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YIELD AND PRODUCTIVE CENTERS OF HYBRID COFFEE AS AFFECTED BY POPULATION DENSITY AND PRUNING METHODS

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ABSTRACT

The production and productivity of coffee are significantly influenced by several factors, including the utilization of unimproved varieties and poor agronomic practices. To address this issue, it is crucial to implement recommended agronomic technologies, such as spacing and pruning methods. This study aimed to determine the appropriate spacing and pruning methods that would enhance the yield of hybrid coffee (Gawe) in Jimma, Southwest Ethiopia. The study spanned seven consecutive cropping seasons from 2014 to 2021 at the Jimma Agricultural Research Center which had nine treatment combinations with three spacing (2.5m*2.5m, 2.0m*2.5m, 2.0m*2.0m) and three pruning methods (capped and topped multiple stems, capped and un-topped multiple stems and free growth) were used. The treatment combinations were arranged in a factorial randomized complete block design with three replications. The clean coffee yield, nonproductive centers (dead and nonbearing branches), productive centers (bearing and new growth branches) and canopy diameter were recorded and analyzed using statistical software (SAS). The result revealed that the highest clean coffee yield was obtained from 2.0m*2.0m followed by 2.0m*2.5m with the respective values of 2333.9kg/ha and 2294.7kg/ha from free growth practice. In contrast, the lowest clean coffee yield (1375.8kg/ha) was obtained from a wider spacing of 2.5m*2.5m with capped and un-topped multiple stems. Similarly, the highest coffee tree nonproductive and productive centers were obtained from closer spacing with free growth practice. The findings indicated that the implementation of pruning methods increased the canopy diameter of the coffee tree. Therefore, it can be concluded that a spacing of 2.0m*2.0m, combined with free growth enhances both yield and productive centers for hybrid coffee variety (Gawe) in mid altitude areas like Jimma. Additional investigation is necessary for the spacing and pruning techniques employed for recently introduced hybrid coffee varieties across different agroecologies.

Keywords: Arabica coffee, Bearing heads, Coffee tree management, Population density

1. INTRODUCTION

Ethiopia serves as the origin and hub of diversity for Arabica coffee, with its growth being adaptable to various agroecologies and a wider range of altitudes, temperature, rainfall, humidity, and soil types [1-3]. However, despite the abundant genetic diversity, the national coffee yield per unit area remains low due to several factors, including the lack of utilization of improved coffee varieties and poor agronomic practices [4-7].It is important to note that solely relying on improved varieties is insufficient to enhance both yield and quality of the crop. The implementation of appropriate agronomic technology, such as optimum planting

space and pruning practices, is crucial [8]. Previous findings has demonstrated that coffee is more suited for a dense planting system and high population density contribute to increased coffee production by effectively utilizing environmental resources such as light, moisture and nutrients throughout the growing period [4, 9-13].

Nevertheless, in the absence of coffee tree management practices such as pruning, the dense population of coffee trees leads to overlapping or mutual shading and aging, resulting in a decrease in coffee yield [13-14]. Various integrated agronomic practices, as highlighted by [15] and [16], have been found to enhance coffee productivity. The research conducted by [8, 17] and [18] demonstrated that both population density and pruning practices significantly influenced the yield and productivity of coffee. However, the utilization of optimal spacing and pruning methods in mid-altitude regions like Jimma for hybrid coffee (Gawe) remains unexplored. Therefore, the aim of this study is to determine the suitable spacing and pruning methods that can enhance the yield of hybrid coffee in Jimma, Southwest Ethiopia.

2. MATERIALS AND METHODS

The experiment was conducted for seven consecutive cropping years (2014 to 2021) at Jimma Agricultural Research Center. The study site is representing mid altitude (1750 meters above sea level) which receives a mean total rainfall of 1556.9 mm per annum and has mean minimum and maximum temperatures of 11.3℃ and 26.2 ℃, respectively. Hybrid coffee variety (Gawe) which has an intermediate canopy nature and released for mid altitude areas was used for the study. Nine factorial combinations of 3 spacing (2.5m*2.5m, 2.0m*2.5m and 2.0m*2.0m) and 3 pruning methods (capped and topped multiple stems (CTMS), capped and un topped multiple stems (CUTMS) and free growth) were arranged in randomized complete block design with three replications. Coffee seedlings were raised as per recommendation and at six pairs of leaves vigor and healthy seedlings were transplanted to the field. After a year of field transplanting, the young coffee plants were trained in three pruning methods: *Capped and topped multiple stems (CTMS)*: the newly growing stems were capped at 45cm height to get the required two verticals and topped at a height of 2.20m. *Capped and un topped multiple stems (CUTMS)*: the young coffee seedlings that were capped at 45cm height to encourage two verticals and allowed to grow freely. *Free growth (FG)*: only dried branches and de-suckering (whippy and stunted young suckers) were removed. The experimental plots were planted with *Acacia abyssinica* shade trees and all field management practices were carried out according to recommended practices [5]. Various parameters such as coffee yield, dead branches, nonbearing branches, bearing branches and new growth branches, and canopy diameter were recorded. The productivity of coffee tree was evaluated at the end of the experiment by categorizing the branches into nonproductive centers (dead and nonbearing branches) and productive centers (bearing and new growth branches). All collected data was summarized and subjected to analysis of variance (ANOVA) using the SAS 9.0 software. Treatment means separation was done by least significant differences (LSD) at a 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Coffee Yield

The result revealed that a significant difference ($P<0.05$) was observed between treatments for the mean clean coffee yield, as shown in Table 1. The highest clean coffee yield was obtained with a spacing of 2.0m*2.0m, resulting in a yield of 2333.9kg/ha followed by spacing of 2.0m*2.5m (2294.7kg/ha) from free growth practice. On the other hand, the lowest clean coffee yield of 1375.8kg/ha was recorded with a wider spacing of 2.5m*2.5m, where

the coffee plants had capped and un-topped multiple stems (Table 1). Figure 1 illustrates the consistent coffee yield achieved through closer spacing in different cropping seasons when implementing the free growth. In general, the yield was higher with closer spacing compared to wider spacing. This finding is consistent with the report by [17], which also found that the highest clean coffee yield was obtained with closely planted coffee using a spacing of 2.0m*2.0m and the free growth habit. Coffee is well-suited for dense planting systems, and its yield increases with higher population density up to a certain level. This is because dense planting allows for efficient utilization of environmental inputs such as light, moisture, and nutrients [4, 9].

The result indicated that the free growth treatment resulted in the highest yield of clean coffee yield compared to the other treatments. The emergence of new suckers or verticals played a significant role in contributing to the yield in the free growth management practice when compared to other treatments. Previous studies have also reported similar findings, highlighted the presence of numerous verticals or bearing heads of varying ages in free growth coffee trees, which contribute to sustaining the coffee yield over time [8, 12]. These findings align with the research conducted by [17], who found that the clean coffee yield was significantly influenced by the interaction effects of planting space and vertical numbers, as well as the main effects of vertical numbers. It was observed that the yield level increased with an increasing number of verticals, and previous studies have shown that the higher yield performance in free growth is attributed to a greater number of bearing heads [18, 19].

Table1. Mean clean coffee yield (kg/ha) of hybrid coffee as influenced by population density and pruning practices

Treatments	Mean clean coffee yield (kg/ha)		
Spacing (m)	Pruning methods		
	CTMS	CUTMS	FG
2.5*2.5	1651.41^{bc}	1375.83^{c}	2035.57^{ab}
2.0*2.5	1587.34^{bc}	1698.75^{bc}	2294.76^{a}
2.0*2.0	1964.28^{ab}	1998.23^{ab}	2333.90^{a}
LSD (5%)			560.18
CV (%)			14.37

CTMS=capped and topped multiple stems, CUTMS= capped and un-topped multiple stems, FG= free growth). Figures followed by same letters are not significantly different at 5% probability level.

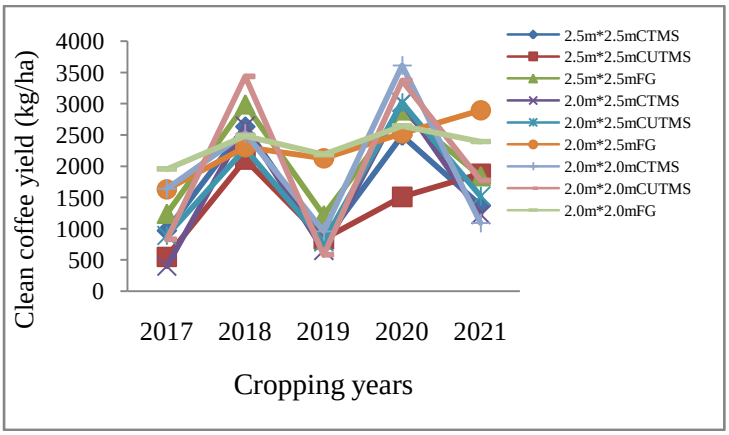

Figure1. Hybrid coffee yield across cropping season from 2017-2021. CTMS=capped and topped multiple stems, CUTMS= capped and un-topped multiple stems, FG= free growth.

3.2. Coffee tree productive centers and canopy diameter

The result showed that the coffee tree productivity centers were significantly influenced by the interaction effect of spacing and pruning methods. Closer spacing (2.0m*2.0m) with free growth resulted in the highest numbers of dead, nonbearing, bearing and new growth branches. Conversely, the lowest productive centers (bearing and new growth branches) were recorded from multiple stems were capped and topped (Table 2). The presence of a large number of dead and nonbearing branches in free growth may be attributed to dark respiration caused by mutual shading. A similar pattern was observed for bearing and new growth branches due to the abundance of freely growing verticals. This finding aligns with previous studies conducted by [17] and [12], which also reported that closer spacing with unrestricted growth resulted in the highest levels of productive centers, while nonproductive centers exhibited similar trends.

The result showed that the act of pruning improved the diameter of the canopy (Figure 2). When the coffee trees were topped at the top, the diameter of the canopy increased, indicating that apical dominance was regulated, lateral growth was stimulated, and ultimately, the canopy diameter was enhanced. This finding aligns with a previous study, which also reported that pruning practices resulted in a higher canopy compared to free growth [17, 18].

Table 2. Coffee tree nonproductive and productive centers as affected by population density and pruning practices

Spacing (m) *pruning methods	**Nonproductive centers (%)**		**Productive centers (%)**	
	Dead branches	Nonbearing branches	Bearing branches	New branches
2.5*2.5CTMS	22.52^{c}	16.33^{cd}	22.96^{bc}	0.13^{d}
2.5*2.5CUTMS	27.33^{c}	27.80^{b}	24.27^{bc}	9.42^{cd}
2.5*2.5FG	52.33^{b}	40.0^{a}	41.67^{ab}	41.67^{b}
2.0*2.5CTMS	26.73^{c}	8.69^{d}	18.31^{c}	0.11^{d}
2.0*2.5CUTMS	24.86^{c}	21.67^{bc}	26.75^{bc}	9.40^{cd}
2.0*2.5FG	60.03^{ab}	40.0^{a}	42.11^{ab}	40.33^{b}
2.0*2.0CTMS	23.73^{c}	14.8^{cd}	14.53^{c}	0.14^{d}
2.0*2.0CUTMS	26.67^{c}	12.33^{d}	16.73^{c}	14.02^{c}
2.0*2.0FG	71.33^{a}	42.77^{a}	60.22^{a}	71.33^{a}
LSD (5%)	13.23	11.04	19.33	9.39
C.V (%)	20.50	25.58	37.57	26.18

(CTMS=capped and topped multiple stems, CUTMS= capped and un-topped multiple stems, FG= free growth). Figures followed by same letters are not significantly different at 5% probability level.

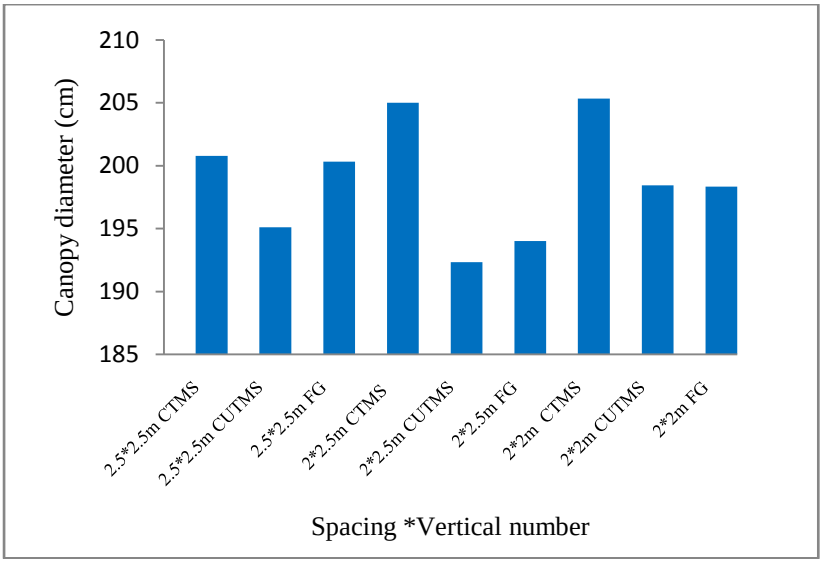

Figure2. Canopy diameter

4. Summary and Conclusion

The mean clean coffee yield and coffee productive centers were significantly influenced by the interaction effect of spacing and pruning methods, as revealed by the findings. Maximum yield was obtained from closer spacing with free growth. Likewise, closer spacing with free growth practice resulted in the highest coffee tree productive centers (bearing and new growth) branches. In addition to this, pruning methods improved the diameter of the canopy as compared with free growth. Therefore, it is advised to use a 2.0m*2.0m spacing with free growth for the hybrid coffee variety (Gawe) in mid altitude regions such as Jimma, as this promotes increased yield, bearing and the development of new growth branches.

5. Recommendations

Further examination is required for the spacing and pruning techniques utilized for recently introduced hybrid coffee varieties in various agroecologies.

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Abbreviations

CTMS: Capped and topped multiple stems
CUTMS: Capped and un-topped multiple stems
FG: Free growth

Conflicts of Interest

All the authors do not have any possible conflicts of interest.

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