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Jatropha curcas as a potential plant for bauxite phytoremediation

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Abstract. Abandon bauxite mining sites can cause serious environmental problems, such as poor soil quality, air pollution, erosion and flood. *Jatropha curcas* could possibly be used to remediate barren bauxite mining sites. The objective of this study was to study the growth performance of *J. curcas* on top soil (control) and bauxite mined soil. Observation of the plant growth was recorded weekly, including days to rooting, number of roots per cutting, days to new bud opening, number of shoots per cutting, number of leaves per cutting, plant height and chlorophyll content. Data collected on the growth performance of *J. curcas* were analyzed using *SPSS 11.5* for *Windows Standard Version*. Based on the results obtained, *J. curcas* could thrive and grow on bauxite mined soil as it has higher significantly difference in number of leaves and plant height after growing on bauxite mined soil. Therefore, *J. curcas* is suitable for phytoremediation, in order to solve the environmental problems that occur on the bauxite mined site.

1. Introduction

Bauxite is a rock shaped from a laterite soil that has been significantly leached from silica and other soluble materials under moist tropical or subtropical weather [1]. High demand in alumina caused excessive bauxite mining activities that leads to environmental issues [2]. Ecological effects of such surface mining operations endured for a long period of time lead to the extinction of plants, runoff of biological materials, and deterioration of soil structure. Moreover, soil fertility is also affected as mining involves complete removal of top fertile soil. It also affects microbial diversity that facilitates agricultural productivity and maintains soil health [3].

Phytoremediation is a rising innovative approach to solve environmental problems. The term“phytoremediation” comes from: Greek *phyto* which means ‘plant’ and Latin *remedium* which means ‘to right or eliminate foul’. Phytoremediation fundamentally utilizes plants and related soil microorganisms to decrease contamination including concentration heavy metalor toxic effect in the environment [4]. Green plants are capable of remediating contaminated sites via phytoextraction, phytofiltration, phytostabilization, phytovolatilization, and phytodegradation [5] [6].

In this study, *Jatropha curcas* was chosen as the tested plant as it is hardy and is a non-crop plant. Besides its ability to grow in tropical regions, it can produce top-quality biodiesel fuel that is usable in a standard diesel motor as the seeds contain 27–40% oil [7] [8]. In addition, *J. curcas* plants are planted as protection hedges in most countries. This is because *J. curcas* can prevent unpleasant red dust from spreading as it has ability to grow until 5 metres tall and reduce soil erosion as it has lateral root near the surface [9]. However, the use of *J. curcas* in remediating bauxite mining sites has not been

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conducted. Thus, the ability of *J. curcas* to grow in bauxite mined soils for phytoremediation purposes was studied.

2. Materials and methods

2.1 Site description

This study was conducted at the Greenhouse and Nursery Complex in Internasional Islamic Universiy Malaysia Kuantan Campus. Soil samples collected randomly at different places in depth of 0-20 cm from a barren post-bauxite mining site (3.891186, 103.272165) were used for planting purposes. Top soil that was purchased from a nursery was used as control. The soil samples were dried and sieved.

2.2 Plant propagation

Stem cutting technique was used in this study. Healthy and uniform stem-cutting with 3-4 cm diameter with length of 17-28 cm and contains nodes was selected. The stems were greyish in colour. The stems were cut slightly slanted after dipping into rooting powder and then placed in a planting tray containing peat moss to speed up the rooting development for 30 days. The rooted cuttings were transferred into polybags filled with bauxite mined soil or top soil (control) at 4 cm depth. The watering process was done using tap water every two days.

2.3 Growth performance of plants

Observation of the plant growth was recorded weekly, including days to rooting, number of roots per cutting, days to new bud opening, days to shoot development, number of shoots per cutting, number of leaves per cutting, and plant (height measured by using measuring tape).

2.4 Statistical analysis

Significant difference in physiological parameters in different plant parts were determined by T-test while the chlorophyll content of the leaves was determined by one-way ANOVA ($p \leq 0.05$). Before running ANOVA, few assumptions were fulfilled, including normal distribution of dependent variable in each group ($p \geq 0.001$), homogeneity of variances that was determined by Levene's Test ($p > 0.05$), and independence of observations. All data were statistically analyzed using SPSS 11.5 for Windows Standard Version.

3. Results and discussion

Few preliminary trials on different type of stem cuttings namely soft cutting, semi hard cutting and hard cutting were conducted in propagating *J. curcas*. The cuttings were grown in peat moss for root formation. Shoot formation took 7 to 14 days, while root development took 14 to 42 days. Soft cutting was found to be the best in propagating *J. curcas* via stem-cutting method (figure 1). This is because soft cutting has faster opening of bud and higher percentage of roots and shoots compared to semi-hard and hard cuttings [10] due to the carbohydrates and other stored materials such that decreasing at the higher distance from the shoot [11]. The rooting and shooting processes of the hard cuttings are slower because of conversion of most of materials for stem lignification [12].



Figure 1. The length of *J. curcas* grown from soft cutting (left), semi-hard cutting (middle) and hard cutting (right) after 42 days.

For growth performance experiments, the plants were grown on polybags containing bauxite mined soil or top soil (control) for 29 days in the glasshouse. Few parameters were recorded weekly: number of shoots, number of leaves, number of roots and height of the plants.

Figure 2, 3, 4 and 5 shows growth characteristics of *J. curcas* grown on top soil and bauxite mined soil that have been analysed by T-test. After 29 days of planting, significant difference in number of roots, number of leaves and plant height were detected in *J. curcas* grown on top soil, while *J. curcas* grown on bauxite mined soil showed only significantly increased in the number of leaves and plant height. The number of roots in *J. curcas* grown on bauxite mined soil remained unchanged ($p > 0.05$) as shown in figure 2. The highly compaction of bauxite mined soil causes the reduction of the water and nutrients uptake by the roots [13].

The number of shoots of plants grown on both top soil and bauxite mined soil remained unchanged after 29 days ($p > 0.05$) as shown in figure 3. In the present observation, most of the shoots formed during the vegetative propagation on peat moss for 30 days. Then, they continued to grow and formed leaves after transfer into respective top soil and bauxite mined soil. The duration of 29 days may be too short to initiate newer shoot.

Figure 4 shows the number of leaves in *J. curcas* grown on both top soil and bauxite mined soil increased significantly after 29 days of planting ($p < 0.05$). Several factors affecting the leaves production include suitable temperature, high light intensity and low soil moisture [14]. Similarly, plant height of *J. curcas* grown on both top soil and bauxite mined soil increased significantly ($p < 0.05$) after 29 days of planting as shown in figure 5. The main factor affecting the plant height is fertility of the soil [15] thus indicating that both soil have high fertility rate.

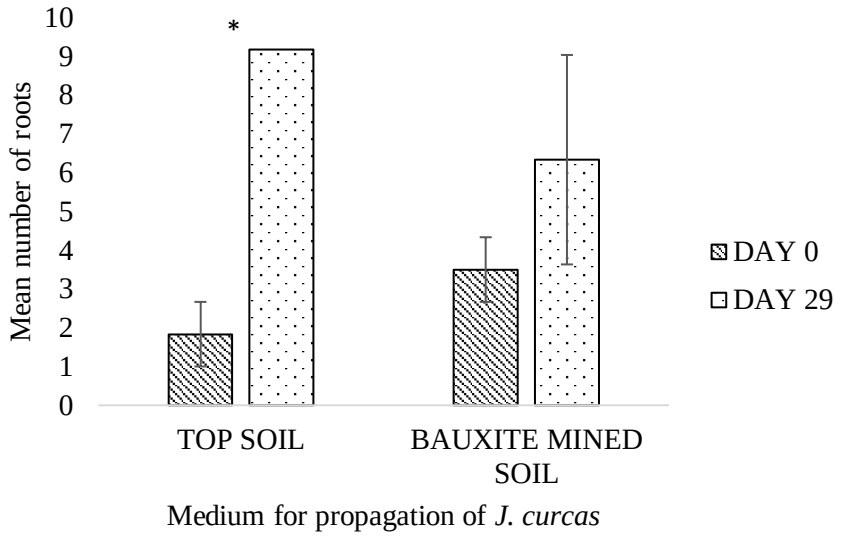


Figure 2. Number of roots on day 0 and day 29 of *J. curcas* grown on both medium (Error bars indicate standard error of the mean, and asterisk indicates significant difference between day 0 and day 29. ($P < 0.05$).

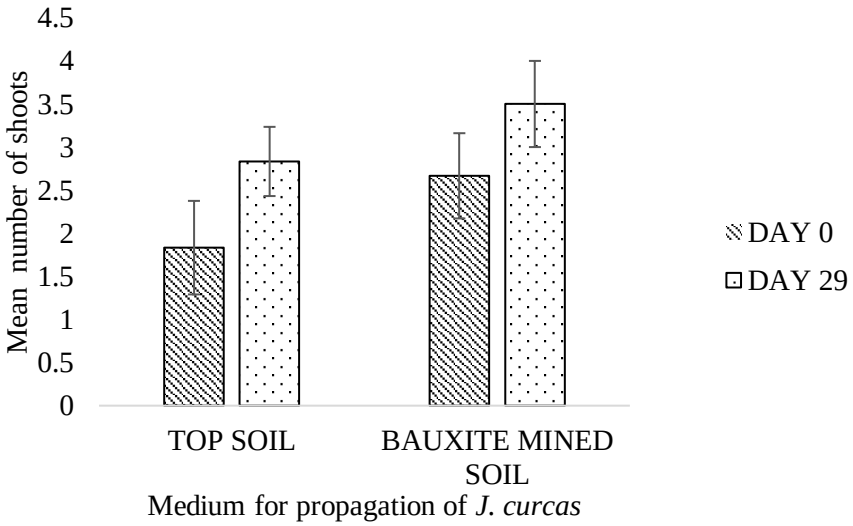


Figure 3. Number of shoots on day 0 and day 29 of *J. curcas* grown on both medium (Error bars indicate standard error of the mean, and asterisk indicates significant difference between day 0 and day 29. ($P < 0.05$).

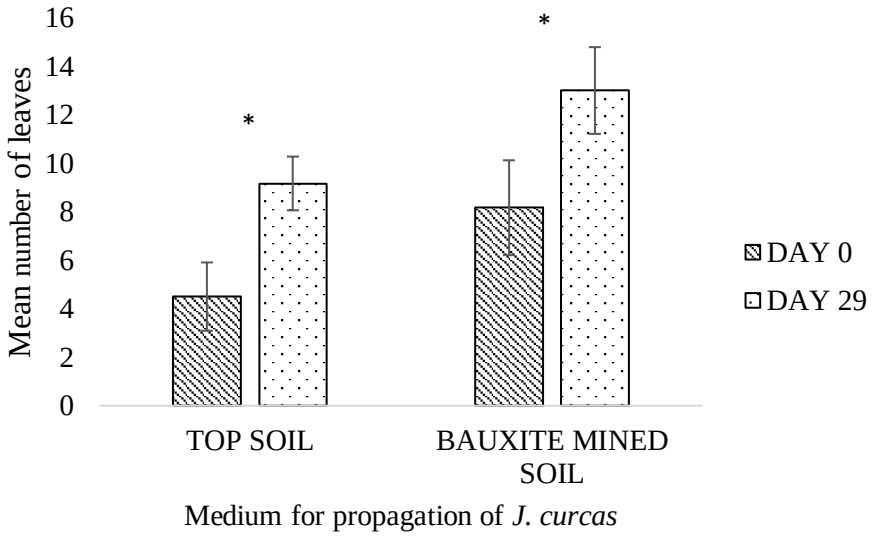


Figure 4. Number of leaves on day 0 and day 29 of *J. curcas* grown on both medium (Error bars indicate standard error of the mean, and asterisk indicates significant difference between day 0 and day 29. ($P < 0.05$).

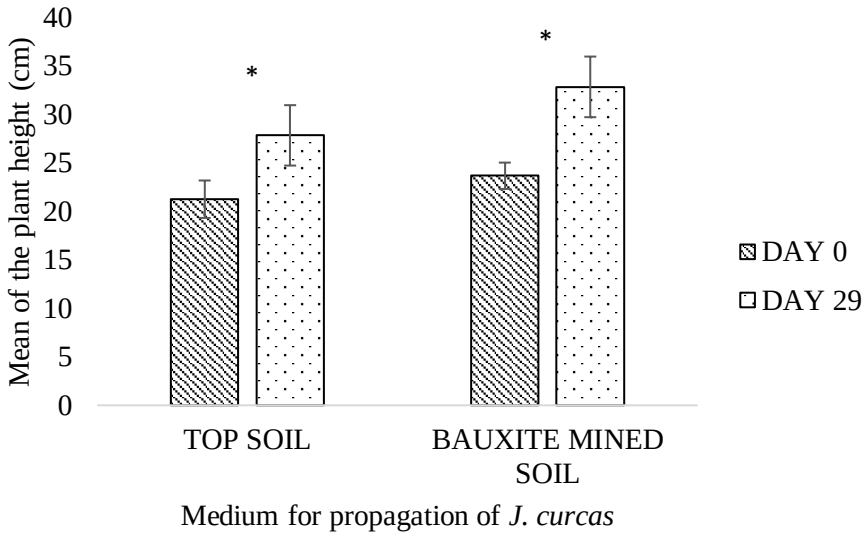


Figure 5: Plant height on day 0 and day 29 of *J. curcas* grown on both medium (Error bars indicate standard error of the mean, and asterisk indicates significant difference between day 0 and day 29. ($P < 0.05$).

4. Conclusion

Stem cutting method was used in the propagation of *J. curcas* as it took a shorter time and easier to propagate compared to direct seedlings and tissue culture method. Soft cuttings between the length of 18 to 29 cm were the most suitable starting materials for plant propagation using stem cutting method. Application of peat moss medium and rooting powder were good alternatives to speed up the root formation. The present study found that *J. curcas* could thrive and grow on bauxite mined soil. The number of leaves and plant height of *J. curcas* were significantly increased after 29 days of planting. Therefore, *J. curcas* has the potential to be used to restore the bauxite mined sites.

5. Acknowledgement

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