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Research Article

Root cutting on growth and yield of oil palm (*Elaeis guenesis* Jacq.)

Cecep Ijang Wahyudin [1,2], Hariyadi [3,*], Sudradjat [3], Sudirman Yahya [3], and Syaiful Anwar [4]

[1] Agronomy and Horticulture Study Program, Graduate School of Bogor Agricultural University (IPB University), Jl. Meranti Kampus IPB Darmaga, Bogor 16680, INDONESIA
[2] Pelalawan Indonesian Institute of Plantation Technology, Jl. Pangkalan Kerinci Kota, Kec. Pangkalan Kerinci, Kabupaten Pelalawan, Riau 28654, INDONESIA
[3] Departement of Agronomy and Horticulture, Faculty of Agriculture, IPB University (Bogor Agricultural University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, INDONESIA
[4] Departement of Soil Science and Land Resources, Faculty of Agriculture, IPB University (Bogor Agricultural University), Jl. Meranti, Kampus IPB Dramaga, Bogor 16680, INDONESIA
* Corresponding author (✉ hariyadi@apps.ipb.ac.id)

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IPB University

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ABSTRACT

Root cutting is speculated able to increase nutrient uptake by oil palm. The objective of this study was to investigate the effect of root trimming on the growth, flowering, and yield of oil palm. The research focused on oil palm plants aged five years old in the field. The experiment used a nested design with two key factors: root-cutting depth as the main plot and root-pruning intensity as the subplot. Results showed that root cutting at a depth of 0 to 20 cm from the soil surface followed by cutting intensities of 50% and 75% enhanced plant height at 0, 3, and 9 months after treatment. The treatments did not affect other variables including flowering and yield of oil palm trees.

Keywords: bunch weight; cutting intensity; root trimming; sex ratio

INTRODUCTION

Oil palm (*Elaeis guineensis* Jacq.) stands as an important commodity in Indonesia's economy. According to GAPKI data (2020), Indonesia emerged as the leading global producer of palm oil with production exceeding 51 million tons in 2019, comprising 47 million tons of Crude Palm Oil (CPO) and 4 million tons of Kernel Palm Oil (KPO). Despite Indonesia's vast planting area of 14 million hectares compared to Malaysia's 5.9 million hectares, Indonesia's palm oil productivity, at 3.40 tons per hectare, remains slightly lower than that of Malaysia, which stands at 3.81 tons per hectare (GAPKI, 2020; Parveez et al., 2021). Therefore, increasing oil palm productivity is important in Indonesia.

Oil palm trees start to produce fruit at 3 to 4 years after planting, and continue for 20 to 25 years. Fresh fruit bunch production increases gradually and reaches the maximum at 12 years after production before gradually declining and rejuvenation by replanting. Annually, Indonesia possesses 2.78 million hectares of oil palm land as potential for replanting due to declining productivity (Nambiappan et al., 2018).

It is speculated that one of the factors affecting low oil palm productivity is the effectiveness of nutrient uptake by roots. To address challenges associated with inadequate nutrient uptake, modifying root morphology emerges as a potential improvement. Root systems significantly influence oil palm nutrient absorption, encompassing root morphology, growth rate, and nutrient uptake capacity, along with chemical interactions with soil and water availability (Jourdan & Rey, 1997). Root density, root length, the presence of root hairs, and root tips are pivotal in water and nutrient absorption (Moelyohadi, 2015), with root density being particularly influential under favorable nutrient conditions.

In general, oil palm as a monocotyle, has a spherical rooting system underground that could be a limiting factor on nutrient absorption. Higher root density and root surface increase could increase the nutrient uptake zone. Root cutting or trimming is a traditional method in arboriculture that is able to stimulate new root branching in various plants, including peas (Cazenave et al., 2014) and citrus (Budiarto et al., 2019). Nevertheless, its study in industrial commodities like oil palm remains limited. Hence, this study aimed to investigate the effect of root trimming on the growth, flowering, and yield of oil palm.

MATERIALS AND METHODS

The research was conducted from January to October 2022 in Teluk Merbau Village, Dayun District, Siak Regency, Sri Indrapura – Riau. The study involved oil palm trees aged 5 years old in the field. It employed a nested plot design with two factors. The first factor, serving as the main plot, focused on root cutting depth, comprising two levels: 10 cm and 20 cm from the soil surface. The second factor pertained to the intensity of root pruning as the subplot, including levels of 25%, 50%, and 75%. Each level was combined to create six combinations, with additional untreated controls. Each treatment was replicated four times, resulting in 28 experimental units. Each unit consisted of 5 plants, totaling 140 plants. Root cutting was performed at 0, 3, and 9 months on selected trees as samples under uniform plant conditions.

Cutting depth and cutting intensity were made by digging the soil around the base of the oil palm tree (called inside circle or *piringan* in Indonesian). The distance of the hole to the tree base was 1.5 m; the total circumference was 9.43 m. The hole depth called cutting depth was 10 cm and 20 cm with similar width, i.e., 20 cm. The cutting intensity was the length of the hole along the circumference. Cutting intensity was setted 25%, 50%, and 75% representing the hole length about ¼, ½, and ¾ of circumference, respectively. Control intensity was no hole. Cutting root was repeated three times, i.e., 0 (first cutting), 3, and 9 months after first cutting. At the second and third cutting, all available roots at similar holes were removed. The hole was maintained open during the experiment.

The observed variables included plant height, stem diameter and circumference, number of flowers and fruits, and weight of fruit bunches. Plant height was measured using a Haga meter from the soil surface to the base of the 17th frond. Height measurements were conducted at the time of the first root cutting, 3, and 6 months after the first root cutting. Plant diameter and stem circumference were measured using a tape at the base of the stem. The number of flowers and bunches, as well as the weight of fruit bunches, were observed at intervals of two weeks for 8 months from the first root cutting.

Data were analyzed with a two-way analysis of variance. The significant differences in values among the treatments were determined by the Duncan multiple range test (DMRT) at a probability level of 5%. Statistical analyses of data were performed by SAS.

RESULTS AND DISCUSSION

Table 1 shows that root-cutting treatment had no significant effect on root distribution, both on primary roots, secondary roots, and tertiary roots. Meanwhile, according to research by Khoiri et al. (2018), root pruning at an intensity of 25%, 50%, and 75% had no significant effect on the distribution of secondary roots. Root cutting with an intensity of 75% in the present study reduced the number of all primary, secondary, and tertiary roots. It is probable that 75% of root pruning intensity restricted the growing of new primary roots. Pradiko et al. (2016) stated that the distribution of roots in oil palm plants is heavily influenced by the physical and chemical properties of the soil. These physical and chemical properties are influenced by tillage and cultivation systems.

Table 1. The number of primary, secondary, and tertiary roots in the treatment of cutting roots in oil palm.

Root cutting	Primary root		Secondary root		Tertiary root	
	0 month	9th month	0 month	9th month	0 month	9th month
Depth 10 cm intensity 25%	0.117a	0.093a	0.036a	0.028a	0.014a	0.011a
Depth 10 cm intensity 50%	0.076a	0.050a	0.013a	0.009a	0.005a	0.003a
Depth 10 cm intensity 75%	0.099a	0.057a	0.033a	0.019a	0.013a	0.007a
Depth 20 cm intensity 25%	0.079a	0.063a	0.028a	0.023a	0.011a	0.009a
Depth 20 cm intensity 50%	0.085a	0.056a	0.042a	0.028a	0.016a	0.011a
Depth 20 cm intensity 75%	0.056a	0.032a	0.010a	0.006a	0.004a	0.002a

Note: Value in columns followed by the same letter is not significantly different in the 5% Duncan level test.

Table 2 shows that root-cutting treatments do not affect tree height at 3 months after cutting, but affect at 9 months after first cutting treatment. Relative to control, cutting at a depth of 20 cm followed by cutting intensities by 50% and 75% demonstrated a significant effect. However, both treatments were not significantly different to the depth of 10 cm with a cutting intensity of 75%. This suggests that the depth and intensity of root cutting play a crucial role in regulating plant growth. This is attributed to the stimulation of new root growth resulting from cutting. It is probable that cutting treatments might affect the production of growth hormone; such speculation needs further research.

Table 2. Changing in tree height of oil palm from different cutting root treatments.

Root cutting	Increasing plant height (cm)*	
	3rd month	9th month
Control	7.23a	60.22b
Depth 10 cm intensity 25%	6.67a	60.98b
Depth 10 cm intensity 50%	7.34a	61.90b
Depth 10 cm intensity 75%	7.25a	65.00ab
Depth 20 cm intensity 25%	6.75a	58.76b
Depth 20 cm intensity 50%	6.75a	70.11a
Depth 20 cm intensity 75%	7.25a	70.10a

Note: The numbers of a column followed by the same letter are not significantly different in the 5% Duncan level test. * = relative to 0 month.

Root cutting is able to increase the growth rate of diameter at breast height (DBH), plant height, and volume to the highest level (Table 3). This root cutting depends on the distance from the stem which significantly affects the physicochemical properties and microbial activity in the rhizosphere soil (Louk & Raharjo, 2017). Poni et al. (1992) carried out research using pot trials for apple, grape, peach, and pear plants that were involved in root cutting; root cutting slows shoot growth in all species except peaches (20%, 30%, and 40% less than controls on grapes, pears, and apples respectively). Stressed plants and newly pruned root development typically have lower levels than controls (on average 25%). Plant growth is identical to control growth 50 days after root cutting. This demonstrated how well plants can adapt to changing environments via their roots.

Table 3 indicates no significant difference among root cutting treatments on stem diameter at 3 months and 9 months after treatment. This phenomenon may be attributed to various factors. Firstly, the duration of the study might have been insufficient to detect substantial variations in stem diameter across treatment groups. Secondly, the plants under investigation could have exhibited minimal genetic variability, leading to uniform responses to the treatment. Finally, the plants' robust regenerative capabilities might have facilitated swift recovery from root cutting, resulting in negligible discrepancies in stem diameter alterations.

Table 3. Increase of stem diameter of oil palm from different root-cutting treatments

Root cutting	Increase of stem diameter (cm)*	
	3rd month	9th month
Control	0.83a	2.23a
Depth 10 cm intensity 25%	0.88a	2.08a
Depth 10 cm intensity 50%	0.85a	2.85a
Depth 10 cm intensity 75%	0.85a	2.85a
Depth 20 cm intensity 25%	0.76a	2.76a
Depth 20 cm intensity 50%	0.77a	2.77a
Depth 20 cm intensity 75%	0.77a	2.77a

Note: The numbers of a column followed by the same lowercase letter are not significantly different in the 5% Duncan level test. * = relative to 0 month.

The diameter of oil palm stems increases with increasing age, directly impacting crop production (Yudistina et al., 2017). In pine seedlings, chemical root pruning influences height, diameter, shoot, and root biomass, as well as quality index (Uthbah et al., 2017). Additionally, root cutting can induce drought stress due to disruption in nutrient and water absorption, ultimately hindering stem and shoot diameter growth in plants (Yudistina et al., 2017; Fini et al., 2015). Nevertheless, root cutting significantly increases shoot dry weight by 22%, and the ratio of stem diameter to plant height by 13% compared to unpruned plants (Hedde et al., 2007). The number of oil palm inflorescence in the present study was not significantly different in male, female, and hermaphrodite inflorescences (Figure 1).

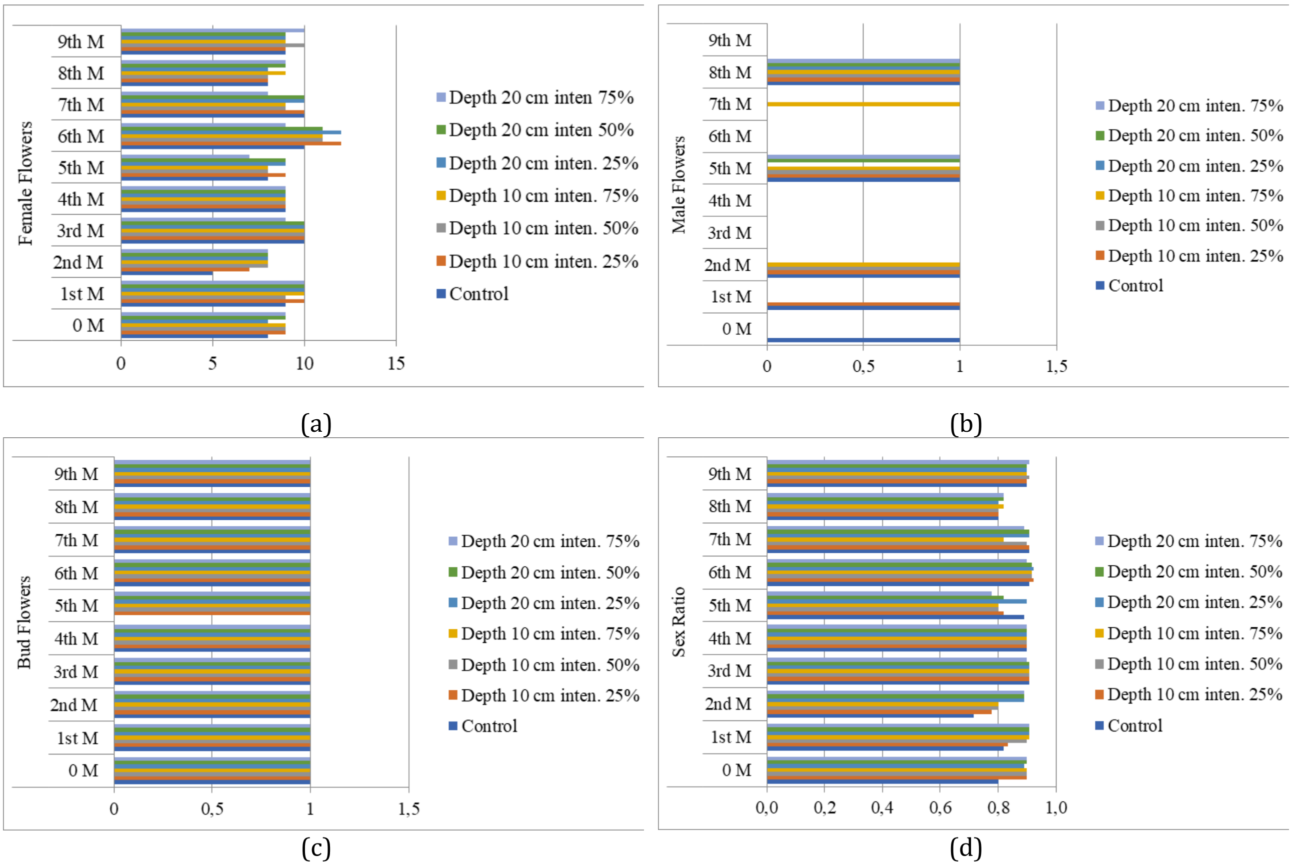

Figure 1. Number of oil palm flowers at 10 months after root cutting: (a) number of female inflorescence; (b) number male inflorescence; (c) number of flower bud; (d) sex ratio female to male inflorescences.

The research finding is in line with the research by Khoiri et al. (2018). Root cutting at an intensity of 25%, 50%, and 75% has no significant effect on the number of flowers of both male and female inflorescences. In the present study, male flowers appeared at certain months. It is speculated that root cutting stimulates water stress on oil palms. Drought stress in oil palms can be characterized by the appearance of many male flowers (Darlan et al., 2016). The sex ratio of female to male inflorescences was interesting in the present study (Figure 1d). Sex ratio affects the production of fresh fruit bunches (Haniff et al., 2014). The sex ratio is related to the availability of the number of male flowers to pollinate the female flowers.

Table 4. Weight of fruit bunches of oil palm from different cutting root treatments.

Root cutting	Weight of fruit bunches (kg) per harvest				
	0 month	1st month	2nd month	3rd month	4th month
Control	20.95b	19.16b	19.16a	16. 08a	22.11a
Depth 10 cm intensity 25%	20.93b	23.83a	20.01a	24.66a	23.93a
Depth 10 cm intensity 50%	16.41b	25.01a	22.46a	22.50a	23.16a
Depth 10 cm intensity 75%	16.33b	25.66a	17.61a	11.16b	17.83ab
Depth 20 cm intensity 25%	15.71b	25.50a	19.37a	21.16a	13.38b
Depth 20 cm intensity 50%	17.66b	25.08a	24.99a	19.33a	23.33a
Depth 20 cm intensity 75%	31.26a	23.33a	25.88a	15.83a	30.02a
	5th month	6th month	7th month	8th month	9th month
Control	13.83a	23.01a	12.91a	23.33a	24.41a
Depth 10 cm intensity 25%	19.83a	19.98a	25.75a	20.41a	19.66a
Depth 10 cm intensity 50%	19.13a	18.75a	23.16a	28.83a	26.01a
Depth 10 cm intensity 75%	14.88a	18.91a	24.66a	27.66a	24.16a
Depth 20 cm intensity 25%	15.39a	16.75a	25.15a	29.51a	23.41a
Depth 20 cm intensity 50%	21.75a	21.16a	24.21a	11.36b	24.41a
Depth 20 cm intensity 75%	15.91a	23.58a	18.16a	22.58a	23.33a

Note: The numbers of a column followed by the same letter are not significantly different in the 5% Duncan level test.

Table 5. Number of fruit bunches of oil palm from different root-cutting treatments.

Root cutting	Number of fruit bunches per plant									
	0 M	1st M	2nd M	3rd M	4th M	5th M	6th M	7th M	8th M	9th M
Control	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	1.0a	2.0a	2.0a
Depth 10 cm inten. 25%	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	1.0a	2.0a	2.0a
Depth 10 cm inten. 50%	2.0a	1.0a	2.0a	2.0a	2.0a	2.0a	2.0a	1.0a	2.0a	1.0a
Depth 10 cm inten. 75%	2.0a	2.0a	1.0a	1.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a
Depth 20 cm inten. 25%	2.0a	2.0a	1.0a	2.0a	2.0a	1.0a	2.0a	2.0a	2.0a	1.0a
Depth 20 cm inten. 50%	2.0a	1.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a
Depth 20 cm inten. 75%	2.0a	1.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a	2.0a

Note: The numbers of a column followed by the same letter are not significantly different in the 5% Duncan level test.

Table 4 shows that in general, the weight of the fruit bunches did not have a significant effect on the root cutting treatment. The difference in weight only occurs in certain months, namely in the 1st, 2nd, 4th, 5th, and 9th months. It is suspected that this difference is influenced by other factors such as nutrient availability conditions pollination factors and others. In addition, the root-cutting treatment also had no significant effect on the number of fruit bunches (Table 5). In general, root cutting induces the growth of new roots which have the potential to increase production increasing absorption of water and nutrients in the soil (Sterckeman et al., 2015). In some types of plants, root cutting is effective in increasing crop production, such as legumes (Carrillo et al. 2011). Increased production of oil palm is much influenced by the shape of the canopy and available nutrient conditions. This is because the condition of the plant canopy plays an important role in the process of photosynthesis, while the root factor plays an important role in the uptake of water and nutrients. So the canopy arrangement also needs to be considered in order to increase the amount of plant production (Gromikora et al., 2014). In addition to increasing production factors in oil palm plants root management is the third priority after crown and stem management (Kheong et al., 2012). So the plant production factors in oil palm are mostly controlled by the management of the upper organs of the plant compared to the management of the lower organs of the plant (Rahman et al., 2019).

CONCLUSIONS

Root cutting significantly stimulated plant height. Oil palm trees significantly had taller stems under treatment of root cutting at a depth of 20 cm and cutting intensity by 50% to 75% than other treatments. On the other hand, the treatments had no effect significantly on growth variables and flowering characteristics. Variations in fruit weight were observed, however, the effect of treatment was not consistent with the significant effect observed only in the 1st, 4th, 5th, and 9th months after particular treatments.

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