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RESEARCH ARTICLE

ENVIRONMENTAL FACTORS IN THE GROWTH OF JATROPHA AT POTORONO VILLAGE, YOGYAKARTA

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ABSTRACT

Jatropha curcas is a perennial crop that has been known by Indonesian people for more than seven decades as a plant that produces renewable biofuel. In the present decade, plants producing biofuel are expected to be developed to overcome the lowering nonrenewable fuel reserves. There is a myth that jatropha can grow well on marginal lands and draught condition, perform well on non-fertile soils, no need for agronomic management and is resistant to plant pests and diseases. This study was conducted to identify the environmental factors that influenced the growth of jatropha on the marginal land at Potorono village, Yogyakarta Province, Indonesia. Jatropha has been planted by local people at the village road sides and on the marginal land field at the local governmental land in this village. They grew jatropha on these areas with the purpose of preventing competition of area utilization with food crops. The results showed that the growth of jatropha was restricted by low content of organic matter, plant nutrition and poor soil drainage. Applications of manure and macro nutrients (N, P and K) to this crop were able to increase crop performance. The number of shoots, flowers and fruit bunches increased by manure and nutrients treatments. Field observation showed that there were several plant pests, such as *Aspidiotus* sp., *Paracoccus marginatus, Poliphagotarsonemus latus, Selenothrips rubrocinctus, Chrysochoris javanus, Valanga nigricornis, Chloracris prasina,* and *Helicoverpa armigera* that attacked plant leaves and fruits. There were plant leaf necrotic symptoms that caused by plant pathogens were also observed. The diseases are bacterial leaf spot (X*anthomonas ricinicola*), cercospora leaf spot (*Cercospora ricinella*) and rust (*Phakopsora jatrophicola*). Thus, jatropha is like any other plants that need a good agro-ecological condition to grow well and produce high yield.

Keywords: jatropha, marginal land, plant nutrition, pests, diseases

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INTRODUCTION

Every day people need energy for sustaining their life. Consumption of the energy always increases from time to time as population increase and with enhanced economic status, people need more energy for their daily activities. The most important energy source is from fuels, and using fuels from oil and gas from earth is very user friendly and people do not need to produce the energy by themselves. Koonin (2006) mentioned that liquid hydrocarbons are well suited for transport uses because of their high energy density and handling convenience. Unfortunately, the oil and gas reserves are not renewable resources and the reserves gradually decrease after huge exploitation, which will continue to persist in five decades.

Nielsen *et al*. (1977) have analyzed several types of plants that have developed the prospect of producing biofuels in the

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United States. Kerr (2010) reported that renewable energy sources have some issues. Fuel sources like corn kernels or wood chips tend to be bulky and their energy content is diffuse. He also mentioned that planting energy crops and building solar or wind farms is a land-hungry process, and the energy they deliver is often intermittent and hard to store. *Jatropha curcas* is a famous perennial crop in the world that grows well in tropical regions. This plant is planted in many tropical countries like in Africa and Asia, also in Indonesia. In the past ten decades, Indonesians have used jatropha seeds to make fire or light as the seeds have high oil content. However, developing jatropha for commercial purposes has not been done as huge exploitation of oil from earth by many giant industries is well developed. There is a myth among people that jatropha is a crop that may grow well and produces fruits on soil with poor chemical and physical properties. They also think that this crop may be resistant to most plant pests and diseases. There are still many people who expect that jatropha could provide hope of using it as part of a material that can substitute for diesel because of its adaptability and high productivity (Darwis, 2009). Volckaert (2011) mentioned that there were three kinds of myth which develop among people on the jatropha, i.e. it can grow anywhere even in marginal soil, it's a hardly non-edible tree, and does not need fertilizer. In reality, he stated that jatropha can survive in marginal conditions, but will give marginal yields in those conditions; Jatropha is not eaten by larger animals, but it has many pests and diseases; and jatropha can survive in low-nutrient conditions but better growth and higher seed yield is observed with higher nutrient levels.

There was an Instruction of the President of the Republic of Indonesia number 1 of 2006 that initiated a scheme to develop alternative sources of fuel supply and the use of biofuels as substitute fuels. The Indonesian Government initially had a plan to develop jatropha as one of the natural resources that will be processed into some products of biofuels. Seeds of jatropha can be pressed and the extracted oil is able to be processed into biokerosene, biodiesel or other products. On the other hand, research on the land suitability and agronomic properties of jatropha, crop production, crop management and plant pest and diseases is still few. In the 2000s, the US Federal Legislation had also begun to explicitly support biofuels to provide opportunities for agricultural and rural development (Committee on Economic and Environmental Impacts of Increasing Biofuels Production, 2011). Accordingly, it needs information and technology in relation to the agro-ecology of jatropha to make clear about how to grow jatropha and the type of environment in which jatropha may grow well.

MATERIALS AND METHODS

The present study was conducted to identify the environmental factors that influence the growth of jatropha on the marginal land in Potorono village, Yogyakarta Province. Field experiment was conducted in the local governmental field that had been planted with jatropha in early 2008. This field location is at a riverside which geomorphologically developed from flooded plains. Cumulative deposition processes of the volcanic material coming from Merapi volcano resulting in alluvial plain and materials are dominated by sand fraction. Water table of the land is fluctuated from near surface in the rainy season until more than one meter in depth in the dry season. Some channels were constructed at every field plot as a boundary of the plot and also to drain the excessive soil water. In order to make the same starting point of each plant, the treated plants were pruned previously. The experiment was designed by application of 2 kg of organic fertilizer as a basic treatment for each plant. Application of the NPK nutrients was done by mixing the urea, SP36 and KCl fertilizers, and there were four treatments. These following treatments were applied at the base of every plant, i.e., control, A (2 kg compost, 40 g urea, 20 g SP36 and 10 g KCl), B (2 kg compost, 80 g urea, 40 g SP36 and 20 g KCl), and C (2 kg compost, 120 g urea, 60 g SP36 and 30 g KCl). This experiment was done with five replicates. Plant management was done including weeding, soil plowing around the plants and clearing the unproductive plant shoot and leaf. Number of branches, width of canopy, height of plant, number of flowering shoots and number of fruiting shoots and number of fruit bunches were measured for the present research to understand the effect of the environmental improvements to the vegetative and generative performance of the plant. All of these measurements were done periodically every two weeks.

RESULTS AND DISCUSSION

Development of jatropha

Before this research was done, the community of the Potorono village had cultivated jatropha along both sides of the road as a hedge plant (Figure 1). They hoped that by planting jatropha they could start to reach self sufficiency in energy. They wanted to process jatropha seeds as a raw material of biofuel. They thought that an availability of the fuels especially from earth would gradually decrease, and also the government had to reduce the level of subsidy to minimize the annual budget. The head of village

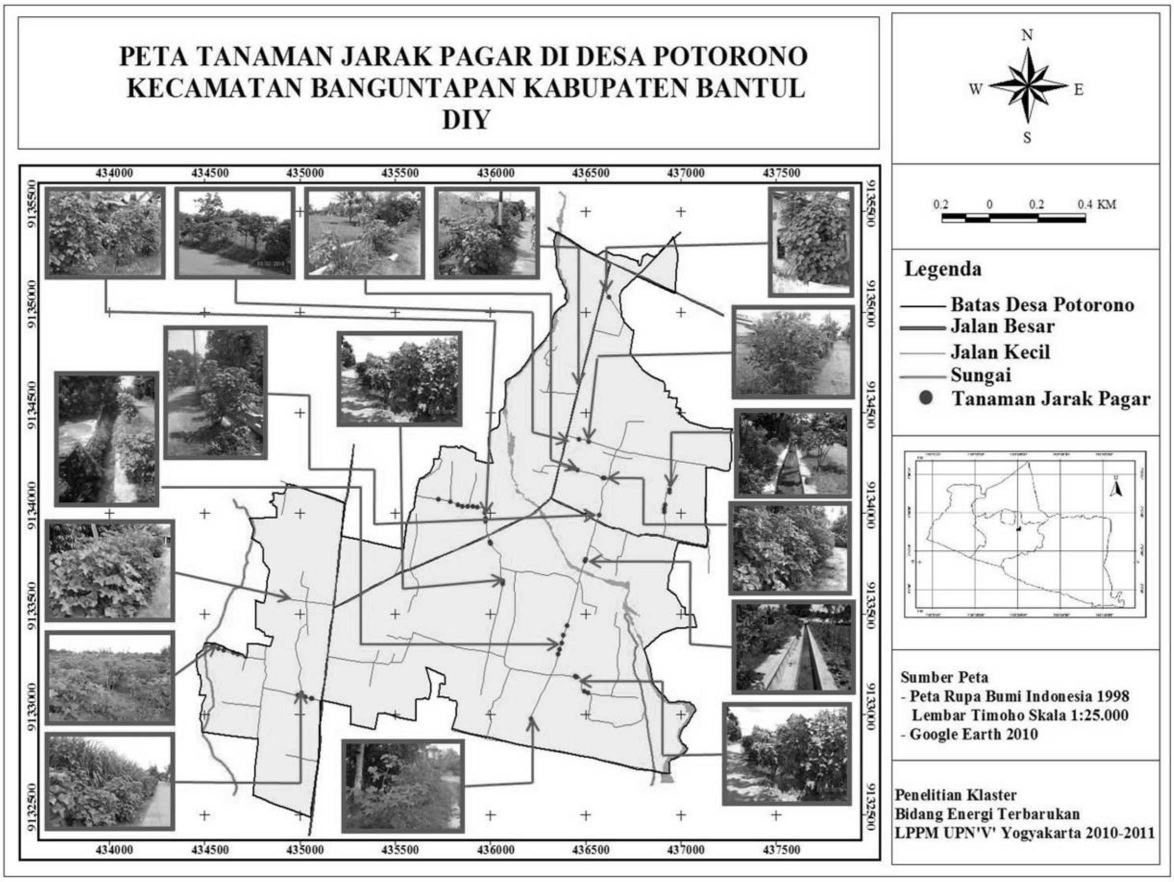

Figure 1. Distribution of jatropha at Potorono village

started introducing jatropha to the Potorono people in 2007, and this program was supported by the Office of Agriculture and Forestry, Bantul regency. They also received some training from the government in jatropha cultivation and how to process jatropha seeds to produce biofuels.

Until the research was done, jatropha was cultivated extensively in Potorono village. However, the plants were not well taken care of and they developed like wild plants. The people were growing jatropha without regular spacing; in general the plant spacing is in the range of 2x2 m to 2x3m. They even planted jatropha more densely than those two kinds of spacing, which caused competition among plants in sunlight uses and nutrition uptake. The result showed that the competition among plants might cause early flowering and fruiting that resulted in low productivity.

Water stress on jatropha

Most jatropha which is cultivated in Potorono village showed a survival to draught effect by shedding the leaf. In this case jatropha showed an arrangement of branches with a few shoots containing young leaves. In this way jatropha is able to reach a balance between the transpiration rate of the plant and availability of soil water. After the soil was irrigated or received water coming from rainfall, jatropha began to sprout immediately and result in a green plant. Accordingly, draught may affect the plant in the stagnant condition and there is a limited metabolism in the plant. As the purpose of the growing plant is for producing fruit, it is impossible to expect that jatropha produce many fruits on the draught condition without irrigating soil. The same statement was made by Hannan-Jones and Csurshes (2008) that *Jatropha* is well adapted to seasonally dry tropical climates and can shed its leaves during the dry season. Therefore, it is difficult to expect jatropha to grow well and produce a large number of fruits in the marginal land without additional water to soil in the dry season. Plant producing fruit needs continuing processes from building the plant body with high performance and then it generates fruit. This process must be supported by availability of water, nutrients and energy for the photosynthesis as long as plant producing fruit until it reaches maturity.

The tropical climate is characterized by a cycle of dry and wet seasons, so that jatropha needs irrigation in the dry season period to support the availability of water in soil. Koshel and McAllister (2010) mentioned that there are three primary sustainability indicators that have been selected as critical for the specific biomass production systems being investigated, i.e.: soil carbon, hydrology and water quality, and direct green house gas emissions.

Pruning and fertilization

Waterlogged healthy condition draught

Figure 2. Jatropha performances in various condition (waterlogged, healthy condition and draught)

Jatropha is characterized as a plant that is able to grow fast when it gets enough water, nutrients and energy. So, it can be stated that jatropha is responsive to fertilization. In the present study, jatropha was treated by addition of organic and chemical fertilizers. So the pruning treatment resulted in the growth of many branches. However, without addition of organic matter and nutrients, the shoots' development did not result in a domed type of plant. The new shoots grew elongated and they developed many branches and a few leaves only. Generally these leaves were yellowish in color and some young leaves were violet in color. The mature leaves fall faster causing the plant to have some long branches with few leaves.

The results of the present research showed that additions of organic matter and nutrients on the pruned plants resulted in the growth of new shoots and development of branches with many green leaves. It means that pruning might stimulate the branches to grow, and the accompanying fertilizer application might give nutrients for developing healthy leaves, whereas pruning only might stimulate the growth of branches but they would not be supported by enough nutrition.

Figure 3 shows the results of the flowering branches on the pruning and fertilizer application. According to the B treatment or applications of organic fertilizer (2 kg) and combination with 80 g urea, 40 g SP36 and 20 g KCl might increase two times the number of flowering branches for every plant, while the C treatment resulted in a lower number than that of the B treatment. In these experiments, some of the plants at the C treatment suffered from the local bad drainage and it caused a stunted plant growth. Based on the results of this study, it can be concluded that jatropha plants grown in marginal environments cannot grow well. The addition of elemental N, P and K is needed to improve the environment quality for vegetative and reproductive growth of Jatropha. It can be as a counter to the notion or myth that jatropha can grow and develop in a poor environment with high production without good crop management.

Figure 4 shows the result of the fruiting branches on fertilizer application. The productivity of growing jatropha in

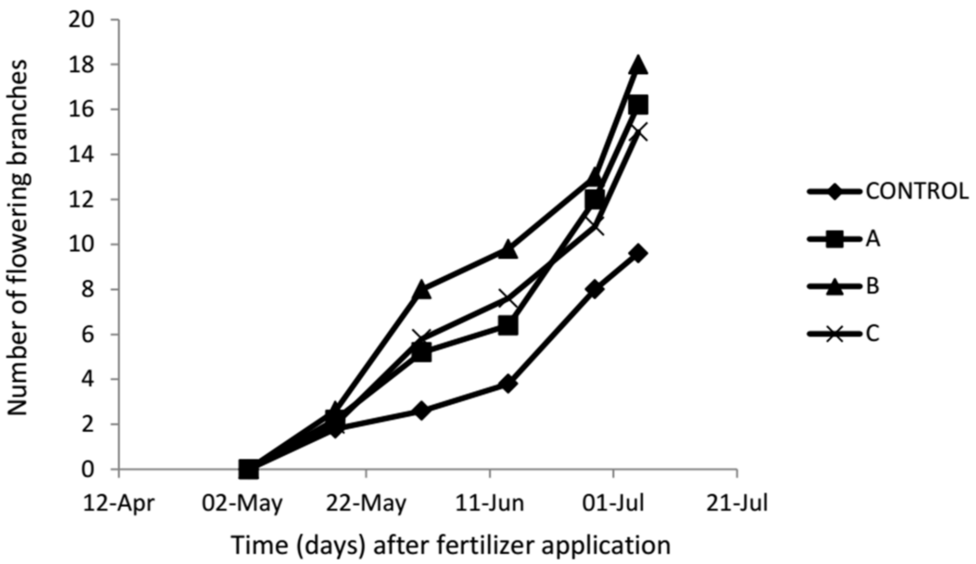

Figure 3. Development of flowering branches on fertilizer application

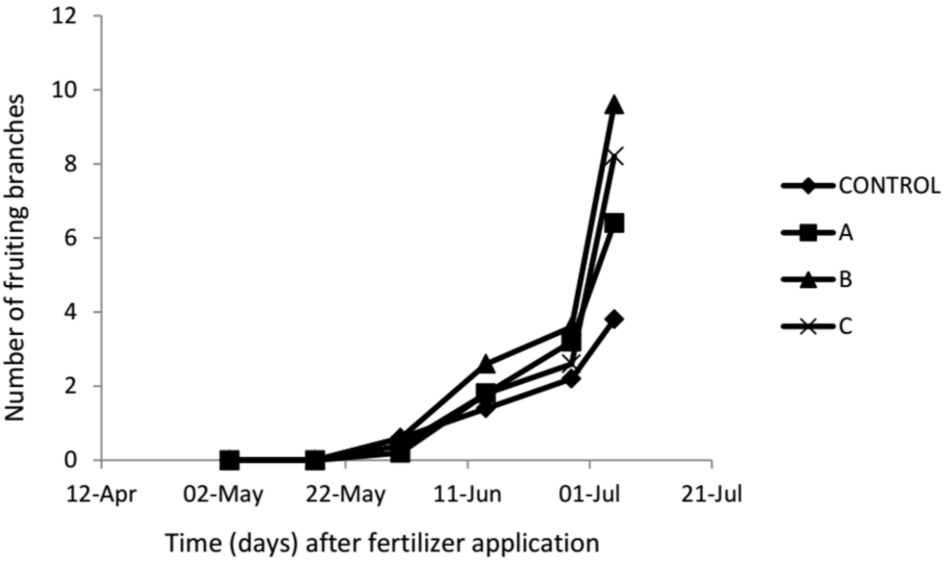

Figure 4. Development of fruiting branches on fertilizer application

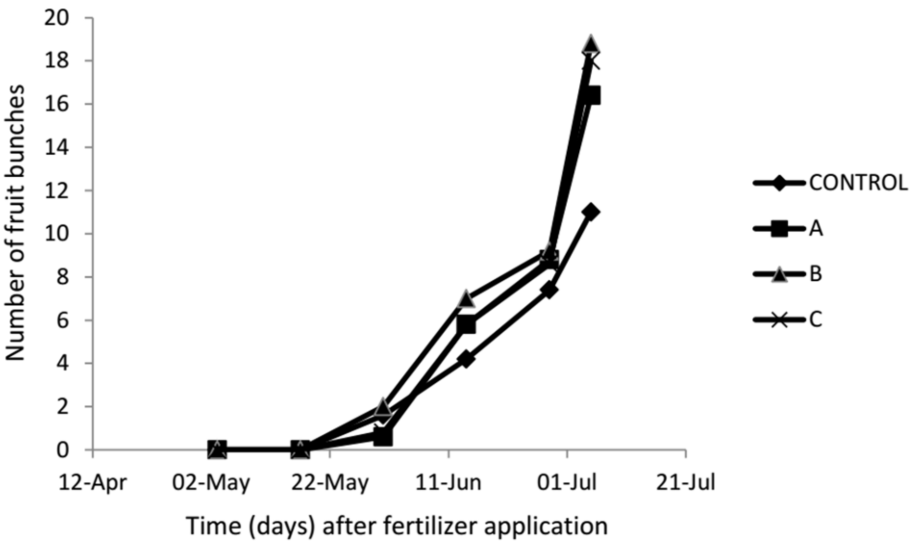

Figure 5. Development of fruit bunches on fertilizer application

marginal environments does not necessarily result in a high level of fruition. Field observations showed that just by pruning the plants they cannot provide a lot of branches that produce fruit. This is because jatropha is planted in soil with a sandy texture and have low fertility rates. For most sandy soils in China, nutrient availability is the most limiting factor (Zhao et al., 2005). These conditions do not favor the formation of new branches and then give the results in the form of fruit. As for pruning, followed by the addition of nutrients, it can increase the number of fruiting branches. By combining Figures 3 and 4 it can be seen that there is a clear trend pattern between the number of flowering branches and fruiting branches.

Figure 5 shows a different development between control and organic matter and nutrients treatments on the fruit bunches. Based on the results of this study it can be inferred that just by pruning without the addition of nutrients the plant cannot produce a maximum quality of fruit. The pruning of Jatropha plants plays a crucial role in growth and in seed production. Jatropha experts have different opinions on pruning methods and the appropriate time for pruning. Nurcholis and Sumarsih (2009) mentioned that jatropha like other plants, also requires maintenance and fertilizer application in order to get higher productivity. Krishna et al. (2008) reported that the application of 5 kg of farm yard manure (FYM) per plant to the un-pruned Jatropha significantly increased the plant height compared to control consistently in three years.

Forming plant crown

Pruning is an effort to increase the number of shoots that then become branches and twigs. By doing the pruning in the proper way, it may result in a forming the composition of the branches and twigs likes the crown. The pruning of plants with the aim of forming a crown can be seen from the correlation between the diameter of the canopy and the number of branches (Figure 6). The results of the present study showed a linear correlation between the diameter of the canopy and the number of branches. Therefore, an increase in the number of branches of the main stem correlates with forming the crown of the plant. Crown formation is also beneficial in improving the condition of the plant so that more leaves can utilize the energy from the sun. Putri et al. (2009) mentioned that every pruning of the primary branch may have the potential inhibition of apical dominance, thereby stimulating the growth of lateral buds that eventually form secondary branches of the plant. However, it should be understood that relying solely on pruning activities without providing nutrients addition cannot provide the maximum branching growth.

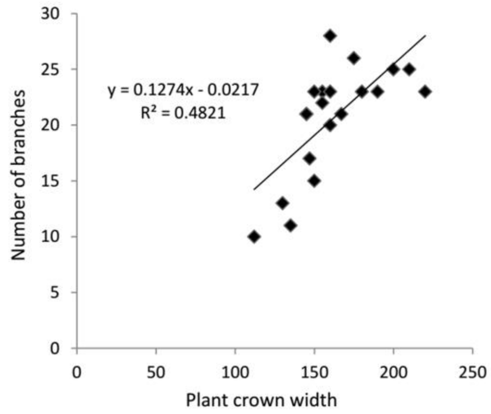

Figure 6. Correlation between crown width and number of branches

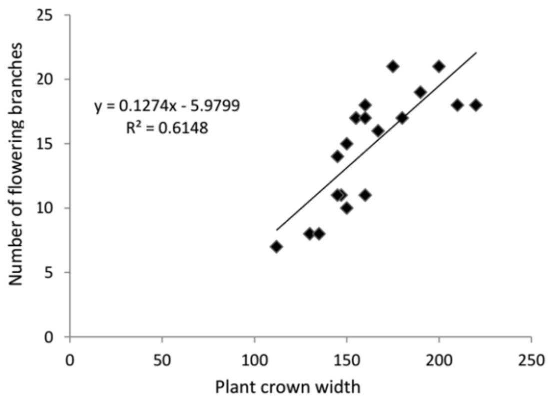

Figure 7. Correlation between crown width and number of flowering branches

Figure 7 shows the width of the plant canopy diameter was positively correlated with the addition of a flowering branch. This is because each branch is growing and can grow and get enough nutrients from fertilizer and then reach the generative growth. Plants are pruned to one bud right at the top of the stem or branch segment can stimulate the growth of new shoots around the segment. The principle of pruning is to stimulate the formation of vegetative and reproductive buds so that a wider field of branching will increase crop productivity. The addition of macro nutrients N, P, K may help the formation of buds into panicles.

Pest and diseases

Field observation found eight insect pests and three diseases attacking jatropha. Figure 8 shows the observed pests in the present study, i.e.: scale insects (*Aspidiotus* sp., *Paracoccus marginatus*), mites (*Polipha-gotarsonemus latus*), thrips (*Selenothrips rubrocinctus*), scutellarids (*Chrysochoris java-nus*), grasshopper (*Valanga nigricornis, Chlo-*

Curly leaf caused by mites attack

Brownish spot on leaf resulting from mites attack

Scutellerids attacks jatropha fruit

grasshopper

Figure 8. Observed pests and symptoms at leaf and fruit

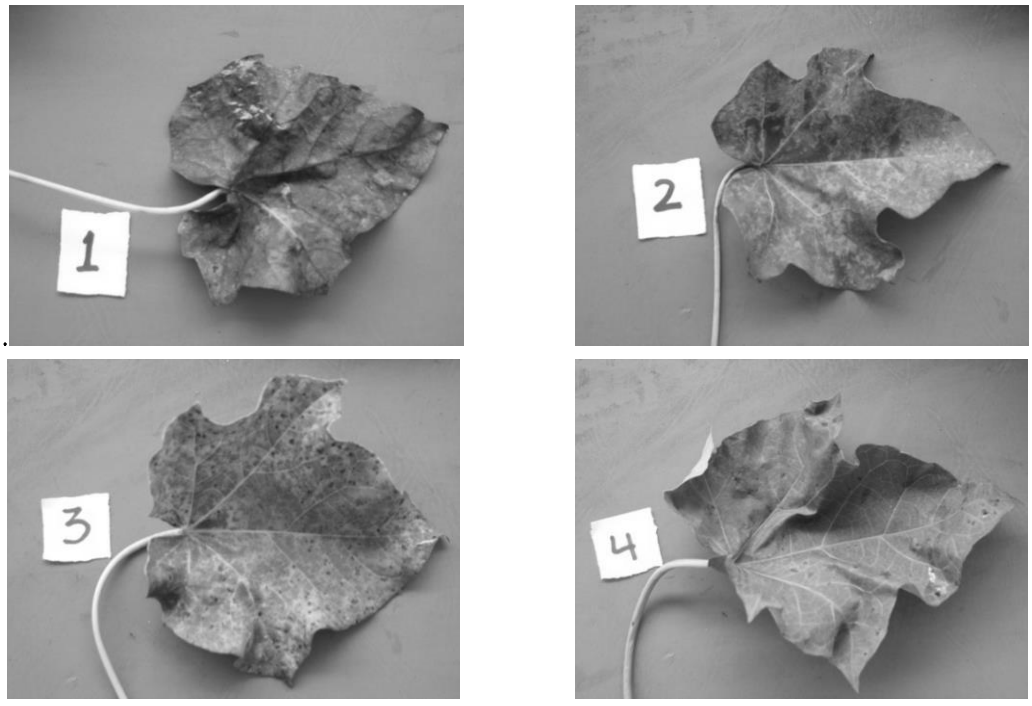

Figure 9. Observed diseases on leaf

racris prasina), and caaterpillars (*Helicoverpa armigera*). The diseases that were identified (Figure 9) are bacterial leaf spot (X*antho-monas ricinicola*), cercospora leaf spot (*Cercospora ricinella*) and rust (*Phakopsora jatrophicola*). Darwis (2009) mentioned that the insect that is commonly found in jatropha is *Chrysacharis javanus*. Furthermore, Putri *et al.* (2009) reported various types of pests found in jatropha, including termites (isoptera), caterpillars and ladybugs (*Chrysochoris javanus* Westw.), grasshoppers, while the disease identified is caused by pathogenic bacteria and fungus. Hannan-Jones and Csurhes (2008) also reported that Jatropha mosaic virus (JMV) is a potential pest of *J. curcas* and has recently been found in southern India following the introduction of its vector silverleaf whitefly (*Bemissia tabaci* 'B biotype').

SUMMARY AND CONCLUSIONS

Jatropha is a plant that can grow well in wet tropical environments. However, the adequacy of water, plant nutrients and sunlight energy is crucial for vegetative and generative growth of this plant. Infertile soils without proper management may not provide a good environment for growing jatropha. Problems, for the dry soil or waterlogged soil, can also cause negative effects on this plant growth. The success of jatropha's generative growth is strongly influenced by the amount of plant shoots. Pruning the plants is very important in increasing the number of shoots of plants. In this study the treatment of pruning, followed by addition of 2 kg compost, 80 g urea, 40 g SP36 and 20 g KCl might give good results in terms of canopy shape, number of branches, flowers and fruit. The study also found pests and diseases in the jatropha plant. They attack the leaves and fruit of jatropha, which can cause negative effects on vegetative and generative growth.

According to the results, it is concluded that the jatropha is not a miracle crop that it can grow well and produce many fruits on marginal soil and even without management of soil and plant. Jatropha is like the general plants that it needs a good environmental condition to grow well and fruitfully. Pruning and fertilizing are needed to stimulate lateral growth, increase the growth of shoots, and branches. Then it will also stimulate to generative growth that may result in productive plants. Some pests and diseases may attack the leaf and fruit of Jatropha, and therefore we need to be aware of their potential for causing lower productivity.

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