International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume:03, Issue:02 "March-April 2017"

EFFECTS OF DIFFERENT RATES OF JATROPHA CURCAS SEEDCAKE WASTE ON GROWTH AND VEGETATIVE TRAITS OF OIL PALM (Elaeis guineensis)

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ABSTRACT

The cost of fertilizer for oil palm planting increases yearly as most soils used in the plantation especially in tropics heavily depend on chemical fertilizer which equally contributes to environmental degradation. A study was carried out to evaluate the effect and suitable rate of J. curcas seed cake waste on growth and vegetative traits of oil palm seedlings as an alternative or substitute to chemical fertilizer. A factorial experiment was carried out using randomized complete blocks design with three replicates. Treatments included ground J. curcas seed cake applied to the seedlings at different rates of 10, 15, 20, 25 and 30 g per plant. Fertilizer, N.P.K Blue 20 g/plant was used as control evaluation. Application of 25 g/plant profoundly performed as the conventional fertilizer N.P.K (control) noticeable in plant growth traits like girth increment. The chlorophyll content in the leaves increased with increasing rate of Jatropha seedcake, but control treatment indicated highest chlorophyll content. There was no significant difference in total dry weight among the treatments, though J. curcas seed cake wastes at 20g, 25g, and 30g showed an increasing total dry weight. Treatment 25 g/plant of J. curcas seed cake gave the highest root: shoot ratio. Results suggest that foliar nutrient from J. curcas was suitable for oil palm seedlings based on nutrient requirements for oil palm seedlings that would achieve high growth vigor and biomass yield.

Keywords: Jatropha curcas seed cake, oil palm, Elaeis guineensis, vegetative traits, fertilizer

ISSN: 2455-6939

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1. INTRODUCTION

Oil palm industry remains the key socio-economic driver of many oil palm producing countries as it eradicates poverty and provides direct employment to more than 610,000 people, including over 177,000 smallholders in countries like Malaysia and Indonesia. However, competition among the main oil palm producers like Malaysia, Indonesia, and Thailand has placed the industries downstream under strain and this has led to a reduction in the price of palm oil. Malaysia is undertaking necessary approach to position itself among the competitors by targeting a total Gross National Income (GNI) from the industry of RM125 billion in the year 2012 to RM178 billion by the year 2020 (Ng et al., 2012). Consequently, palm oil has been recognized among the Eight Entry Point Projects (EPPs) in the national key economic area (NKEA). One of the EPPs is to accelerate the replanting and new planting of oil palm.

This EPP aims to speed up the ongoing replanting efforts by plantation companies and smallholders, replacing approximately 449, 415 ha of low-yield and old trees with new, high-yielding seedlings. This is due to huge demand in oil palm seedlings to implement the new planting and replanting program. The high total production cost on fertilizer management for establishing the new seedlings is a factor on research development. Thus, the use of waste materials from plant residues as organic fertilizer could have a potential effect on oil palm seedlings. Interest in Jatropha curcas for oil production had led to the production of 3 tonnes of waste material produced in the form of seedcake from the plant (Kavalek et al., 2013). Application of this waste material could potentially serve as alternative fertilizer and soil amendment for enhancement of oil palm seedlings performance. Moreover, there are inadequate nutrients in some of the soils used in oil palm plantation. This has been attributed to the ability of the soil to retain water and nutrients due to high clay content (Salisu et al., 2013).

Use of Jatropha curcas seed cake as the substrate has been proven as suitable growing medium for plant growth like protease production (Thanapimmetha 2012). Interestingly, the use of substrate like the soilless eliminate all biological effect and optimum growth and biomass is achieved Salisu et al., (2016). In addition, Ghosh et al., (2007) reported an increased growth and production of Jatropha curcas above 100% due to the right application of Jatropha seedcake as an organic fertilizer. Jatropha seed cake has also been used as organic nourishment for planting and production of vegetable crops (Srinophakun et al., 2012). Jatropha seedcake is formed from 70 to 75 percent of the Jatropha seed and left as waste during the oil extraction process. Once the oil is extracted, about 50 percent of the original seed weight remains mainly in the form of protein and carbohydrates (Singh et al., 2008). It is an excellent organic fertilizer with high nitrogen content similar to or better than chicken manure, making a valuable contribution to micronutrient requirements (Bhattacharjee, 2012) as shown in (Table 1 and 2).

Table 1: Nutrient concentration in Jatropha seedcake and other organic materials

Nutrient content (%)	J. curcas seed cake	Neem oil cake	Cow manure
Nitrogen %	3.2-4.44	5.0	0.97
Phosphorus %	1.4-2.09	1.0	0.69
Potassium %	1.21-1.68	1.5	1.66

Source: Bhattacharjee (2012)

Table 2: Nutrient concentration in Jatropha seedcake waste

N %	P %	K %	Ca %	Mg %	Sources
4.4 –6.5	2.1 – 3.0	0.9 – 1.7	0.6 – 0.7	1.3 – 1.4	Achten et al. (2008)
3.0 – 4.5	0.65 – 1.2	0.8 – 1.4	-	-	Ghosh et al. (2007)
4.91	0.9	1.75	0.31	0.68	Wani et al. (2006)

Currently, there is no research work and there is a lack of literature on the effectiveness of Jatropha seedcake waste on the growth of oil palm seedlings. Therefore, the objective of this study was to evaluate the potential effect and most suitable rate of Jatropha seedcake waste on the growth of oil palm seedlings in a nursery.

2. MATERIALS AND METHODS

2.1 Experiential design and treatments

This study was carried out in the research farm of the Universiti Putra Malaysia, under shelter house. Three-month-old oil palm seedlings were transplanted into black polyethene bags containing Munchong series classified as Oxisol soil (USDA soil taxonomy: Typic Hapludox; FAO/UNESCO Legend: Haplic Ferralsol). It is a clayey soil containing a yellowish brown to strong brown color (Van et al., 1996; Paramananthan, 2000). Golden Hope 500 series (D x P oil palm seeds) from Sime Darby Seeds and Agricultural Services Sdn. Bhd supplied oil palm seedlings used in this study. There were six treatments with three replicates and arranged in Randomized Complete Block Design (RCBD).

One month after transplanting, Jatropha seedcake waste was applied as treatments. The different rates coded as (T1 control, T2 10g, T3 15g, T4 20g, T5 25g and T6 30g) of the Jatropha seedcake waste were suggested by Gillbanks (2003). Compound fertilizer of N.P.K Blue with

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formulation ratio ($12N:12P_2O_5:17K_2O:2MgO$) at 20 g/seedling was applied as a control treatment. Seedcake waste and the fertilizer (control) application were carried out at four weeks interval with different rates. The study duration was three months, and data were recorded at the end of the study. Weeding and irrigation were carried out manually as at when due. Plant height was measured with a standard measuring tape. Stem diameter of the plants was measured with digital Veneer caliper. This was measured 10 cm from the surface of the soil respectively. Actual chlorophyll content was extracted, analyzed and determined using the described and published equation by Commbs et al., (1987).

Chlorophyll A = (13.19 × 664) – (2.57 × 647)
Chlorophyll B = (22.1 × 647) – (5.26 × 664)
Total chlorophyll = (A + B)

$$\text{Actual total chlorophyll} = 3.5 \times \frac{\text{total chlorophyll}}{\text{Amount of disk of the leaf}} \quad (7)$$

For total dry matter (DM), plant tissues were oven-dried at 50°C for 48 – 72 hours and weighed (g) to a constant weight of 0.01 g using a weighing scale. Root/shoot ratio was also determined using the following equation (Wilson, 1988).

$$RSR = \left(\frac{Total\ root\ dry\ weight\ (g)}{Total\ shoot\ dry\ weight\ (g)}\right)$$

2.2 Foliar nutrient analysis

The foliar analysis was carried out according to the rubber industry foliar sampling techniques which specify four basal leaves from the first sub-terminal whorl for the leaf samplings (Noordin, 2012). The leaves were oven-dried at 50°C for 48 – 72 hours. A 0.25 g of the weighed ground dried sample was put into digestion tube. Then 5 ml concentrated sulphuric acid (H_2SO_4) was added, shaken and left for about 2 hours to adsorb moisture. Thereafter, the mixture digestion tubes were placed in the digestion block in a fume chamber at the temperature 450°C in the Fume Chamber for approximately 45 minutes. The digestion tubes were removed and allowed to cool, after which, 2 ml of hydrogen peroxide (H_2O_2) were added and the heating process was repeated in the Fume Chamber. After the stipulated heating period (precise duration), the sample in the tube became colorless. The solution was left to cool and later diluted with distilled water to make up 100 ml. The samples were analyzed for N, P, and K using Auto Analyzer (precise the model of the apparatus), while Mg was analyzed with Atomic Absorption Spectrophotometer (Perkin-Elmer, Model AAS 3110). All the data were subjected to analysis of

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variance (ANOVA) using statistical analysis system (SAS Ver 9.4). The mean separations were compared using Tukey's Studentized Range (HSD) at 5% level.

3. RESULTS AND DISCUSSION

3.1 Effect of different rates of Jatropha seedcake on growth characteristics of oil palm seedlings

In the first month of planting, there was a significant difference among different rates of Jatropha curcas seed cake waste used. Girth size of plants grown with J. curcas rate 25g was significantly different $p \leq 0.05$ from plants grown with rate 10g and 20g as shown in Table 3. There was no significant difference between plants grown with J. curcas seed cake waste rate 25g and plants grown with the other rates of J. curcas applied. However, the values recorded in plants grown with 25g and 30g rates of J. curcas seed cake waste were significantly greater and comparable to the value recorded in plants grown with 20g of N.P.K blue. Noticeably there was no significant difference between plants grown with the N.P.K blue fertilizer and plants grown with different rates of J. curcas seed cake waste.

Table 3. Effects of different rates of J. curcas on growth characteristics of oil palm seedlings

Treatment	Girth increment (cm)			Height increment (cm)		
	1st month	2nd month	3rd month	1st month	2nd month	3rd month
T1(control)	3.17 ab	2.50 a	1.92 a	4.93 ab	5.67 a	5.77 a
T2 (10 g)	2.13 b	2.25 a	1.92 a	3.32 b	3.67 c	3.71 b
T3 (15 g)	2.42 ab	2.33 a	1.97 a	4.50 ab	4.31 bc	4.09 b
T4 (20 g)	2.13 b	2.38 a	2.15 a	4.84 ab	5.45 ab	4.59 ab
T5 (25 g)	3.59 a	2.13 a	2.42 a	5.79 a	5.74 a	5.50 a
T6 (30 g)	3.21 ab	1.88 a	2.46 a	5.66 a	5.45 ab	5.54 a
Mean	2.77	2.24	2.13	4.84	5.05	4.87
CV %	22.57	28.65	24.12	15.54	10.83	11.06
H.S.D. 0.05	1.44	1.48	1.18	1.73	1.26	1.24

Means followed by the same letter within a column are not significantly different at $p \leq 0.05$ by HSD.

Furthermore, there were no significant differences between rates of J. curcas seed cake waste and N.P.K blue fertilizer in the second and third months of applications. Nevertheless, there were considerable significant differences in height increment between low and the higher rates of Jatropha seedcake treatments. Over a period of the three months of planting, oil palm seedlings which received higher rates of Jatropha seedcake (25g and 30g) were significantly taller than in low rate (10g). The seedlings treated with a low rate of Jatropha seedcake seem to have retarded development and the pinnae tend to be short and rather broad.

Thus, these abnormal leaves' vigor resulted in less height increment. Application of Jatropha seedcake at higher rates resulted in continuous increment on girth and height of oil palm seedlings in the nursery and comparably performed similarly to the control (conventional N.P.K fertilizer) especially when High rates of Jatropha seedcake were applied. This indicated that application of Jatropha seedcake could have been better and environmentally safe due to its organic nature. However, Jeppsson (2000) reported that higher application of fertilizer significantly increased plant growth.

Furthermore, Selanon Saetae and Suntornsuk (2014) found out that application of J. curcas seed cake waste significantly stimulates plant growth which could be noticed in plant stem diameter due to the presence of protein hydrolysate. As a result, J. curcas could serve as natural plant growth stimulant.

The application of treatment with 25 g of Jatropha seedcake (T5) was sufficient for the optimal growth of oil palm seedlings as higher rate, while 30 g of Jatropha seedcake (T6) indicated similar plant growth. From the results, 25 g of Jatropha seedcake (T5) was the best rate to be applied for oil palm seedlings, while the lower rate (T2, T3 and T4 with 10 g, 15 g and 20 g respectively) showed lower increment in plant height.

In addition, some studies had been conducted by using *Jatropha* seedcake on other crops, and it had been proved that *Jatropha* seedcake can be used as a substitute for chemical fertilizers instead of being considered as waste. The study conducted by Myint et al. (2009) on soybean using different organic amendments and chemical fertilizer, revealed that *Jatropha* extract produced significantly taller plants compared to the plants treated with other organic amendments.

3.2 Effect of different *Jatropha* seedcake rates on leaf chlorophyll content

The influence of N.P.K blue as a control fertilizer and different rates of *Jatropha* seedcake on the chlorophyll content of the seedlings leaves are shown in Table 4. In the first month after application, significant differences were observed among the treatments in terms of chlorophyll content. Higher chlorophyll content (52.55) was recorded when N.P.K blue was applied and significantly different from the low rate (10 g) of *J. curcas* seed cake waste (37.93).

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Table 4. Chlorophyll content of oil palm seedlings grown with different rates of *Jatropha* seedcake

Treatment	Chlorophyll content		
	1st month	2nd month	3rd month
T1 - control	52.55 a	60.46 a	64.68 a
T2 (10 g)	37.93 b	51.46 a	53.64 b
T3 (15 g)	42.99 ab	56.91 a	56.64 ab
T4 (20 g)	46.22 ab	58.96 a	61.33 ab
T5 (25 g)	46.83 ab	57.89 a	62.63 ab
T6 (30 g)	47.2 ab	56.29 a	59.76 ab
Mean	45.60	57.00	59.70
CV %	11.49	7.87	7.00
H.S.D. 0.05	12.04	10.30	9.58

Means followed by the same letter within a column are not significantly different at $p \leq 0.05$ by HSD.

There were no significant differences between N.P.K blue fertilizer and other rates of *J. curcas* seed cake waste. In the third month, the treatments (T2) had the lowest mean of chlorophyll content (37.93). Noticeably, there were no significant differences among the plants grown with different rates (T3, T4, T5, and T6) of J. curcas seed cake waste and (T1) N.P.K blue fertilizer. This showed that J. curcas seed cake waste (organic) at the optimum of higher rate could increase plants chlorophyll content like N.P.K fertilizer does. As such, chlorophyll content is essential and could serve as an indicator of photosynthesis activity. Consequently, optimum rate of fertilizer increases chlorophyll content in plant leaves, thus providing the available nutrient for the photosynthesis process.

In this study, the chlorophyll content in the plant leaves at each month indicated that when applied to the plants, treatment (T1) N.P.K blue fertilizer yielded highest mean values compared to plants treated with different rates of Jatropha seedcake. This could have been due to the fact that nitrogen and magnesium are constituents of chlorophyll molecule which could have resulted from high percentage (12%) of nitrogen (N) in N.P.K blue compared to Jatropha seedcake which contains only 4 - 6% of N. This finding was in line with results obtained from the studies conducted by Posada et al. (2012) which stated that net photosynthesis rate was highest in plants that were maintained at the highest nutrient level. The high photosynthesis rates were possibly due to greater chlorophyll contents.

3.3 Effect of different rates of Jatropha seedcake on the nutrient content of oil palm seedlings

Nitrogen concentration in plant leaf

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Optimum nutrient requirements of oil palm seedlings were given by Von Uexkull and Fairhurst, (1991), as 2.6 – 3.0%, 0.16 – 0.25% and 1.10 – 1.80% for N, P and K respectively. Foliar nutrients analysis showed nitrogen concentration over a period of three months after planting and was in conformity with the optimum requirements. Different rates of Jatropha seedcake on the nitrogen content varied greatly among the treatments (Figure 1). Plants grown in N.P.K blue (control) had the highest mean value of nitrogen content (1.9%) and were significantly different $p<0.05$ from plants grown at a higher rate (25 g) of J. curcas which recorded the lowest value (1.47%). However, there were no significant differences between the conventional fertilizer N.P. K blue applied and the other rates of J. curcas.

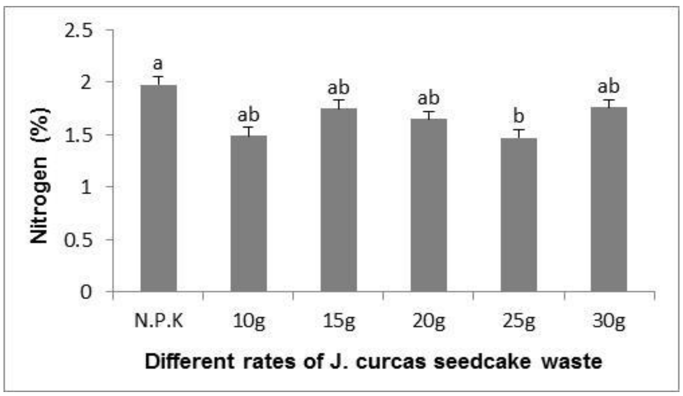

Figure 1. Effect of different rates of Jatropha seedcake on the nitrogen content (%) in above-ground part of oil palm seedlings at third month after treatments

Means with the same letter are not significantly different by Tukey's Studentized Range (HSD) at $p\leq 0.05$ (Critical value = 0.4902)

3.4 Phosphorus concentration in plant leaf

The result obtained for phosphorus content showed there was no significant difference among plants grown in all the treatments including N.P.K blue (Figure 2). This could have been due to immobility of the P and adsorption by soil particles. This was noticed in the data obtained as available P amount was generally low. However, the value recorded from this experiment was suitable for oil palm seedlings (Von Uexkull and Fairhurst, 1991). It has been reported that cultivation of J. curcas with other plants stimulates plant growth as it contributes to soil quality because it contains nitrogen and phosphorus (Ogunwole et al., 2008).

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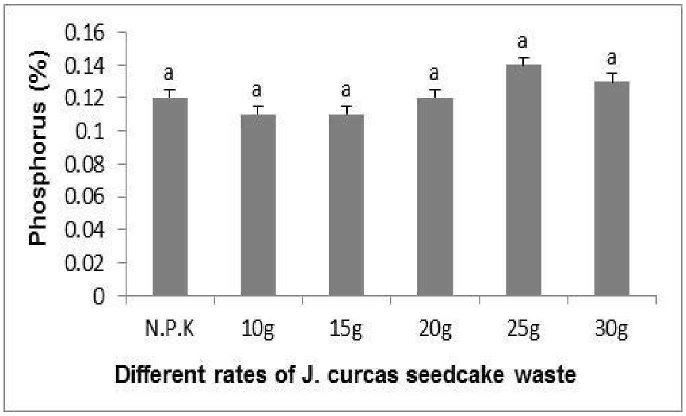

Figure 2. Effect of different rates of Jatropha seedcake on the phosphorus content (%) in above-ground part of oil palm seedlings at third month after treatments

Means with the same letter are not significantly different by Tukey's Studentized Range (HSD) at $p \leq 0.05$ (Critical value = 0.0436)

3.5 Potassium concentration in plant leaf

The results with similar K content indicated that there was no significant difference among plants grown in all the treatments including N.P.K blue (Figure 3). This showed that J. curcas seed cake waste could supply the same amount of K as N.P.K blue fertilizer especially when higher rates like 25 g or 30 g are applied. Consequently, J. curcas seed cake could serve as a potential alternative to inorganic fertilizer. However, the value recorded due to the application of J. curcas and N.P.K blue was suitable for oil palm seedlings. The consistency of nitrogen, phosphorus, and potassium in the plant tissues among the treatments indicated that Jatropha seedcake was effective in promoting growth and increasing the nutrient availability for plants.

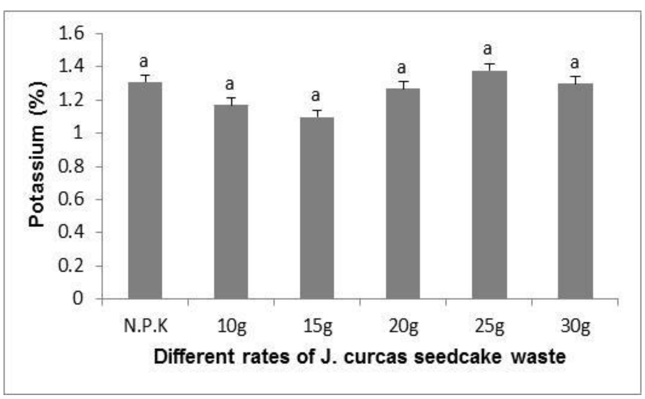

Figure 3. Effect of different rates of Jatropha seedcake on the potassium content (%) in above part of oil palm seedlings at third month after treatments

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Means with the same letter are not significantly different by Tukey's Studentized Range (HSD) at $p \leq 0.05$ (Critical value = 0.3539)

3.6 Effect of different rates of *Jatropha* seedcake on total dry biomass of oil palm seedlings

Total biomass production increased irrespective of the rate of *Jatropha* seedcake being applied (Figure 4). The increased total plant dry weight was mainly due to the increased mass of the above and below ground plant parts. Application of *Jatropha* seedcake produced no difference in total biomass compared to the control treatment (N.P.K). The result indicated proven effects of *Jatropha* seedcake as potential alternative fertilizer for oil palm seedlings. Six tonnes of *Jatropha* cake had shown substantially greater dry weight (3086.67 and 3055.00 kg ha^{-1}) compared to other organic amendments (Myint et al., 2009). In addition, Tasosa et al. (2001) reported from the studies conducted on tomatoes, where higher amount of *Jatropha* seedcake and castor cake significantly increased growth rate and shoot dry matter.

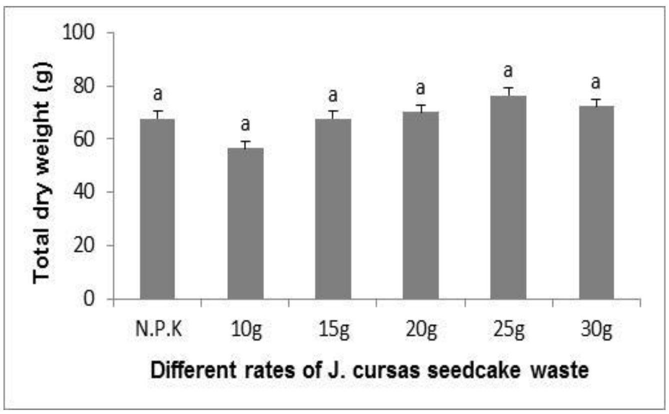

Figure 4. Effect of different rates of *Jatropha* seedcake on total dry weight of oil palm seedlings at third month after treatment

Means with the same letter are not significantly different by Tukey's Studentized Range (HSD) at $p \leq 0.05$ (Critical value = 30.648)

3.7 Effect of different rates of *Jatropha* seedcake on the root/shoot ratio of oil palm seedlings

Different rates of Jatropha curcas seed cake waste remarkably affected root/shoot ratio after the third month of application (Figure 5). There was a significant difference ($p \leq 0.05$) between plants grown with *J. curcas* (10g) 2.0 and the rate (25g) 2.72. However, there were no significant differences among plants grown in N.P.K (control) and different rates of J. curcas.

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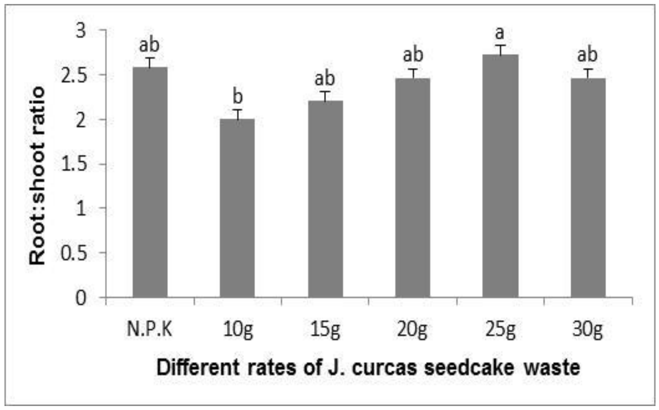

Figure 5. Effect of different rates of Jatropha seedcake on root: shoot ratio of oil palm seedlings at the third month after treatments

Means with the same letter are not significantly different by Tukey's Studentized Range (HSD) at $p \leq 0.05$ (Critical value = 0.709)

CONCLUSION

Higher rates of *Jatropha* seedcake appeared to have similar performance as that of conventional fertilizer NPK blue used for oil palm seedlings. Application of high rates of *Jatropha* seedcake demonstrated good performance for various seedling growth traits and biomass yield such as girth, height increments, and root: shoot ratio. The experiment revealed the suitability of seedcake waste at different rates whereby 25 g/plant (T5) could be considered suitable for oil palm seedling growth. Though higher rate (30 g) could be used but the former was sufficient as there was no significant difference in growth of oil palm seedlings grown with both rates. Utilization of *Jatropha* seedcake, instead of becoming a waste after oil extraction could potentially serve as agricultural byproduct and natural plant growth stimulant. The cost incurred on fertilizer could drastically reduce if a little amount of chemical fertilizer is applied with the addition of *Jatropha* seedcake as an alternative to NPK fertilizer. Therefore, application of *Jatropha* seedcake as alternative fertilizer in oil palm nursery at seedling stage could be explored by farmers. This is due to its potential effect as shown in this study. It has profoundly increased plant nutrient level which could produce vigorous and healthy seedlings and equally reduce environmental pollution due to its organic nature.

ACKNOWLEDGEMENT

The authors would like to thank University Putra Malaysia for the grant in supporting the research study. We equally thank the staff of the research field 2 of the university where *Jatropha* seeds were collected and analytical laboratory of the department of crop science for their support throughout the experiment.

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