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Architecture Pruning Technique (Pollarding) of Moringa (*Moringa oleifera*)

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Abstract

Moringa is a fast-growing, deciduous tree that can reach a height of 10–12 m and is not traditionally pollarded in agriculture production. A field experiment was conducted between May 2023 and Jun 2024 in MARDI, Serdang to determine the effect of pollarding at different levels of pruning heights on vegetative growth and yield of Moringa. The trial was laid down in a randomized complete block design (RCBD) with four replications and five plants per plot and the data was analyzed using ANOVA in SAS (SAS 9.4) software. Differences between means were compared using Duncan's Multiple Range Test (DMRT) at $P \leq 0.05$. Five months after being cultivated on field condition, trees were pruned pollarding at four levels: 30, 60, 90 cm and control (unpruned). Subsequently, the growth performance was evaluated by collecting data on plant height, diameter of the main stem, length of the secondary branch, number of budbursts, diameter of the secondary branch and leave area. Meanwhile, the yield components were recorded based on the fresh weight and dry weight of the leaves. Results showed that different levels of pruning heights significantly affected overall dependent variables. Unpruned trees produced an optimal response for all dependent variables, but it is not suggested due to the trees growing erratically, challenging to harvest, and having an uneven canopy structure. Meanwhile, for the yield components' pruning at 60 and 90 cm from the ground level was comparable and did not differ significantly from unpruned trees. Therefore, pruning at 60 cm was suggested as an architecture pruning technique for moringa production cultivated on mineral soil under tropical climates. Pollarding can be a way to improve the productivity of agricultural produce, but further evaluation of yield trends must be conducted to ensure the consistency of production.

Keywords: *Moringa oleifera*; Pruning Height; Pollarding; Vegetative Growth; Yield components

1. Introduction

Moringa (*Moringa oleifera*) is a well-known plant, especially among Asians; in fact, this plant is known by a variety of names, including Miracle Tree, Mother's Best Friend, Horseradish Tree, Drumstick Tree, African Moringa, Moringa, Merunggai, and Kelor [1]. For generations, the leaves and fruits of this plant have been used for aesthetic and therapeutic purposes. However, as technology has evolved, inventive uses have emerged for downstream products (tea and essential oils), medicine, pharmaceutical products, and food formulations for human consumption and livestock industries [2]. The moringa tree, which originated in India and Pakistan before spreading to South Asian and African countries, has been cherished for centuries because of its exceptional properties. This plant is rich in nutrition (vitamins, minerals, and antioxidants) and has a diverse nutritional profile for health [3], drawing interest among researchers and a variety of industries until it was designated as a "superfood" plant by the World Health Organization (WHO).

Moringa is one of 13 unique genus species in the Moringaceae family [4]. This woody plant can grow up to 12 meters tall and has tripinnate compound leaves that are obovate or elliptical with a 1-2 cm leaf width [5][6]. This plant has white blossoms and fruit (pods) that can grow up to 1 m long and winged seeds with a unique shape [7]. It also has a

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high level of resilience and adaptability to environmental variations. In practice, this plant is propagated by seeds, and according to moringa farmers in Malaysia and Indonesia, seeds are used as plant material for large-scale seedling production because they are more easily obtained in large quantities than stem cuttings. The initial harvest can be done 5-6 months after planting with subsequent harvests every 30-40 days after pruning.

Nowadays, Moringa industries have recently emerged and farmers are switching to farming this crop due to the high domestic demand and commercial potential of this commodity for export and import purposes. Based on Global Market Insight 2019, the global Moringa leaf powder market is expected to reach USD 6 billion by 2025, owing to increased demand in the dietary supplement and food industries [8]. From an economic perspective, this crop has the potential to create income for farmers because raw material production in the country is currently insufficient for the production of downstream products such as formulation in the food industry and therapeutic purposes. Up to this point, India has been the leading producer, producing between 1.1 and 1.3 million metric tons of fruit per year, while Indonesia has been recognized for its exports of dried leaf powder to the United States, China, Australia, and Japan [9].

Insufficient local produce of Moringa leaves economically affects the industry's ability to develop new products and formulations for superfoods purposefully for health benefits. Agronomic practices play an essential role in boosting the production of raw materials. Pollarding is a traditional practice consisting of topping the trunk of a tree and pruning all branches [10]. Pollarding the trees may reduce the light and water competition of the trees and consequently enhance crop yield [11]. To have adequate productivity, the trees should be pruned promptly because biomass production highly depends on these practices [12]. Understanding Moringa's fundamental response to pruning (pollarding) provides valuable knowledge for manipulating the plant in the future to promote vegetative and reproductive growth on mineral soil in the hot and humid tropical climate of Selangor, Malaysia. Subjecting Moringa trees to pollarding techniques with different levels of pruning heights should reveal whether their growth initiation is significantly affected by pruning activity. Therefore, this study aimed to determine the effect of pollarding at different levels of pruning heights on vegetative growth, branch biomass and yield of *Moringa oleifera*, which are not traditionally pollard, in agricultural production.

2. Material and methods

2.1. Plant material and experimental plot setup

Seeds were sampled at Ladang Organik Bersepadu MARDI, Headquarters, Serdang, Selangor (2°59'30"N, 101°41'43"E). Healthy seeds were classified manually by removing all the impurities, abnormal and out-of-shape seeds. The seeds were tested for viability using the tetrazolium test according to the ISTA Rules for Seed Testing [13] with a concentration of 0.01%, and a germination test was conducted. Three-month-old seedlings with uniform plant height were selected and transplanted in a field experiment (2°98'43"N, 101°70'45"E) with an area of cultivation of 7 m × 30 m. Land preparation was done using mechanization by plowing, rotor, and raised bed, while the organic matter was spread manually (3 t/ha). Planting system with 1 m × 1 m plant spacing and a plant population of approximately 10,000 trees per ha. The compound fertilizer of NPK (12:12:12) with an amount of 250 kg/ha was used, and the fertilizer was given every month.

2.2. Soil physical analysis and precipitation data (monthly rainfall)

Moringa trees were susceptible to high moisture content and saturated soil. The trees can't withstand high water-holding capacities and are susceptible to disease. A physical soil analysis and monthly rainfall was conducted and recorded to test the soil texture, bulk density, moisture content, and porosity (Table 1) (Figure1). Eight points of soil samples were tested at two different soil depths: 0 - 0.5 cm and 5- 10 cm. The soil was classified as clay soil, and the bulk density of the soil samples averaged 1.32 g/cm^3 at both depths. The ideal value for clay type is < 1.10 g/cm^3. However, values close to or greater than 1.39 g/cm^3 will affect root growth in soil, while > 1.47 g/cm^3 will limit root growth in soil as referred to USDA. The optimal soil porosity of agricultural land is 50%, and based on soil porosity analysis, it is at the optimum level.

Table 1 Physical soil analysis at two different soil depths sampled within an experimental plot

Point	Depth	Bulk density (g/cm³)	Moisture content %	Porosity	Sand	Clay	Silt	Texture
1	0-5 cm	1.27	3.27	0.52	30.65	52.5	16.8	Clay
2	0-5 cm	1.08	34.84	0.59	31.5	55	13.5	Clay
3	0-5 cm	1.19	14.84	0.55	30.1	52.5	17.4	Clay
4	0-5 cm	1.73	-16.47	0.35	26.6	67.5	5.9	Clay
5	5-10 cm	1.32	21.64	0.5	27.8	40	32.2	Clay
6	5-10 cm	1.21	28.65	0.54	28.1	55	16.9	Clay
7	5-10 cm	1.3	21.15	0.51	30.7	52.5	16.7	Clay
8	5-10 cm	1.32	22.73	0.45	28	42.5	29.5	Clay

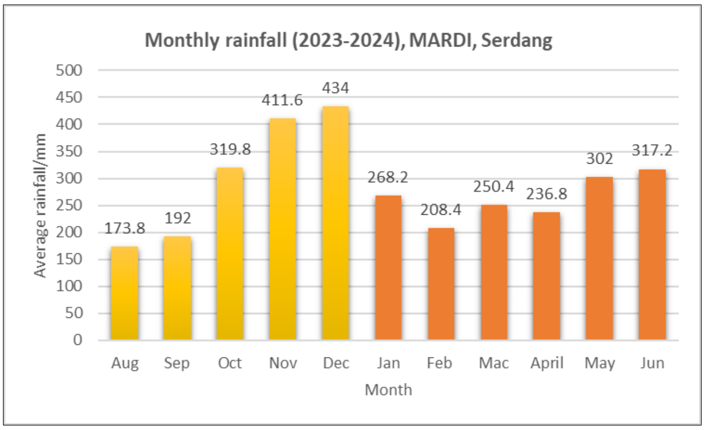

Figure 1 Monthly rainfall was recorded from August to Jun 2024

Monthly rainfall was averaged and monitored from August 2023 to June 2024 in MARDI Headquarters, Serdang (figure 1). The trend of monthly rainfall was observed slightly fluctuated start January - June 2024 as compared to August - December 2023. Planting activities began in February 2024, and based on the rainfall distribution data, there was an increase of 35.5% in the study area from February to June 2024.

2.3. Growth performance and yield components

Figure 2 Vegetative growth of moringa; a) 1st week after pruned, b) 2nd weeks after pruned and c) a month after pruned

The height and diameter at 10 cm from the ground level of each tree (pollard and control: a total of 80 trees) were measured monthly. Plant growth performances (plant height (cm), basal stem diameter (mm), leave area (mm2), length of secondary branch (cm), number of budbursts) of each tree were monitored every two weeks, starting on February 22, 2024. The phenology of the 80 trees was recorded simultaneously, documenting four stages: budburst, end of short shoot expansion, end of long shoot expansion, and leaf fall (Figure 2). Each cut branch's number and basal diameter were measured at the second pollarding. Pruning (1st cut) was carried out on 4-month-old seedlings, and data on yield components (fresh weight of leaves (g) and dry weight of leaves (g)) were collected every month consecutively.

3. Results and discussion

3.1. Growth rate (plant height and basal diameter) four months before pruning

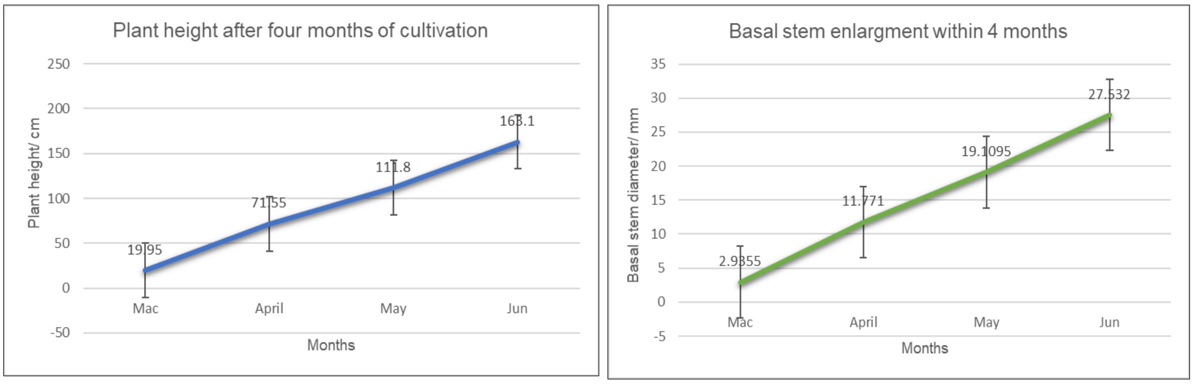

Figure 3 Average of plant height and basal diameter monthly (Mac – Jun) before 1st cut

Moringa growth rates (plant height and basal stem diameter) were observed in the first two weeks until the treatment of pruning height was executed at four months of cultivation periods. This data reveals how vigorous and significant this study of pruning height was carried out for Moringa trees to maintain the desired height to ease the cultural practices and harvesting activity for Moringa production. These data can be as a baseline of the growth rate of Moringa on field cultivation for four-month cultivation periods before pruning. Based on Figure 3, the maximum plant height was recorded at 1.6 m and the main stem elongated steadily in the range of 51 – 59 cm each month. At 1.6 m height, the trees required extra tools (ladder and pruning saw) to ease the harvesting activity. Moringa is a deciduous tree or shrub with a mature height of about 12 meters and is a fast-growing, drought-resistant plant [5].

Basal stem diameter of Moringa enlarged from 2.93 mm to 27.53 mm (24.6 mm increase). The growth rate with respect to the plant height was discovered to be affected by increments in stem diameter size. Enlargement of stem diameter was discovered to result in an increment ranging from 7 mm – 9 mm per month. According to [15], study on the varied stem diameter sizes, the plant height increased linearly with the stem diameter it was observed, the linear increase was noted to be non-significant.

3.2. Growth performance of Moringa after one month of pruning (1st harvesting)

Table 2 Data on the growth performances of Moringa after a month of pruning

Treatments (Pruning height)	Plant height (cm)	Diameter of main stem (mm)	Number of budbursts	Diameter of secondary main branch (mm)	Length of secondary branch (cm)	Leave area (mm^2)
T1 (30 cm)	109.038d	46.535a	10.5b	37.078a	76.9b	4779a
T2 (60 cm)	131.05c	44.493b	11.25b	32.07ab	71.05b	6103a
T3 (90 cm)	154.55b	45.995ab	11.5b	29.013b	64.55b	5752a
T4 (Control)	291.65a	48.91a	17.25a	30.038b	291.65a	6729a
p-value	**	*	*	*	*	ns

**significant at 1% probability level, * significant at 5% probability level, ns: Not significant. Mean values in the same column followed by the same letter are not significantly different at p<0.05 Duncan's Multiple Range Test (DMRT)

A significant effect (P<0.05) was observed for the tree that was subjected to pollarding pruning at different levels of pruning height (30, 60, and 90 cm) for most of the dependent variables of growth performance (plant height, diameter of main stem, number of budbursts, and length of secondary branch) (Table 2). This indicates that when the moringa tree is pruned by removing the top vegetative part, it will influence the growth rate and thus impact the yield components. Among the treatments, T4 (control) recorded the highest plant height (291.65 cm) and showed significant differences compared to T1, T2, and T3. Control trees, remain undisturbed, and strive for the highest plant height. Meanwhile, for the diameter of the main stem, T1 (46.53 mm) and T4 (48.91 mm) recorded the most significant enlargement of the primary stem compared to other treatments. Results also showed that the number of bud/shoot emergences significantly increased from T1 (10.5) to T4 (17.25) as the levels of pruning height increased.

The maximum budburst was seen at T4, where an unpruned main stem can produce more buds/shoots per tree than pollard trees. The results also revealed a significant difference in the trees cut to the lowest pruning point from the ground level, which grew larger and regenerated the largest secondary branch diameter compared to the control. The length of secondary branches grew at a similar pace, and the stem extended consistently for T1, T2, and T3, indicating no significant differences compared to the control. The leaf area did not differ significantly across the treatments.

Understanding moringa's basic structure and responses to different pruning strategies (pollarding) is vital. Moringa trees require a specific pruning technique to ensure the correct level of cutting height for optimal growth in cultural practices, particularly for harvesting. After being transplanted into the field, the Moringa tree thrives and develops strongly, reaching a height of 2 - 3 metres (Table 2) after 4-5 months of cultivation in mineral soil. Pollarding and coppicing have been proposed as pruning methods to induce branching, increase productivity, and facilitate harvesting [13]. Moringa is typically pollarded to a height of one to two metres to promote branch regrowth.

The observation of plant height revealed that T4 (control), an unpruned tree, had the most significant plant height (291.65 cm) after 3 - 4 months of cultivation, which affected harvesting activity, as it required specific tools to collect the green leaves. The main stem diameter differed significantly by different pruning height levels and increased linearly with plant height [14]. Inconsistency in stem diameter was observed in this study, where lower pruning heights stimulated larger stem growth due to more vigorous regrowth, whereas higher pruning heights could redirect resources to lateral growth, influencing stem diameter differently and contradicting the results reported by [16]. In addition, a different pattern was detected in the diameter of the secondary stem, where T1 has a higher stem circumference than T4. However, stem circumference was increased over time in all treatments, and further evaluation was conducted before concluding this data.

The number of budbursts was manually counted after two weeks of pruning, and based on the observations, the higher the pruning height, the more buds/shoots produced per tree. According to [17], cutting at 1 m resulted in more branches with sparse leaves and increased the formation of lateral buds when compared to 20 cm, 40 cm, and 50 cm. The taller the main stem, the more potential buds/shoots emerge. Additionally, the availability of carbohydrates and proteins is crucial for the formation of new sprouts after pruning [18].

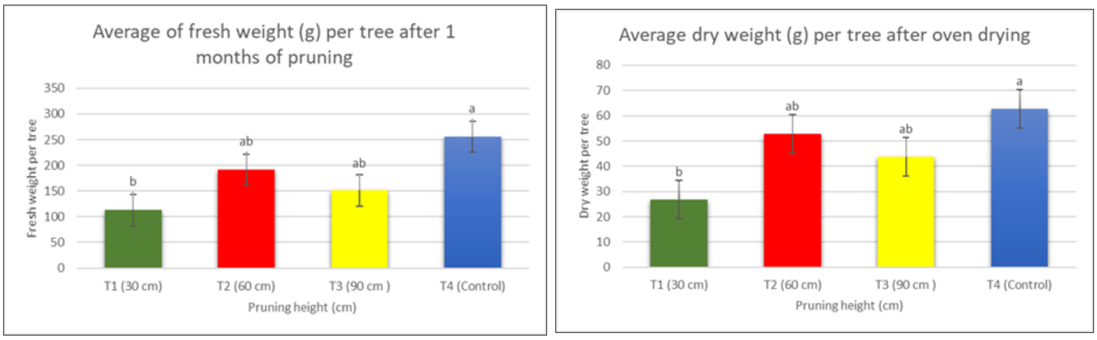

Figure 4 Average of the fresh and dry weight of leaves per tree after one month of regrowth on field condition

The yield components (fresh and dry weight of leaves) were harvested and measured after one month of pruning. The fresh weight gradually increased with pruning height (Figure 2). There were significant differences in fresh and dry weight between treatments harvested after one month of cutting. T4 (control) recorded the highest yield of 255.55 g, but no significant differences were observed as compared to T3 (151.49 g) and T2 (191.48 g), respectively. However, the yield declined by 21% between T2 and T3. Pruning at 90 cm would leave enough nodes and enable the harvest of mature stems at the second harvest [19]. A similar trend was observed in dry weight, where the higher the level of pruning height, the heavier the yield recorded. Other studies also revealed similar results when maximum and minimum dry leaf biomass were obtained at 0.5 m cutting height and control (un-pollarded [20]. Similar to [16], moderate pruning recorded significantly higher fresh weights than light, and generally moringa trees are sensitive to climate conditions, where the highest fresh and dry weights were obtained during the dry conditions, which were partially correlated to temperature and rainfall over time.

4. Conclusion

In summary, pollarding pruning (manipulating different levels of pruning height) had a substantial impact on moringa trees. T4 (control) produced an optimal response for all dependent variables, but it is not suggested because the trees grow erratically, are challenging to harvest, and have an uneven canopy structure. Meanwhile, for the yield components, pruning at 60 and 90 cm from the ground level (pollarding) was comparable and did not differ significantly from unpruned trees. Therefore, it was suggested as an architecture pruning technique specifically for moringa production on mineral soil and tropical climates (hot and humid).

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there are no conflicts of interest to be disclosed.

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