different NPK rates over four months (Experiment I)

To compare the response of all varieties to fertilizer rate, the growth data were pooled and analysed. For height, India variety gave the best response while Sabah variety had the poorest response at all fertilizer rate. For diameter, Indonesia variety had the best response while Thailand variety had the poorest response at all fertilizer rate (Figure 3). At 10g NPK/plant height range from 40.23mm (Sabah) to 77.5cm (India). At 5g NPK/plant diameter range from 9.55mm (Thailand) to 16mm (Indonesia).

Table 2: The mean height, diameter and number of leaf *Jatropha curcas* seedlings of Sabah and Thailand variety applied with different NPK rates (Experiment I)

	Experiment II (Height, cm)				
		0g	5g	10g	15g
1	Sabah	7.22	40.23	35.64	19.96
2	Thailand	28.14	59.32	49.04	37.81
	Experiment II (Diameter, mm)				
		0g	5g	10g	15g
1	Sabah	8.98	14.77	11.77	7.50
2	Thailand	5.92	9.55	7.27	3.43

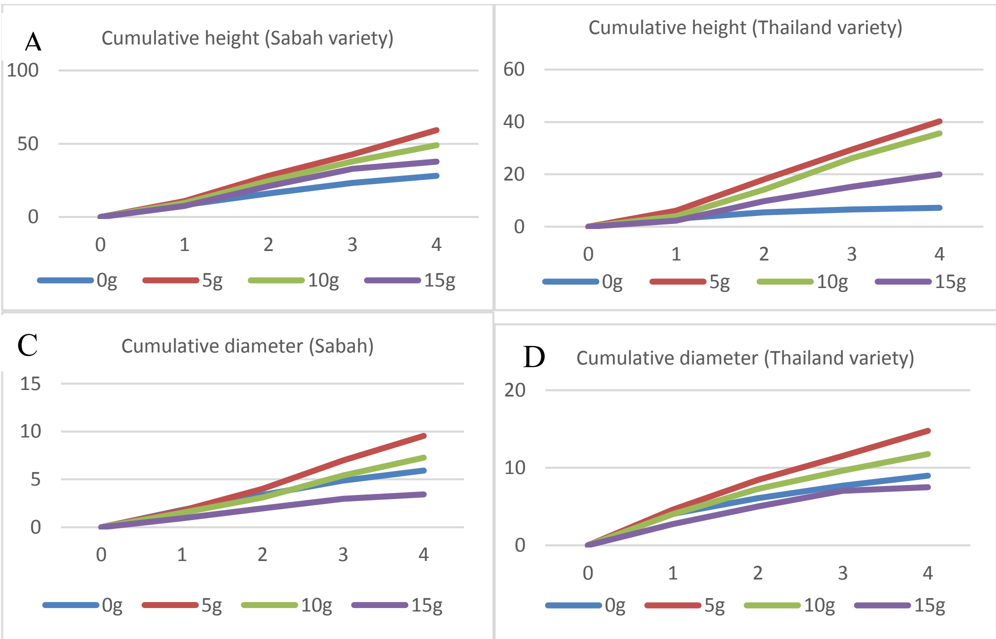

Figure 2: The mean cumulative height and diameter of *Jatropha curcas* seedlings of Sabah (A, C) and Thailand (B, D) variety applied with different NPK rates over four months (Experiment II)

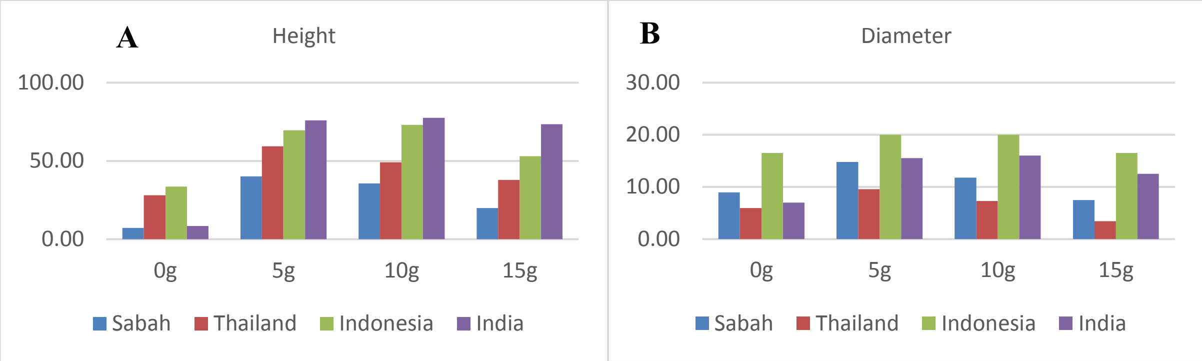

Figure 3: (A) Mean cumulative height increment (cm) and (B) Mean cumulative diameter increment (mm) of *Jatropha curcas* varieties and NPK application

DISCUSSION

The quality of planting stock is directly influenced by the nature and composition of the potting mix used in the nursery (Fagbenro et al., 2013). Our result suggests that the use of small amounts of NPK (15:15:15) of 5 to 10g per plant (soil volume of 77.2L) was sufficient to induce good growth response. Different *J. curcas* varieties also responded differently to the amount of NPK fertilizer. We found that NPK application at any rate increased the growth parameters of *J. curcas* seedlings compared to the control, which indicates that potting medium is low in fertility. Similarly, NPK application improved the growth of *Irvingia* gabonnesis compared to control treatment (without treatment) resulting in increased N, P, K, Ca, Mg, pH and organic matter of soil and seedlings (Moyin-Jesu, 2008a). Fagbenro et al. (2013) found that higher application of inorganic NPK (15:15:15) or biochar fertilizer had similar beneficial effect on most growth parameter of *Moringa* seedlings except for the number of branch development which did not appear to be affected. Both types of fertilizer produced vigorous seedlings. Ros et al. (2015) reported that increasing NPK fertilizer to rice seedlings in the nursery increased shoot dry weight and grain yield of transplanted seedlings that were treated with submergence, drought and nutrients stress after transplanting. NPK treated seedlings were vigorous with higher nutrient concentration. Thus, the seedlings could survive low fertility and stress prone areas. Therefore, supplying NPK fertilizer to *J. curcas* at the nursery stage could be beneficial for their survival and development when planted on marginal lands but this needs to be tested.

Detailed nutrient analysis conducted by Omar et al. (2014) indicated that N was an important nutrient for the production and quality of oil of *J. curcas* than K in Espinal, Colombia. A combination of high N and lower K increased fruit and seed production by 92% and 95% respectively and thus boosting oil production by 100%. Furthermore, oil content was up by 40% (w/w). In the arid region of eastern India, five year old *J. curcas* trees responded with maximum seed yield of 60g N/tree and combination 50g N, 100g P and 60g K (Mohapatra and Panda 2011). According to Ngwu (2016), poultry manure had significantly promoted the growth of young *J. curcas* seedlings. This was followed by seedlings applied with goat manure, then seedlings applied with NPK 15:15:15, and lastly seedlings applied with NPK 20:15:15 had the least growth performance. This contradicted with those of older *J. curcas* plants (Mohapatra and Panda 2011, Omar et al. 2014). This also supports our finding that lower amount of NPK application is preferable for early stage development of *J. curcas* seedlings. Ige et al. (2011) suggest that the application of NPK (15:15:15) can be enhanced when combined with organic fertilizer such as cow dung at a rate of 100g NPK + 10g cow dung. But, fertilizer should only be applied two weeks after transplanting. However, manure are not easily sourced and can be costly (Moyin-Jesu, 2008a; Fagbenro et al. (2013).

CONCLUSION

Potted *J. curcas* seedlings need about 5 to 10g of NPK 15:15:15 at per seedling for good growth response. At the nursery stage, Indonesia and India *J. curcas* variety has good early growth compared to Sabah and Thailand variety. Testing in the field under Malaysian condition in needed to validate the performance of these varieties. Previous study supports the importance of NPK fertilizer application during nursery stage to buffer the seedlings against environmental stresses to growth under field condition. NPK fertilizer application also improves the chances of survival and ensure good growth and productivity. Future study could explore the combination on NPK with available organic fertilizer or biochar to utilize agriculture waste.

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REFERENCES

Bionas. (2017). http://www.bionas.com.my/ accessed on 2/6/2017.

Bosswell, M. J. (2003). Plant Oils: Wealth, health, energy and environment. In *Proc. International conference of Renewable Energy Technology for rural Development*, Kathmandu, Nepal, Oct 12-14, 2003.

Dorado, M. P, Cruz, F., Palomar, J. M., Lopez, F. J. 2006. An approach to the economics of two vegetable oil-based biofuels in Spain. *Renew Energy* 31, 1231–7.

Chhetri, A. B., Islam, P., Mann, H. (2007). Zero-waste multiple uses of jatropha and dandelion**.** *J. Nat. Sci. and Sust. Tech.* 1, 75-99.

Chhetri, A. B., Martin, S. T., Budge, S. M., Watts, K. C. and Islam, M. R. (2008). Non-Edible Plant Oils as New Sources for Biodiesel Production International. *Journal of Molecular Sciences* 9, 169-180.

Commodity Basis, (2014); http://www.commoditybasis.com), Accessed on 4th May 2017.

Fagbenro, J. A., Oshunsanya S. O., and Onawumi, O. A. (2013). Effect of saw dust biochar and NPK 15:15:15 inorganic fertilizer on *Moringa oleifera* seedlings grown in an oxisol. *Agrosearch* 13, 1, 57 – 68

Foidl, N., Foidl, G., Sanchez, M., Mittelbach M, Hackel, S. 1996. Jatropha curcas L. as a source for the production of biofuel in Nicaragua. *Bioresource Technology* 1996, 58, 77–82.

Gui, M. M., Lee, K. T., and Bhatia, S. (2008). Feasibility of edible oil vs. waste edible oil as biodiesel feedstock. *Energy* 33, 1646–53.

Gubitz, G. M., Mittelbach, M., Trabi, M. (1999). Exploitation of the tropical oil seed plant. *Jatropha curcas L. Bioresource Technology* 67, 73-82.

Haas, M. J., McAloon, A. J., Yee, W. C., Foglia, T. A. (2006). A process model to estimate biodiesel production costs. *Bioresource Technology* 97, 671–8.

Ige, P.O., B. Oyeleye, & B.M. Awosusi. (2011). Seedling growth of *Jatropha curcas* L. at various levels of fertilizers in Nigeria. *Journal of Forest Science and Technology* 7, 2, 82-86.

Mansor, P. and Sivapragasam, A. (2008). *Jatropha curcas*: economical and technical perspectives as a smallholder crop in Malaysia. Malaysian Agricultural Research and Development Institute (MARDI). http://www.jatropha.pro/PDF%20bestanden/MARDI.pdf. Accessed on 12/1/2017.

Mofijur, M., Masjuki, H. H., Kalam, M. A., Hazrat, M. A.., Liaquat, A. M., Shahabuddin, M., Varman, M. (2012). Prospects of biodiesel from Jatropha in Malaysia. *Renewable and Sustainable Energy Reviews* 16, 2012, 5007–5020.

Mohapatra, S. and Panda, P. K. (2011). Effects of fertilizer application on growth and yield of *Jatropha curcas* L. in an aeric tropaquept of Eastern India. *Notulae Scientia Biologicae* 3, 1, 95-100.

Mohibbe, A. M, Waris Amtul, Nahar, N. M. (2005). Prospects and potential of fatty acid methyl esters of some non-traditional seed oils for use as biodiesel in India. *Biomass Bioenergy* 29, 293–302.

Malaysian Automotive Association. (2009). Vehicle sales summary. http://www.maa.org.my/ accessed on 2/6/2017.

Moyin-Jesu, E. I. (2008). Comparative evaluation of different organic fertilizers on the soil fertility, leaf minerals composition and growth performance of dikanut seedlings (*Irvingia gabonnesis* L.). *Emir. J. Food Agric*. 20, 2, 01-09.

Mukunda, H. S. (1999). *A biomass option for enhancing energy security*. IISc. Bangalore: National Institute of Advanced Studied, p. 36.

Ngwu, O. E. (2016). Effects of organic and inorganic fertilizers on the growth and yield of physic nut (*Jatropha curcas*). *International Journal of Advances in Agricultural and Environmental Engg*. 3, 1, 131-135.

Omar, M.R., S. Magnitskiy, and M.C. Henao. (2014). Effect of nitrogen and potassium fertilization on the production and quality of oil in *Jatropha curcas* L. under the dry and warm climate conditions of Colombia. *Agronomía Colombiana* 32, 2, 255-265.

Ofari-Boateng, C. and Lee, K. T. (2011). Feasibility of Jatropha oil for biodiesel: economic analysis. *Bioenergy Technology World Renewable Energy Congress* 2011-Sweden. 8-13 May 2011, Sweden:.Linköping.

Pant, K.S., Kumar, D., and Gairola, S. (2006). Seed oil content variation in *Jatropha curcas* L. in different altitudinal ranges and site conditions in H.P. *India. Lyonia* 11, 31-34.

Pramanik, K. (2003). Properties and use of *Jatropha curcas* oil and diesel fuel blends in compression ignition engine. Renewable Energy 28, 2, 239–48.

Pradeep, V. and Sharma, R. P. (2007). Use of hot EGR for NOx control in a compression ignition engine fuelled with bio-diesel from Jatropha oil. *Renew Energy* 32, 1136–54.

Raymond, H. (2010). *Biofuel annual report, Malaysia*. Kuala Lumpur: USDA Foreign Agricultural Services.

Ros, C., White, P. F. and Bell, R. W. (2015). Nursery Fertilizer Application Increases Rice Growth and Yield in Rainfed Lowlands with or without Post-Transplanting Crop Stress. American *Journal of Plant Sciences* 6, 2878-2892.

Sheehan, J., Camobreco, V., Duffield, J., Graboski, M., Shapouri, H. (1998). *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus,* Report, Midwest Research Institute, pp. 98 – 107.

Singh, S. P. and Dipti Singh. (2010). Biodiesel production through the use of difference sources and characterization of oils and their esters as the substitute of diesel: A review. *Renewable and Sustainable Energy Review* 14, 200-216.

Yusuf, N. N. A. N., Kamarudin S. K., and Yaakub, Z. 2011. Overview on the current trends in biodiesel production. Energy conversion and Management 52, 2741-2751.

Zulkefly Sulaiman, Khairul Ashraf Adrutdin, Badrul Ezam Badaruddin, Mohd Fauzi Mohd Yusoff and Nor Hassifi Suib. (2013). Research and Development on JATROPHA (*Jatropha curcas*). Malaysian Rubber Board Malaysia-Indonesia Scientific Meeting on Jatropha Royeal Chulan, Kuala Lumpur, 6 February 2013.