Oil security is a major issue in the world today. For the very first time the price of crude oil reached up to USD145 a barrel due to limited production sources and increase in demand for fossil fuel. Hence, many investors, policy makers and scientists are involved in an urgent search for renewable energy. In many countries, biofuel is now the focus of this search for renewable energy, after wind energy, microhydro energy, solar energy and geothermal energies. As a consequence, today, there is high demand for biofuel materials. Palm, coconut, sunflower, rapeseed and jatropha oils are the materials available in today's market as biofuel feedstock. *Jatropha curcas* Linn has been given priority because the other sources listed above are also food materials. It was forecasted that each year for the next 5 to 7 years approximately 2 million hectares of jatropha will be planted around the world (GEXSI 2008). Biofuel technology based on jatropha requires further investment, supported by a broad body of information from various researches. As jatropha is considered a new and developing crop to the plant science community, there has been a great deal of research on it.

Poor harvesting has been the major limiting factor for commercialization of this crop, which has been highlighted in various publications (ERIA 2010, Biswas et al. 2006 and Heller 1996). 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. Further the fruits have to be harvested manually at regular intervals. Sivapragasam and Puteh (2008) reported that the amount of harvested jatropha fruits was only about 100 g.minute$^{-1}$ or about 6 g.hr$^{-1}$. Furthermore, they concluded that 80% of seeds production costs was mainly in harvesting and postharvest handling. Mechanical harvesting of this crop was considered impossible due to its indeterminate flowering and growth habit. Today,
jatropha fruits are still harvested by hand in small and plantation scale farms. Jatropha seeds in Myanmar’s eight million acres were reported to be rotting on the farm due to poor harvesting technology (Jim 2009). The indeterminate reproductive habit of this crop is thought to be responsible for this problem, but little information exists on these characteristics.

Crude jatropha oil (CJO) content has been related to harvesting time but the recommendations were inconsistent. Heller (1996), Wiesenhutter (2003), Nurcholis and Sumarsih (2007), Priyanto (2007) and Hambali et al. (2008) recommended that harvesting of fruits be done at 90 and 55 (Santoso 2008), 45 (Wanita and Hartono 2006), or 37 (Annarao et al. 2008) days after anthesis. The 90 days as an indication of harvest time by previous research was due to a claim that dry fruit results in high CJO. In contrast to the recommended 90 days as harvesting time, Wanita and Hartono (2006) reported that high CJO was from fully yellow jatropha fruits or when bunch age was 45 days after anthesis. The seed oil was reported to be 10.93, 26.98, 29.38, 22.83 and 23.68% in green, green with yellow, fully yellow, yellow with black and black fruits colors respectively. Santoso (2008) also found that the kernel oil content was in agreement with Wanita and Hartono’s report. Inconsistencies in the recommendations indicate the importance of future study on this issue.

Multiple harvesting requirements being a main contributor to high harvesting costs could be due to the recommendation to harvest individual dry or yellow fruits. To increase the harvestable volume, harvesting fruits bunches has been recommended. It was recommended that fruit bunches are ready to be harvested when 50% (Hambali et al. 2008), 60 - 70% (Nurcholis and Sumarsih 2007) and 75% (Priyanto 2007) of the fruits in a single bunch are ripe. If fruit bunches’ characteristics are to serve as a harvesting indicator then the next problem would be to solve the problem posed by variations in the fruits’ ripening stage after harvest, especially the green fruits. The harvested fruits that are yet to reach the required ripening stage for high oil extraction rate might require postharvest handling such as ripening treatments with external ethylene gas treatment. However, no such treatments are available for jatropha at this time. It is important to note that there are
physiological and biochemical ripening differences between the fruits that ripen on (in situ) and off the tree. According to Wills et al. (1998) the development and maturation of fruits is complete only when it is attached to the plant, but ripening and senescence may proceed on or off the plant.

Contrary recommendations on harvesting time based on days after anthesis was also thought to be due to this indeterminate growth habit of the crop. Long term solutions could be the breeding of varieties whose growth habits are determinate with uniform fruit maturity. These traits can make harvest scheduling possible for maximum economic yield. Unfortunately, the breeding of new varieties is costly and time consuming and, therefore, near-term solutions are also needed during domestication of local accession. One of the solutions involves harvest and postharvest treatments. Physiologically mature fruits could be ripened off the tree with similar oil extraction quantity like those that ripen on the tree. However, scarce information is available in the literature, related to postharvest handling of this crop.

Since poor harvesting efficiency has been attributed to the indeterminate growth habit and contrary recommendations on the harvesting time and indicators, this research was designed to determine selected reproductive characteristics followed by determining physicochemical occurrences during the life of the fruit on and off the tree. To further understand the extracted oil yield, effects of selected postharvest handling practices on oil yield was determined. Ripening characteristics of various individual fruits and fruits bunches was determined to recommend harvesting indicators. The final work carried out involved determining the effect of various ripening enhancers on the ripening percentage of harvested green fruits. This research is thought to be useful from the economic perspective of jatropha industries because all the possibilities explored will contribute to reduction in harvesting costs.
Objectives of the Research

Two main objectives of this research were to determine the physiological occurrences during ripening on and off the tree and improve ripening uniformity off the tree.

Four specific objectives were:
1. To characterize jatropha productive heterogeneity,
2. To determine physicochemical characteristics based on fruit color,
3. To determine harvesting indicators of individual and fruits bunches and
4. To improve ripening uniformity of harvested mature green fruits off tree through postharvest approach.

Benefits of the Research

Since poor harvesting efficiency has been related to the indeterminate growth habit and lack of harvest and postharvest physiology information, therefore, the results of this research would be shed light into how to increase harvesting efficiency and reduce harvesting costs. The technologies developed would be desirable from the economic perspective of jatropha industries.

Boundaries of the Research

The study was limited to a specific jatropha accession, specific targets of reproductive characteristics, specific target of fruit maturity, specific target of physicochemical character and within a specific time frame.

a. Jatropha accession: Luanti accession from Luanti Baru Village, Keningau, Sabah, Malaysia become the main samples for this study but several different accessions were used for study on the fruit maturity uniformity according to different
accession. Two other specific accession namely Tanzania and IP1 were used for preliminary experiment and respiration study.

b. Targeted reproductive characters: uniformity of fruit maturity, number of active and non-active branches, number of buds, number of inflorescences, fruit production, total number of bunches, frequency of fruits per bunch and days required to reach specific stage of development.

c. Targeted fruit maturity: immature fruits or young fruits, mature green fruits, ripe or yellow fruits, senescence wet black fruits and senescence dry fruits.

d. Targeted physicochemical characters: ripening percentage, size, soluble solid concentration, free fatty acids, crude jatropha oil, pH value, water content, carbon dioxide concentration, color, weight loss and firmness.

e. Time frame: Two years of data collection. 2009 and 2010.