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Effects of Vertical Number and Topping Practice on Growth and Yields of Stumped Coffee (*Coffea arabica* L.) at Awada South Ethiopia

Leta Ajema Gebisa

Ethiopian Institute of Agricultural Research, Awada Agriculture Research Sub-Center, Yirgalem, Ethiopia

Email address:
letajema@gmail.com

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Abstract: Coffee (*Coffea arabica* L.) is known to be one of the most important beverages in the world and is a very important source of foreign exchange for many countries. Old coffee rejuvenation or stumping is one of the most and commonly used by coffee producing countries for productivity enhancements methods especially for those poor productive due to old age and as well as genetic conservation practice. The most and large coverage of old coffee plantation is the most production constraints in almost all coffee growing areas of Ethiopia. A field experiment was conducted at Awada Agriculture Research Sub-center experimental site between 2013 and 2020 with improved south Ethiopian coffee selections to determine appropriate Vertical number and topping practices for enhanced yield and yield component. Four vertical or bearing head number and topping practices (Topped single stem, Topped multiple stems, Untopped multiple stems, and Free Growth) were used as treatments and laid out in a randomized complete block design (RCBD) with three replications, to identify the effects of old coffee tree stumping and number of verticals with topping practice. Analysis of variance revealed that; clean coffee yields and growth parameters were significantly influenced by the different numbers of verticals and also topping practice. The analysis of variance also revealed highly significant yield variations among topping practice and the number of verticals. Free growth and topped multiple stems revealed the highest and statically similar yield performance throughout the cropping season as compared to the other treatments. Therefore, these finding indicates that topping practice and the number of verticals significantly promoted the yield responses of Arabica coffee cultivars under field condition. Therefore, topping multiple stems and free growth were selected as a promising practice to enhance coffee yield and yield components.

Keywords: Coffee, Vertical Number, Pruning, Stumping, Topping

1. Introduction

Coffee (*Coffea arabica* L.) is known to be one of the most important beverages in the world and is a very important source of foreign exchange for many countries [1]. For Ethiopia's coffee is the most important export commodity, which covered/cultivated by over 6 million smallholder farmers in the country, and accounting for about one-third of the country's commodity exports [2]. Even though coffee production has increased over the last decade, several productivity constraints like too old coffee tree coverage remain very challenge full for small scale coffee producers that is the leading productivity or low-yielding coffee trees in particular, the sector cannot attain its full potential [2].

High density planting, may lead, to more favorable conditions for the maintenance of gas exchange, increasing crop yield [3]. Old coffee rejuvenation or stumping is one of the most and commonly used by coffee producing countries for productivity enhancements methods especially for those poor productive due to old age and as well as genetic conservation practice [4].

Most of the world's coffee report has been indicated as coffee plantation is fewer than 2500 trees ha^{-1}. However, several reports have also indicated that coffee may be more suitable to high density plantings [5]. Even some evidence suggests an optimal planting density of about 5000 trees ha^{-1} for short stature cultivars of arabica coffee [6] for the new plantation, but there is no report that indicate the effect of a

vertical number and topping practice on coffee yield and yield components of old coffee tree stumped at the study area. Therefore, the experiment was aimed to study the effect of a vertical number and topping practice on coffee yield and yield components at Sidama Region of Ethiopia.

2. Material and Methods

2.1. Site Descriptions

An experiment consisting of two promising improved south Ethiopian coffee selections with distinct compact type (85/238) was conducted at Awada Agriculture Research Sub-center experimental site, south Ethiopia. Awada Agricultural Research Sub-center is situated in the Tepid to cool semi arid mid highland agro-ecology. It is located at about 315 km south of Addis Ababa at 603' N of latitude and 380 E of longitude at an altitude of about 1740m a.s.l nearby Yirgalem town. The area has a semi-bimodal rainfall distribution characterized by double wet and dry seasons with an average precipitation of 1342 mm per annum.

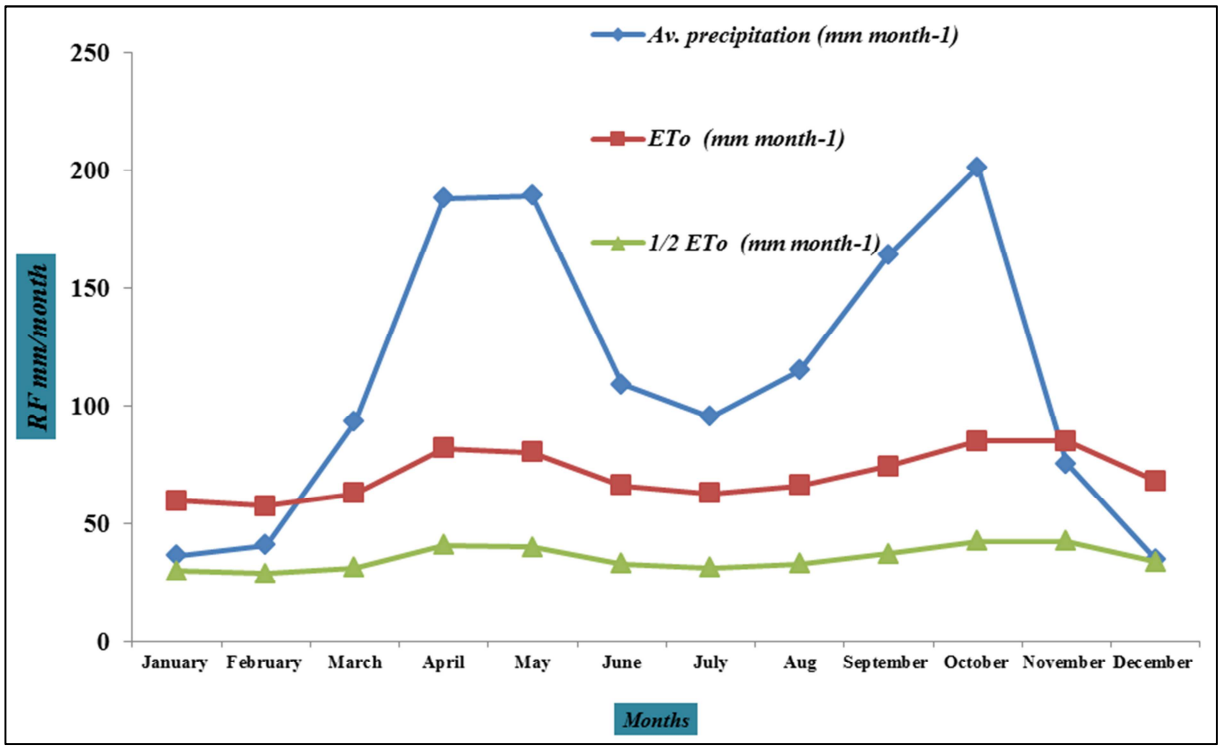

Figure 1. *Awada Agricultural Research Sub-center metrological station for the last decade (2010-2020).*

In this decade of the year, there is no time, at which ½ ETo is greater than Monthly precipitation. Therefore, the length of growing has been throughout the year and there was no cessation period.

2.2. Experimental Design

The experiment was super imposed on compact coffee varieties with four tree management treatments, which are single stem topped, multiple stem topped, multiple stem untopped and free growth management practices with a randomized complete block design with three replications at Awada agricultural research center sub-center. The raised suckers from the stumped coffee plant or the newly bearing heads were determined before starting to bear yields. Topping/ apical bud removing practice was also conducted at 2.20m top and all the managements were conducted as per its recommendation.

Four vertical or bearing head number and topping practice (Topped single stem, Topped multiple stem, Untopped multiple stem and Free Growth) were used as treatments and laid out in a randomized complete block design (RCBD) with three replications. All routine field management activities were uniformly and timely applied as per there commendations. From each plot, sixteen representative trees from the central rows of each plot were identified by excluding the borders to collect yield and yield contributing characters such. Number of primary branches: This parameter was recorded by counting the number of primary branches. Number of nodes of primary branch: This parameter was recorded by counting the number of nodes. Number of nodes on main stem: Measured as a total number of nodes count per tree, Stem girth (cm): This was measured above 5 centimeter at the ground level using caliper Canopy diameter (cm): Average length of tree canopy measure twice, east-west and north- south, from the widest portion of the tree canopy. Inter node length on longest primary branch (cm): This parameter calculated as LLPB/NNPB, where Length of longest primary branch (cm), NNPB = number of nodes on longest primary branch. Coffee yield (Kg ha^{-1}): Fresh cherry weight that had already been recorded per tree bases was used and converted to clean coffee in quintals per hectare.

The collected data were statistically analyzed using SAS computer soft ware version 9.0 English and the significance difference between any two treatments means were tested by least significant difference (LSD) at 5% probability level.

3. Result and Discussion

3.1. Stem Girth and Canopy Diameter

The recorded data on stem girth and canopy diameter of coffee tree were not significantly influenced by the topping practice and vertical numbers (Table 1). This indicates that there is no variation in coffee stem girth due to the effect of different topping practice and vertical numbers determination. However, the maximum stem girth (4.26cm) was recorded from single stem, and topped multiple stem trees (3.82cm) (Table 1). Similarly, the canopy diameter was not significantly ($P < 0.05$) affected by topping practice and vertical numbers.

3.2. Number of (Nodes on Main Stem, Primary Branch, Secondary Branch)

Number of nodes on main stem (No. NMS) and number of primary branch (No. PB) were significantly ($P<0.05$) affected by topping practice and vertical numbers determination. Accordingly, the highest number (276.66) of nodes on main stem were recorded from free growth followed by (266.90) that were recorded from untopped multiple stem (Table 1). On free growth of coffee tree management, the bearing verticals are more contributing to yield similar to untopped multiple stem and other training and pruning practices which depend on the new branches and length of lateral growth. On the other hand, the highest primary branch (61.90, 50.81, 49.71), were recorded from topped multiple stem, topped single stem, free growth, respectively. Similarly, the numbers of secondary branches were statically ($P<0.05$) affected by topping practice and vertical numbers determinations. As a result, higher (158.48, 127.43, and 120.62) number of secondary branch were recorded from the plot treated with free growth, topped multiple stem and untopped multiple stem, respectively. The result in line with the previous outcome reported at the study area as the number of vertical, in most harvesting seasons clean coffee yield significantly influenced by different number of verticals [8]. Gizachew *et al.* [9], also reported at south Ethiopia similarly indication that, the highest direct positive effects was shown by percentage of bearing primary branches stem diameter, average length of primary branches, number of primary branches, and number of main stem nodes, average green bean yield per tree.

3.3. Length of Longest Primary Branch and Number of Nodes on Longest Primary Branch

The length of longest primary branch (108.90cm) and number of nodes on the longest primary branch (34.28), (31.66) were recorded from the plot treated with topped single stem while the lower length of longest primary branch (74.76) and lower node number on longest primary branch (23.76) were recorded from the plot treated with free growth vertical number. This could be because of the resource competition among the higher number of vertical growth and all other vegetative growth of the free growth plots. Although a densely planting system may increase production per unit area, increases along with population density up to a certain level, but the yield per tree could be decreases with high planting density [10]. The reduction of yield per individual tree with close spacing may be attributed to the effect of shading on the number of fruit-bearing nods and fruit number per node by [11].

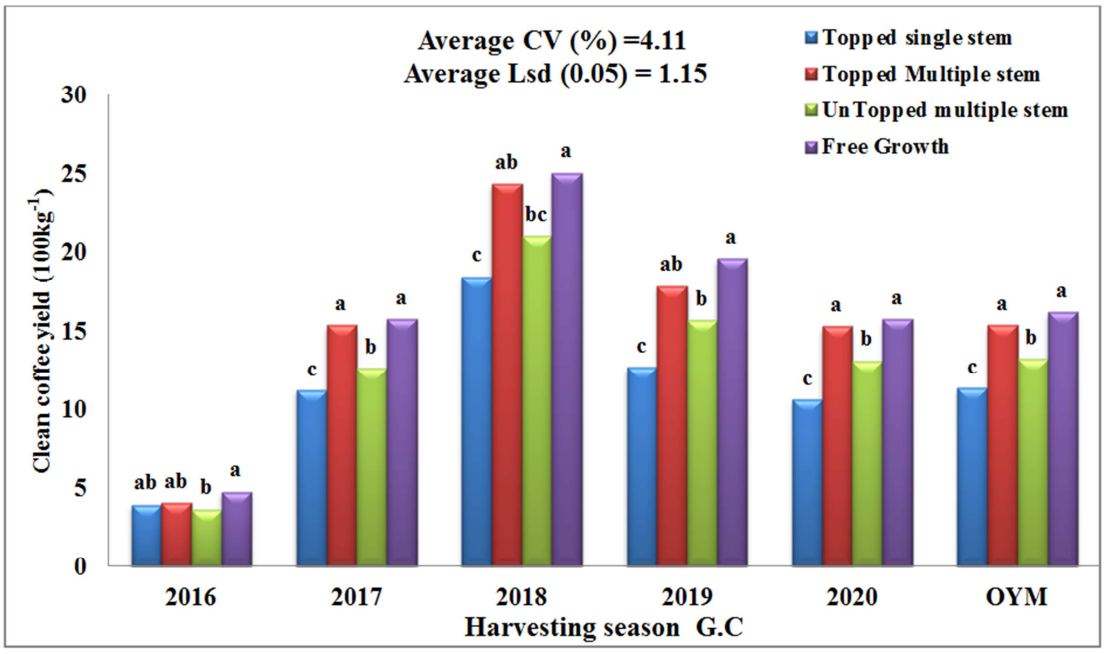

Figure 2. *Awada Agricultural Research Sub-center metrological station for the last decade (2010-2020).*

Table 1. *Effects of topping and vertical numbers on stumped coffee tree growth at Awada.*

Treatments	SG (cm)	CD	No. NMS	No. PB	No. SB	LLPB	NNLPB	ILLPB
TSS	4.26	160.29	238.57^{b}	50.81^{ab}	74.96^{b}	108.90^{a}	34.28^{a}	5.80
TMS	3.82	160.84	239.38^{b}	61.90^{a}	127.43^{ab}	99.23^{b}	31.66^{a}	5.57
UnTMS	3.70	163.04	266.90^{a}	43.47^{b}	120.62^{ab}	94.47^{b}	25.81^{b}	6.04
FG	3.54	161.71	276.66^{a}	49.71^{ab}	158.48^{a}	74.76^{c}	23.76^{b}	5.71
CV (%)	NS	NS	2.52	12.83	24.92	4.47	5.63	NS
LSD (0.05)	0.75	2.45	12.89	13.19	59.93	8.43	3.25	0.81

Topped single stem = TSS, Topped Multiple stem =TMS, UnTopped multiple stem = UnTMS, Free Growth =FG, SG= Stem Girth, ILMS= Inter node length on main stem, CD= Canopy Diameter, NPB= Number of primary branch, NSP = Number of secondary branch, LLPB= Length of longest primary branch, NNLPB = Number of nodes on the longest primary branch, ILLPB= Internodes length on the longest primary branch.

3.4. Coffee Yield Result

Analysis of variance revealed that, at each cropping season clean the yield was significantly ($p<0.05$) (Figure 2) by topping practice and vertical number determination. At all harvesting season, statically higher yields were harvested from the plot treated higher vertical number with free growth (16.16Qha^{-1}) and multiple stem topped (15.36 Qha^{-1}) at par with each other and significantly different from the rest treatments. This higher yield performance appeared as a result of the increased number of bearing head within the free growth and higher number of the bearing branch on the topped multiple stems enhanced due to topping and/or controlling the orthotropic/apical dominance to initiate the lateral growth. Several studies in lined with this result have indicated that, coffee may be more suited for a dense planting pattern. [11], Reported that the productivity of densely planted coffee is generally much greater than that of traditional/single stem plantings. It has been also reported that, a closely planting space favors the individual coffee plant to utilize the environmental resources such as light, moisture and nutrients throughout the growing period [12].

Even though the highest primary branch were (major yield contributing parts) were recorded from the single stem topped, the lowest clean coffee yield (11.37 Qha^{-1}) was recorded from this plot. The result was in line with [8], in which the pooled mean of free growth and double stem resulted statically the higher clean coffee yield reported. The result could be due to the maximum use of the land resource by the higher population with the free growth. Similar findings showed better vegetative growth performances of two distinct coffee cultivars planted using a high density planting system at Jima [13]. Maximum coffee yield due to increasing number of bearing heads has been documented by [14, 15].

4. Conclusion

Even though, there are a number of coffee tree managements practices reported at different corners of coffee producing countries, there is no report that indicates the effect of a vertical number and topping practice on coffee yield and yield components of stumped old coffee tree at the study area. Therefore, this study show that, topped multiple stem and free growth of the stumped coffee tree vertical growth management indicted the best yield and yield contributing growth performance as compared to the rest management practice. Therefore, it is very important to determine the stumped coffee tree vertical number and topping practice that enhance the yield and yield contributing growth expected for yield maximization and further research should be conducted at different location with different coffee varieties having different growth habit.

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