Preliminary Effects of Pruning on Oil Yield Production of Six *Jatropha Curcas L.* Accessions

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Abstract

A preliminary evaluation of pruning treatment effects on oil yield production of six *Jatropha curcas L. accessions* was conducted. The objectives of this research were, to study the effects of pruning on number of seeds, to identify the effects of pruning on oil yield production and to determine the best accessions among six *Jatropha curcas L. accessions* for breeding program. Pruning treatment was carried out on one year old plants of six *Jatropha curcas L. accessions* collected from various locations in Peninsular Malaysia. For this experiment, a split-plot design with three replications was used, where the main plot was pruning and non-pruning treatment and the sub-plot was accessions. Findings from this study revealed no effects of pruning as compared to non-pruning tree in all the growth and yield character. Observation was made for seven months after pruning. The ANOVA results showed that variation among accessions was not consistent in individual recording month for number for growth and yields and yield component character. Accession 1, (V1) and accession 5 (V5) is the best performer after pruning on numbers of seeds, oil to seed ratio and oil yield. Thus, it was potential accession for the selection in future breeding program.

Key words: Jatropha curcas, Pruning, Accessions

1. Introduction

Jatropha curcas L (*Jatropha*) or known as '*Jarak Pagar'* in Malaysia is one the neglected crop that has been discovered as a new future energy source which is ecological-friendly, renewable and cost-effectively . Among the different types of energy sources, bio-energy source from plants plays a vital role as the end of fossil fuel age has already begun. The liquid bio-energy production from plants (vegetable oil) is considered very promising because of its renewable nature and is proposed as one of the possible options to reduce greenhouse gas emissions. Plants yielding oil are considered suitable for production of bio-fuel particularly biodiesel.

Oil palm is the biggest plantation in Malaysia and palm oil has been one of the nation's source income. However, the use of biodiesel from the edible oil has coped with many objections because of the possibility of the oil prices to be increased when affected by the increase of food price. This crisis can be overcomed by using non-edible oil. Based on this background, biodiesel production from *Jatropha curcas L.* is potentially to be commercialized and become a booming business. *Jatropha* also is an easy adaptable species, as compared to oil palm, *Jatropha* can be cultivated on marginal or degraded land. The *Jatropha* oil has been identified as an efficient substitute to be used as fuel for diesel engines. The engine performance and fuel consumption with *Jatropha curcas* oil has been compared favorably with normal diesel oil (Ginwal, 2004).

Several studies were performed on *Jatropha* in terms of fertilization, crop management, engineering, biomass and other related field with the aim to attain a maximum and high yielding *Jatropha.* According to Henning (2007), an early and a good ramification is important for the high yield of *Jatropha* because its inflorescences are only developed terminally, at the end of branches. Hence, a plant with more branches can produce lots of fruits. Pruning is one of practices that can be used in order to stimulate branching (Gustaaf, 1977). Proper pruning practices of *Jatropha* helps in producing more branches with healthy inflorescences. The pruning of apical buds of the main stem (top-pruning) of one- year-old plants can increase the number of main and secondary branches (Kureel, 2006). This enhances flowering and fruit set that ultimately increases yield (Gour, 2006). As a consequence, pruning should be a standard practice in *Jatropha* plantations.

1.1 Problem Statement

Pruning practices have been applied in cultivation of *Jatropha.* However, there is a lacking of scientific evidence to show the effectiveness of top pruning on the performance of *Jatropha.*

1.2 Objectives

An evaluation research on six *Jatropha curcas L.* after top pruning was undertaken with the following objectives:

1.2.1 To study the effects of pruning on a number of seeds among six *Jatropha curcas L. accessions.*

1.2.2 To identify the effects of pruning on oil yield production among six *Jatropha curcas L. accessions.*

1.2.3 To determine the best accessions among six *Jatropha curcas L. accessions* for breeding program

2. Literature Review

2.1 Taxonomy, Origin, Distribution and Ecological

The physic nut or purging nut, is botanically known as *Jatropha curcas Linn* (Jatropha). It also known by nearly 200 different names, indicating its occurrence in various countries. In Malaysia, it is known as '*Jarak Pagar*'. The genus name *Jatropha* is derived from Greek word, *'jatros'* means 'Doctor' and '*trophe*' means 'Nutrition'. *Curcas* is the common name of *Jatropha* in Malabar, India (Correll, 1982). Linnaues (1953) was the first to name the physic nut *Jatropha curcas L.* according to binomial nomenclature of "Species Plantarum" and this is still valid today. The genus *Jatropha* belongs to *Joannesieae of Crotonoideae* tribe in the *Euphorbiaceae* family and it contains approximately 170 known species (Heller, 1996).

The centre of origin of physic nut is still uncertain but it is believed that *Jatropha curcas L.,* is native to Mexico and Central America and now it is found abundantly in many tropical and subtropical regions throughout Africa and Asia. From the Carribean, *Jatropha* was distributed by Portuguese seafarer via the Cape Verder Islands and former Portuguese Guinea to other countries in Africa and Asia (Heller, 1996).

Jatropha is a unique plant as it is best adapted to arid and semi-arid conditions. It grows almost everywhere even on gravely, sandy, acidic and alkaline soils except waterlogged lands (Kumar and Sharma, 2008). Thus, *Jatropha* should never be planted on soil with risk of evenephermal water logging such as Vertisol or other heavy clay soils (Achten*et al.*, 2008). *Jatropha* is not sensitive to day length. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient (Heller, 2006).

Regarding climates, *Jatropha* can tolerate extremes of temperature and will grow under a wide range of rainfall regimes from 250 to over 1200 mm per annum. *Jatropha* is a succulent plant and will shed its leaves when it is in low rainfall areas and in prolonged rainless period. It's shedding most of its leaves as a counter to drought and to reduce transpiration loss. The leaves shed will form mulch around the base of the plant and this organic matter enhances the activity of the earthworm in the soil thus will improve soil fertility (Katwal and Soni, 2003). *Jatropha* is a highly adaptable species, but its strength as a crop comes from its ability to grow on poor, dry sites (Heller, 2006).

2.1.1 Morphological Characteristics

The physic nut is a dicotyledonous and deciduous plant type. It is a small tree or large shrub which can reach a height of three to five meters, but under underfavorable conditions it can attain a height up to 8 or 10m tall and with diameter up to 20cm (Kumar and Sharma, 2008). The plant is a monoecious and protandrous plant. The life expectancy of physic nut is up to 50 years (Heller, 1996). The type of physic nut seedlings obtained through seeds or cuttings shows a different root formation. Normally, five roots are developed from seedlings, one central which is a deep taproot and four peripheral roots which are shallow lateral roots (Heller, 1996). The seedlings from cuttings will develop a root system without a tap root. A tap root is not usually formed by vegetative propagated plants (Kobilke, 1989).

2.1.2 Uses of *Jatropha* Products

Jatropha also known as multipurpose shrub, since it has many uses from the bark to the leaves. *Jatropha* is an excellent hedging plant generally grown in most part of Malaysia and usually used as a fence for protection of agriculture fields against damage by livestock as it is unpalatable to cattle and goats. Thus, *Jatropha* has served as a cost-effective fence and more environmental friendly compared to the wire fence. (Kumar & Sharma, 2008).

The seed cake of *Jatropha* is a by-product of oil extraction, and have a potential as a fertilizer or biogas production (Gubitz*et al.,* 1999). It also can be used as fuel for steam turbines to generate electricity if available in large quantities (Makkar et al.*,* 1998). Seed cake is also rich in nitrogen, thus, it can be an excellent source of plant nutrients. The application of 10 tonnes of fresh physic nut biomass resulted in increased yield of many crops (Sherchan et al., 1989). This seed cake can be straight fertilizer for nitrogen.

All parts of *Jatropha* (seed, leaves and bark) have been used in traditional medicine and for veterinary purposes for a long time (Kumar & Sharma, 2008). The seed oil can be applied to treat eczema and skin diseases and to soothe rheumatic pain (Heller, 1996). Furthermore, the plant sap and extract also can be used to treat dermaomucosal diseases, allergies, wounds and cuts, inflammation, leprosy, leucoderma, scabies and small pox. The tender twig/stem traditionally used for tootache, gum inflammation, gum bleeding and pyorrhea.(Kaushik and Kumar, 2004). *Jatropha* contains some compound (Curcacyline A) with anti-tumor activities (Van de berg et al.*,* 1995). The latex of *Jatropha* has been found to be strong inhibitors to watermelon mosaic virus. The leaves and the latex are used in healing of wounds, refractory ulcers, and septic gums and as a styptic in cuts and bruises. An investigation of coagulant activity of latex showed whole latex significantly reduced the clotting time of human blood.

The most valuable product of *Jatropha* that will give high economic value is the oil which serves as energy sources and can be processed to be biodiesel. It can be used as fuel in diesel engines either directly or by blending it with methanol (Gubitz et al., 1999). This oil also has been used as diesel substitute during the World War 2. Engine testeds with *Jatropha* oil showed satisfactory engine performance.

The *Jatropha* seed contains viscous oil. *Jatropha* oil has various uses. It can be used to manufacture candle and soap, and also in cosmetics industry, as a paraffin substitute or extender (Foild and Kashyap, 1999). This oil produces a soft, durable soap and is a simple one, well adapted to household.

Other beneficial products from *Jatropha* are the oil and aqueous extract from oil have potential as an insecticide. These have been used in the control of insect pests of cotton including cotton bollworm and on pests of pulses, potato and corn (Kaushik & Kumar, 2004).

2.1.3 Pruning

Pruning refers to the methodical removal or cutting away unwanted plants parts, typically shoots, branches, fronds and flower from plants (Gilman and Black, 2005). Pruning involves removal of branches with minimum damage to cambium or the growing tissue so that the wound will heal properly in the shortest possible time with the least possibility of wound infection (Gustaaf, 1977).

Pruning is a vital practice in plant maintenance as it would affect the growth of the plant. Plant should be pruned regarding to the objectives; to improve the appearance or health of a plant, to control the size, to prevent personal or property damage, to train young plant, to influence flowering and fruiting and for rejuvenation (French and Appleton, 2001). Pruning also affects the physiological system of the plant. The physiological effect of pruning in rose plant (shrub) showed results that pruned plants have higher capacity for better promoting the photosynthetic light reaction than non-prunedplants. Pruning promoted a large number of metabolic sinks (flower removal) that may cause depletion of stored carbohydrate flowering from lower plant parts (arched shoots) due to their translocation to the new developing flower shoots plants (Angeles et al., 2007). After a prolonged growth period, the pruned plant can recover its reserves, partially or completely, and restore their floral production. The degree of plant recovery will depend on pruning height and period of time the plants are kept from flowering (Zieslin & Mor, 1981).

Pruning practices consists of five types and each one differs based on the techniques of cuttings. The five pruning types are pinching, heading back, thinning, topping (top-pruning) and renewal pruning. The techniques and timing of pruning are also different for each plant type. Based on that, one should know the plant type and study the technique of cuttings for plant that will be pruned.

3. MATERIALS AND METHOD

3.1 Plant Material

One year old of 6 *Jatropha curcas L. accessions* from various locations in Peninsular Malaysia growing at Field 10 were used in this study (Table 1). Trees averaged at 1-1.14m in height.

Table 1. The Six Accessions of *Jatropha curcas* and its Origin

Accessions	Origin
V1	Muar,, Johor
V2	Beseri, Perlis
V3	Kluang, Johor
V4	Marang, Terengganu
V5	Field 2,UPM,Selangor
V6	Lundang,Kelantan

3.2 Experimental Design

The experiment was a Split-Plot Design, with 3 replications consisting of two pruning factors in a fixed plot and six accessions (variety) of *Jatropha* treatments which were randomized in a plot. The pruning treatments were the top pruned plant and non-pruned plant. These treatments were used in three replications.

3.2.1 Top Pruning Method

Top Pruning was done after a week of fertilizer application, each of the plant was top pruned with secateurs and a 90 cm wood is used to measure the height of top pruned at 50 cm height (1.5 feet) from ground level. The top was cut off cleanly at a 45° angle across the branch by using secateurs. The cut surface should angle downward and away from horizontal to prevent water from ponding on the cut. Immediately, the cut surface was painted with wound dressing to protect it from rotting wood organisms and cracking upon drying.

3.3 Data Collection

Data were recorded for every month from April to August on individual plant which comprises o number of seeds production, oil to seed ratio and oil yield.

3.3.1 Numbers of Seeds

Seeds per tree that were separated from the husks were collected and counted for every recording month.

3.3.2 Oil to Seed Ratio

Thirty dried seeds from each sample were taken and grinded by using blender. Grinded seeds were filtered to get fine dust and the samples were packed in small filter paper. 5 g of fine dust and the sample were taken for oil extraction.

Oil was extracted using the Soxhlet Apparatus with hexane solvent. The process of oil extraction was operated for 24 hours to remove oil from the sample. After extraction, the sample was dried in oven for 48 hours at 40 ^{0}C. The drying process was performed to remove water and hexane solvent available in the sample.

The percentages of oil to seed ratio were calculated by using fthe ormula below:

$$\text{Oil to Seed Ratio (\%)} = \frac{\text{Sample weight before extraction} - \text{Sample weight after extraction}}{\text{Sample weight before extraction}} \times 100$$

3.3.3 Oil Yield

Oil yield per tree was calculated by using the formula below:

Oil yield (g/tree) = Oil to Seed Ratio (%) X Total Fresh Weight (g)

3.4 Statistical Analysis

Data from individual tree were used in the statistical analysis. Data were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS Program 9.1).

4. Results and Discussion

4.1 Number of Seeds

4.1.1 Analysis of Variance

The results from ANOVA (Table 2) shows a highly significant difference was observed among replication for number of seeds on August and among accessions in July. Interaction between pruning and accession item was highly significant in the months of April, May and June as well as total number of seeds. The pruning item was not significant for all the months and total seed number. The variation between replications could be due to the environmental effects and the accessions showed a significant interaction with pruning treatment in the first five months after pruning.

Table 2. Means Square for Monthly and Total Number of Seeds.

Source of Variation	df	April	May	June	July	August	TNOS
Replication	2	136.18 ns	7.34 ns	19.62 ns	1272.58 ns	18781 **	30882 *
Pruning(P)	2	432.09 ns	132.25 ns	0.17 ns	130.31 ns	8045.11 ns	17906 ns
Error (a)	2	83.86	471.61	59.77	404.86	24.74	624.98
Accession(A)	5	117.05 ns	285.75 ns	90.1 ns	707.14 **	10436 ns	19899 ns
P X A	5	160.26 **	478.55 **	221.18 **	30.28 ns	2480.72 ns	8303.43 **
Error (b)	250	42.71	91.3	30.31	136.5	1215.59	1640.62

Note: * Significantly different at $p \leq 0.05$, ** significantly different at $p \leq 0.01$, **ns**=No Significant Differences,**d.f**= Degree of freedom.**TNOS**= Total Number of Seeds

4.1.2 Means Comparisons among Accessions.

The highest number of seed production was recorded in V1 (50.4 seeds/tree) and followed by V5 (40.65) in August (Table 2). There was no number of seed produced for V4 (0.00) in July. Month of August showed the highest mean of seeds production whereas the lowest seeds production was in June. Nevertheless, number of seeds in July was significantly different among accessions as compared to other observation months. Most of the accessions started to increase seed production in August.

High number of seeds resulted from high number of fruit production. This shows the peak season of fruit production occurred in August. Meanwhile, number of seeds was low starting from April to July. The low number of seeds was due to low fruit production.

Accessions of V1 and V5 were the highest in total number of seeds produced with a mean 66.57 and 62.21 seeds/tree, respectively. Thus, the top accessions performer for seed production was accessions 1,(V1), followed by accession V5, V2, V6, V4 and V3.

Table 3. Mean Comparisons for Monthly and Total Number of Seeds (seeds/tree)

ACCESSIONS	April	May	June	July	August	TNOS
V1	4.18	5.58	1.72	4.46	50.46	66.57
V2	4.5	9.29	4.88	2.14	29.83	50.64
V3	1.41	3.10	2.12	0.69	7.14	14.45
V4	0.48	2.06	0.35	0.00	23.65	26.54
V5	2.73	6.35	2.06	10.42	40.65	62.21
V6	0.98	4.79	2.17	1.88	21.5	31.31
Mean	2.36	5.15	2.17	3.4	29.18	42.25
Tukey	Ns	Ns	ns	7.14	ns	ns

Notes: Mean with the same letter are not significantly different base on Tukey's Studentized Range Test (HSDRT) at probability level **$p \leq 0.05$, TNOS**= Total Number of Seed

4.1.3 Means Comparison among Pruning

There was no significant difference between pruned and non-pruned tree for number of seeds in all months (Table 4). The highest mean value for number of seeds was observed in August on non-pruned tree with a mean of 33.72 seeds/tree. The lowest month for seed production was in June with a mean of 2.17seeds/tree.

Non Pruned tree (Contol) (49.29 seeds/tree) were recorded higher than pruned trees (34.78 seeds/tree) in total number of seeds. However, there were no significant difference observed in total number of seeds. This shows that there were no effect of pruning on the seed number.

Table 4. Mean of Pruning Treatments for Monthly and Total Number of Seeds (seed/tree)

PRUNING	April	May	June	July	August	TNOS
Pruned	1.02	4.62	2.18	2.60	24.36	34.78
Control	3.62	5.65	2.16	4.14	33.72	49.29
Mean	2.36	5.15	2.17	3.40	29.18	42.25
Tukey	ns	ns	ns	ns	ns	ns

Note: Mean with the same letter are not significantly different base on Tukey's Studentized Range Test (HSDRT) at probability level **$p \leq 0.05$, TNOS =** Total Number of Seed.

4.2 Oil to Seed ratio

4.2.1 Analysis of Variance and Mean Comparison among Accessions

The results from ANOVA (Table 5), revealed that there was significant difference observed in oil to seed ratio among accessions. This indicates that there are variations among the six accessions. However, no significant difference was observed among replication, between pruning treatments and interaction between pruning treatment and accessions.

Accessions V1, V2, V4, V5 and V6 are in similar group, where they were no significant differences among each other with oil to seed ratio, with means ranging from 19.59% to 26.46% (Table 6). The lowest percentage was V3 with a mean of 10.24%. In general, most of the accessions presented similar range of oil percentages indicating that lack of variability among accessions.

Table 5. Mean Square of ANOVA for 30 Seed Weight, Oil to Seed ratio, and Oil Yield

Source Of Variation	Df	30 Seed Weight	Oil to Seed Ratio	Oil Yield
Replication	2	236.06 ns	462.73 ns	1360.18 **
Pruning(P)	2	468.32 ns	1255.71 ns	3660.69 ns
Error (a)	1	332.24	272.05	4.30
Accession(A)	5	955.65 *	1460.36 *	739.98 ns
P X A	5	127.72 ns	238.63 ns	234.95 **
Error (b)	250	85.51	84.51	71.05

Note: * Significantly different at $p \leq 0.05$, ** significantly different at $p \leq 0.01$, **ns**=No Significant Differences,**d.f**= Degree of freedom.

Table 6. Mean Comparisons for 30 Seed weight, Oil to Seed Ratio and Oil Yield

ACCESSIONS	30 Seed Weight (g/tree)	Oil to Seed Ratio (%)	Oil Yield (g/ tree)
V1	20.43 a	24.54 a	12.79
V2	13.93 b	19.66 a	8.31
V3	7.02 c	10.24 b	2.27
V4	15.67 ab	19.59 a	5.71
V5	18.35 ab	24.46 a	12.12
V6	15.16 ab	20.67 a	6.87
Mean	15.31	20.47	8.14
Tukey	5.64	7.22	Ns

Notes: Mean with the same letter are not significantly different base on Tukey'sStudentized Range Test (HSDRT) at probability level **$p \leq 0.05$**

4.2.2 Means Comparison between Pruning Treatments

Means comparison analysis (Table 7) revealed that there was no significant difference found between pruning treatments. The oil percentages for pruned trees and control trees were 18.52% and 22.14% respectively.

Table 7. Means of Pruning Treatments of 30 Seed Weight, Oils to Seed Ratio and Oil Yield.

PRUNING	30 Seed Weight (g/ tree)	Oil to Seed Ratio (%)	Oil Yield (g/ tree)
Pruned	14.26	18.52	7.18
Control	16.18	22.14	8.97
Mean	15.31	20.47	8.14
Tukey	ns	ns	Ns

Note: Mean with the same letter are not significantly different based on Tukey'sS tudentized Range Test (HSDRT) at probability level **$p \leq 0.05$**

4.3 Oil Yield

4.3.1 Analysis of Variance and Mean Comparison among Accessions

Analysis of variance in oil yield per tree revealed that there were high significant differences among replications and interaction between pruning treatment and accessions (Table 5). Wheras, there was no significant difference observed between pruning treatment and accession.

Oil yield is important to determine the superior accessions for best genotypes for crop improvement. A high significant difference among replication showed there were soil heterogeneity and other climatic factors such as rainfall, pest and disease, etc. All oil yields among accessions (Table 6) indicated no difference, ranging from 2.27 g/tree (V3) to 12.79 g/tree.

4.4 Mean Comparison between Pruning Treatment

There was no significant difference found in oil yield per tree between pruning treatments (Table 7). This is because pruned and non pruned trees produce similar range of oil yield. This could be the fact there were lacks of variability found in all the traits studied and directly influenced the oil yield value.

Based on the results, in the seven months period of experiment, non-pruned trees which was the control gave higher oil yield value than pruned trees. Nevertheless, there were no significant differences between them. This could be due to the fact that pruned trees have to expand more time to rejuvenate and for yield production. In contrast, non-pruned trees have already developed flowers and required a few months earlier to produce yield.

5. Conclusion

The evaluation of six *Jatropha curcas L.* accessions after top pruning from various sources in Peninsular Malaysia showed that there were no effects of pruning treatments on number of seeds and oil yield as compared to non-pruned trees (control). This could be due to the short period of observation time in this study. Accessions 1 (V1) had highest oil yield/tree among accessions within pruning treatments. While, accessions 5 (V5) is the highest number of seeds and the highest of oil percentages. Moreover, V1, originated from Muar and V5, originated from UPM showed a good interaction with pruning treatment and could performed effectively. It may be concluded that both accession showed the best performance after top pruning and were the superior accessions. Therefore, they were the best genotypes and are potential to be selected in tree breeding program of the *Jatropha curcas L.* crop for high oil yield production that will benefit future energy conservation plantantion.

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