EFFECT OF FRUIT DROP ON HARVESTING SCHEDULE AND OIL YIELD OF *JATROPHA CURCAS* L.

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ABSTRACT

The trend in jatropha fruit drop was determined as it has been shown to influence harvesting technique and affect harvesting schedule. The effect of fruit drop on oil extracted yield was also determined to substantiate the claim that this phenomenon is detriment. Twenty five bunches having a minimum of eight fruits per bunch from randomly selected twenty five individual trees were tagged to observe fruits drop. Oil extracted yield from dropped and fruits that were still on tree bunches were chemically extracted and compared. The results showed a logarithmic trend (R^2=0.94) for dropped fruits with delay in harvesting. After two months delay in harvesting, about 95% of the observed fruits were fall. Oil extracted yield from dropped fruit was lower compared to undetected fruits. The result of this study demonstrated the disadvantage of drop fruit to harvesting schedule and loss on extracted oil yield.

Keywords: Jatropha, harvesting, fruit drop, oil yield

INTRODUCTION

Jatropha has received research and development attention due to the perceived potential as a biodiesel feedstock as it is non-edible compared to the other sources such as oil palm and coconut. Being non edible for biodiesel feedstock, many other advantages of this crop has been reported. For examples its oil has been used as a purgative to treat skin diseases and to soothe pain such as that caused by rheumatism, it leaves have been used against cough or as an antiseptic after birth (Heller 1996).

Being multipurpose species, poor harvesting has been identified as a major factor retarding the commercialization of this crop (Heller 1996; Achten et al. 2008; Biswas et al. 2008; Silip et al. 2010a; ERIA 2010). Jatropha fruits mature heterogeneously which leads to laborious and time consuming harvesting because the harvesters have to select only the fruits that are of the right ripening index for processing. Silip et al. 2010b and Silip et al. 2011 have reported alternative approaches to tackle this problem through good postharvest handling practices and harvesting of multiple fruit maturity stages. The harvesting of multiple fruit

maturity stages has been reported to prolong harvesting visits and increase harvestable volume.

The limiting factor of harvesting visits was implied not solely due to fruit maturity heterogeneity but due to the occurrence of fruit drop. Therefore, the main objective of this study was to determine the trend in fruit drop and its effect on oil extraction yield.

MATERIALS AND METHODS

Sources of Samples

The source of samples for this study was from local *Jatropha curcas* Linn Luanti accessions harvested from a jatropha pilot project conducted by the Institute of Agro-Biotechnology Malaysia at Luanti Baru village, Keningau, Sabah, Malaysia (5^o 20' N: 116^o 10' E) on an Acrisol soil type. The plot used in this study was previously cropped with hill paddy but has been left idle for more than a year. A one hectare plot size was prepared by manual land clearing followed by minor open burning after the weeds had dried within two weeks of slashing. The seedlings were obtained from wild jatropha trees growing around the village. Only yellow and black fruits were collected, separated from fruit coat and dried under shade for three days. The seeds were directly planted onto the plot using a planting distance of 2 x 2 m^2 with two seeds per hole. No fertilizer was applied during the observation period but weeds were controlled chemically with glyphosate (N-phosphnomethyl glycine) and hand weeding as necessary, especially for weeds around the tree.

Test Samples for the Study on Dropped Fruit

Twenty five bunches having minimum of eight fruits per bunch with at less one fruit at yellow maturity stage from the selected 25 trees of one year old jatropha in the farm were tagged for this observation. The number of fruit-drop was counted every three days for 60 days.

Test Samples for the Study on Oil Extraction Yield from Dropped Fruits

About 1000 g of dropped fruits were randomly collected during the wet season (August 2010) from the jatropha plot. The samples were then prepared according to method of Silip et al. (2010b) prior to oil extraction analysis.

Test Samples for the Study on Oil Extracted Yield from Undetached Fruits

At the end of the dry season (March 2010), various stages of development of dry fruit bunches still attached to their parent plant from the bottom to the tip of all main jatropha branches were observed. For oil extraction analysis, undetached fruits were collected separately based on their fruit bunch maturity stages. Five fruit bunches maturity stages were pre-determined from older bunches at the bottom as

stage one and followed by younger fruit bunches at the top on identified single jatropha branch. The samples were then prepared based on the methods of Silip et al. (2010b) prior to oil extraction analysis.

Percentage of Fruit Drop

The percentage of fruit drop was calculated by dividing the total of fruits drop during the day of observation with the total number of fruits in the bunch during the first day of observation and multiplied by hundred.

Extraction and Measurement of Oil Yield

The soxhlet technique was used for chemical extraction with hexane solvent (boiling point of 40 – 60 ^{o}C). The extracted lipid was obtained by filtrating the solvent using a rotary evaporator apparatus at 40 ^{o}C followed by heating in an oven at 105 ^{o}C for three hours to evaporate any remaining solvent and water. The extracted oil yield was calculated by dividing the amount of extracted oil with the weight of sample before extraction.

Experimental Design and Statistical Analysis

The experimental design for the experiment on the oil extracted yield was a completely randomized design with a fixed identified variable and was replicated accordingly with measurable variables. The data was analyzed using ANOVA and the differences between means were calculated from the standard error of measurements. The study on the fruit drop was a non-experimental quantitative research with no manipulation on the identified variables. The source of variance was the 25 randomly selected bunches from 25 selected trees. The data collected were analyzed descriptively and from which mean and trend lines were obtained, summarized and described.

RESULTS AND DISCUSSION

Fruit Drop during Delay in Harvesting

The results showed a logarithmic trend (R^2=0.94) for fruits fall with delay in harvesting (Figure 1). Delays in 1, 2, 3 and 4 weeks cause about 38, 45, 55 and 70% of fruit fall, respectively. After two months delay in harvesting, about 95% of fruits dropped which is the plateau of this occurrence. Results of this study highlighted the importance of minimizing any delay in harvesting. These results are inconsistent with the three harvesting times per year recommended by Carels (2009) for this crop.

Fruit drop, which normally occur during senescence phase, indicated the limit of minimum delay in harvesting for this crop. Previous studies showed that the number of days required to reach the wet- black senescence from fruit set was about 34 days

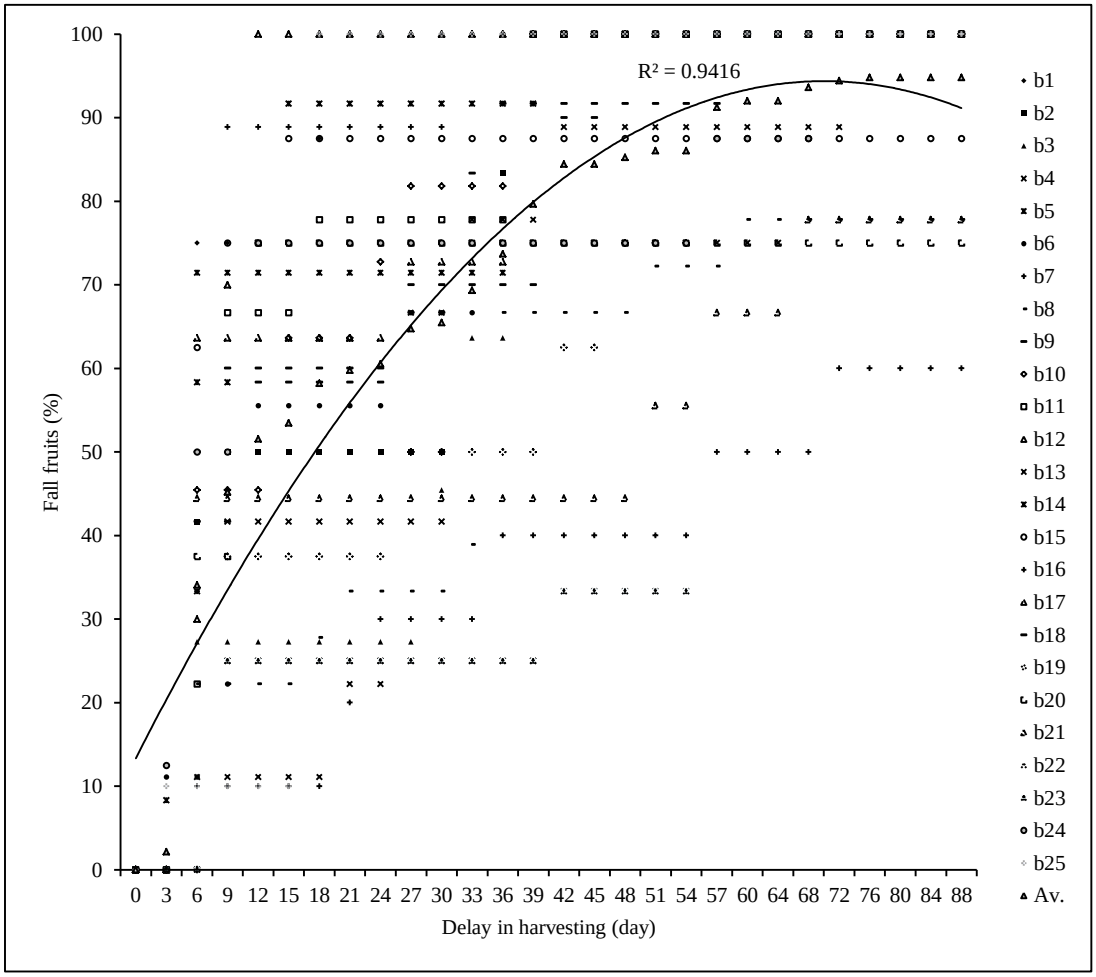

Figure 1. Percentage of *J. curcas* L. Luanti accession fall fruits during delay in harvesting (day). Different legends indicate the different observed bunches, b1 to b25 indicate the observed bunches and solid lines indicate the average logarithmic trend (R^2=0.9416).

(Silip et al. 2010a). However, only about 6 days on average was recorded for fruits to reach wet-black senescence from a mature green stage. Thus, this study suggest a minimum of about 6 days as the harvesting visit interval after first flowering to avoid fruit drop.

Since an increase in the percentage of fruits drop increases with delay in harvesting and especially during the wet-black senescence stage, the results of this study lead

to questioning the recommendation that harvesting be done during the dry senescence stage. The results imply that if these senesced fruits did not drop at some period in time then, the harvesting visit could be delayed for some period of time. This approach is suggested as an important selection criterion to reduce harvesting problem for this crop. However, limited information is available in the literature on this criterion which demands future research.

The percentage of fruit drop in this study was affected by agro-climate conditions especially rain fall and wind. Eventually all organisms die (Kivilaan & Bandurski 1981) and jatropha fruits are no exception. Environmental and other factors that accelerate senescence and abscission (e.g., mineral deficiency, drought, low light and lack of pollination) have been well documented (Kays 1991). During the dry season, as many as five stages of dry fruit bunches were still attached on the observed branch. However, only one, two or three stages of dry fruit bunch were still attached during normal or rainy season. An important variable related to this character is the extracted oil yields from different stages of dry fruit bunch development on a similar tree. Fruit drop is a natural process called abscission and this occurs in the jatropha trees to remove senescent fruits.

Extracted Oil Yield from Undetached fruits

Interestingly, the extracted oil yield from the five undetached fruit bunch maturity stages from a pre-determined single branch were significantly different (Figure 2). The extracted oil yield (chemical extraction), was significantly high in fruit bunch number two from bottom end of the branch with a value of about 60% compared to only about 55% from the other bunches. The highest oil yield observed in this case was similar to the extraction from fruits that ripened off the tree reported by Silip et al. (2011). This result indicates a benefit in harvesting during the dry season.

High extracted oil yield in these samples were expected because samples were collected during dry season. High extracted oil yield was also reported by Sontoso (2008) during the dry season compared to the wet season. The extracted oil yield from this study also highlights benefit of having multiple undetached dry fruit bunches on the tree. However, due to the occurrence of fruit drop, lower numbers of multiple dry fruit bunches were observed in the field.

The fruit- and seed-abscission-dispersal mechanism in jatropha did not follow the normal seed dispersal of legumes. The separation between fruit and seed was incomplete and this is a potential character in the selection of jatropha accessions. In general, this occurrence has been reported to be a species-dependent mechanism (Addicott 1982). Jatropha accessions, without this character, will be of benefit as there will be a lower risk of seed loss during a delay in harvesting. However, limited information on this characteristic in jatropha has been cited in the literature.

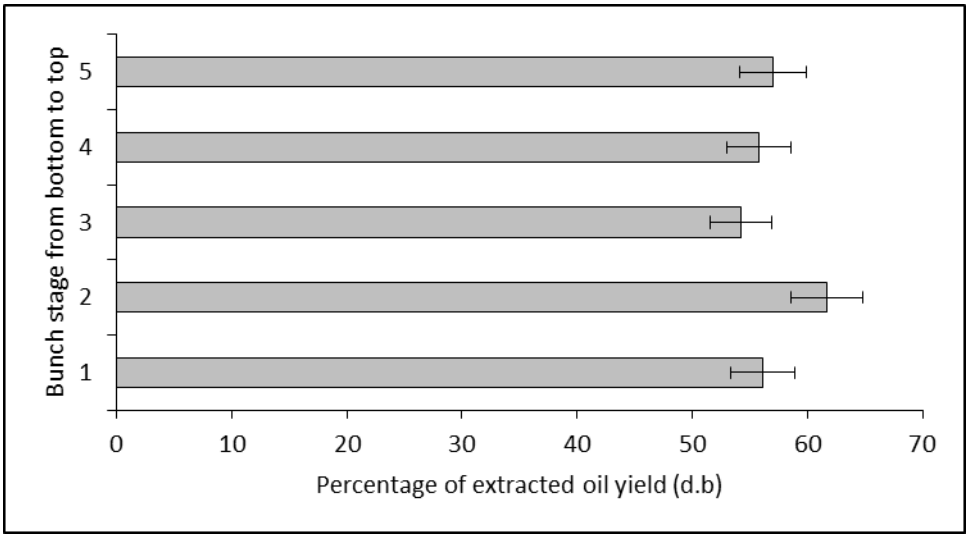

Figure 2. Percentage of extracted oil yield (dry base) from different fruit bunches of pre-determined same jatropha branch. Horizantal lines indicate standard error of measurements (n=5).

Extracted oil Yield from Dropped Fruits

Extracted oil yield from dropped fruits was lower compared with off-tree black and on-tree dry fruits (Figure 3). These results indicate a disadvantage of dropped fruit which should be avoided. Reduction in the extracted oil yield was expected because some of the dropped fruits were germinated. The oil might be converted to chemicals required for the germination processes (Kornberg & Beevers 1957).

Low extracted oil yield from dropped fruits in this study could also be due to the variability of the samples. Most of the collected seeds might have dropped from the tree for a certain period of time and the fruits might have been from wet-black or dry-senesced fruits. Extracted oil yield may differ according to duration after drop and this variation is accentuated by the conditions of the samples and environmental condition. For example, the result from a previous experiment showed much variation in the extracted oil yield from different dry samples from a similar branch (Silip et al. 2011). Thus, future research to identify the reduction rate of the oil content in relation to time lags of post fruit drop occurrence is needed. This information is important to provide an alternative for solving the problem related to unavoidable fruit drop in this crop. If the reduction rate is lower with increase in time lag, then harvesting visits could be reduced. Calculations on the harvesting cost between the reduction in oil content and picking cost should be compared for economic decision making.

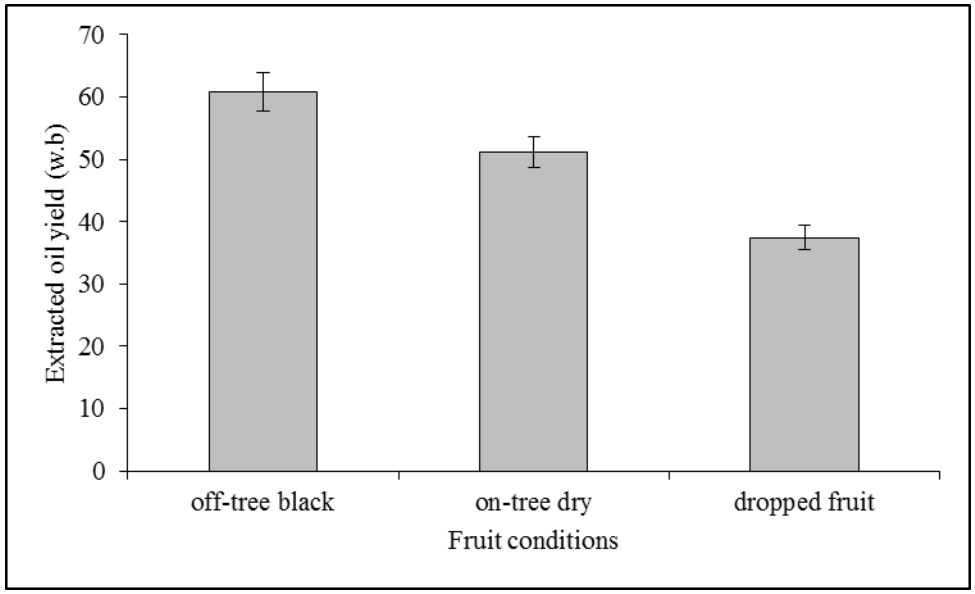

Figure 3. The percentages of extracted oil yield (wet base) from different harvested fruit conditions (off-tree senescence (n=3), on-tree dry (n=5) and dropped fruits (n=2)). Verticals bars indicate the error bar of measurements at 5%.

Hand picking of dropped fruits and seeds as a harvesting approach for this crop was proposed when basic mechanical harvesters are not available (Henning 2003). This approach involves hitting the dry fruits with a stick. The picker then collects the dropped fruits. It was reported that the best way to harvest the jatropha fruits is by using a long wooden stick attached to a circular comb with a cotton bag at one end. This mechanism allows for dry fruits to be picked from the trees, the fruits drop into the bag and do not have to be collected on the ground. However, the picking cost in jatropha is high and thus, several mechanical harvesting techniques have been suggested. Placing a net under the tree is commonly used for many fruits such as olive, mango and durian. Many shake-and-catch systems for processing apples have been evaluated (Markwardt et al. 1969). Apart from manual shaking, chemical desiccation has been suggested as an alternative harvesting method in rapeseed (Pauzet 1995) and cuphea (Johnson et al. 1997). According to Bowerman (1984), the chemical desiccation method can limit seed losses and improve seed quality. A jatropha harvester called OxboKorvan 900, which is based on the blueberry harvesting technology, could be the only jatropha mechanical harvester but no scientific data has been reported for its efficiency. Thus, future research on harvesting technology for this crop is required.

CONCLUSIONS

Increase in the percentage of dropped fruits was a function of time and best described as a logarithmical trend. The trend in the fruit drop plateaued after about two months of observation indicating occurrences of multiple dry fruit bunches in

single jatropha branch. This occurrence was more pronounced during dry season. The extracted oil yield from up to five different levels (points of attachment on a branch) of the dry fruit bunches from single branch was uniform with a value of about 55%. However, the extracted oil yield from dropped fruits was significantly lower with a value of only about 40%. This study has demonstrated the disadvantage of fruit drop as it causes a harvesting problem for this crop and this required future research.

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