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Evaluation of Coffee Tree Productive Center Performance to Cycle Change

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ABSTRACT

An experiment was conducted to determine the coffee cycle change period on medium and higher agro ecologies with the objective of to identify coffee tree exhaustion period and indicator parameters to be consider when a tree became uneconomical and implement the first cycle change period of the coffee cultivars. The experiment was super imposed oncompact and open varieties with four tree management treatments, which are single stem topped, multiple stem topped, multiple stem un-topped and free growth training and pruning practices which stayed at the field for fifteen years. The coffee trees productive center evaluated in addition to yield; and raw and cup quality. In all coffee tree management practices, coffee yield response oscillated after giving one or two optimum crop at both locations for both compact and open varieties. The overall average crop yield for the last 12 cropping years for all tree management practice were in between 1450kg/ha - 2450kg/ha. Four indicator parameters are identified to evaluate the coffee tree productive center. These are the dead, non-bearing, bearing and new branches. After fifteen years, evaluating the exhaustion of coffee tree productive center revealed that the dead branch part reached in between 61% - 75%, the non-bearing branch 3% - 6%, the bearing portion range 17% - 28% and the new and future potential branch part range 2% -4% on different tree management practices. There is a significant variation on some of the quality parameters among varieties and coffee tree management practices, the raw quality of coffee showed that maximum amount of coffee beans werefound under screen no. 16 which is medium size about 55% of the sample coffee bean. Fewer amounts of coffee beans found from screen no. 20 which is the very large bean size and counted 1.55% of the total sample. Therefore, for medium and higher altitude agro ecologies like Jimma and Gera, coffee trees becameexhausted after15 years and coffee tree can be more productive only for 12cropping years if intensively applied all management practice at nursery and field level. As the coffee tree became older the size of the beans became smaller due to the exhaustion of the source to the sink.In general, when the coffee tree became unproductive up to 70%, cycle change is crucial.

INTRODUCTION

Coffee producing countries follow a systematic way of tree management and sustain life span of coffee trees and this requires knowledge and skill of application and management (Mulugeta, 2009) and time as well. The life span of coffee trees depends on agro ecologies, management on the field, and other physiological disorder like branch die back, disease, pest, drought and other external factors. According to Yacob*et.al.* (1996) described coffee exhaust due to aging, unregulated tree growth and population density, heavy overhead shade, and rugged and undulating topography and associated factors such as soil erosion are among the major constraints, which accounts for such low productivity of coffee yield in Ethiopia.In most cases, cycle change is practiced when the coffee yields are below the critical level at a given location.

Rejuvenation or cycle change is one of the many versions of coffee pruning methods. It is generally defined as the cutting of vertical stems of old trees to bring old nonbearing coffee to profitable production by improves yields, cherry quality, more uniform flower development and cherry maturity. The purpose of rejuvenation is not only to rehabilitate uneconomical coffee trees to obtain more yields from the worn out of old coffee farms, but also in a way as genetic conservation practice (PauloseDubale (1977).

Coffee farmers are reluctant to stump their coffee trees due to the reason as Mulugeta (2009) indicated, old coffee stumping technology is relatively labor intensive activity and has risks that they loss more than two years production until the new suckers emerge, growth and reached production stage. The second reason is that, farmers are discouraged due the damage of the newly growing suckers

by cattle because of the free grazing system of most coffee areas (Alemseged, 2017)

There are various methods of old coffee tree rehabilitation. The major rehabilitation method is clean stumping. Clean stumping should be carried out as soon as after the harvesting of the previous crop has been completed. This will counter the temptation to leave the old stem which might have flowered or budded and shown some crop potential. It is widely accepted practice for revitalizing coffee farms and has been found to be more advantageous than replanting when the coffee trees is healthy and having enough population stands at the field.

On the other hand, there is a prevalence of coffee wilt disease, to control or minimize dissemination of this disease it is better every coffee grower know how to protect the disease during stumping, which brings wounding in coffee trees should be done with efficiently disinfected tools to protect the coffee wilt disease (Girma *et al.*, 1997.)

In Ethiopia, rejuvenation or cycle change is done on the willingness of the individual farmers or producers. Hither to, there is no enough information when to implement a cycle change or after how many cropping season would be recommended for rejuvenation across different agro ecologies. Besides, the indictors' parameters to be considered in a coffee tree is going to the next life cycle is not known. Therefore, it is imperative to study and determine the cycle change period which is the one to alleviate or solve problem of decline of production due to age of coffee trees across different agro ecologies.

OBJECTIVE

- To identify coffee tree exhaustion indicator parameters to be consider when a tree became uneconomical.
- To determine and implement the first cycle change period of the improved coffee cultivars.

MATERIALS AND METHODS

The experiment was super imposed on compact and open varieties with four tree management treatments, which are single stem capped, multiple stem capped, multiple stem uncapped and free growth training and pruning practices using randomized complete block design with three replications which stayed at the field for fifteen years at Jimma and Gera agricultural research center. Besides, the coffee yield, the tree productive center was evaluated based on cropping and none cropping branches zone and other major yield components. The newly bearing heads contribution to yield also considered during the study period. Raw and cup quality of coffee also evaluated at Jimma agricultural research center quality laboratory. The process of determining coffee bean size, or grading, is done by passing unroasted beans through perforated containers, or sieves. All the data was analyzed using SAS program version 9.2 or 9.3 (SAS, 2008/2011).

RESULT AND DISCUSSION

In all coffee tree management practices, coffee yield response oscillated after giving one or two optimum crop at both locations, but at Jimma the yield variation between cropping years is high as compared to Gera location on both compact and open varieties. The overall average crop yield for the last 12 years for all tree management practice were in between 1400-2453kg/ha (fig.1-4).

At Jimma the mean yield for 12 years for open variety (75227) range from 2184- 2453 kg/ha clean coffee and also for the compact variety (74110) was 1417- 1722kg/ ha clean coffee. Coffee yield variation between consecutive years is high especially in compact variety than open.

At Gera, on the same topic, the open variety (75227) means yield ranges 1730- 1865kg/ha and for the compact variety (74165) ranges from 1524-1876kg/ha cleans coffee.

Comparing the yield response of the two cultivars, compact varieties is more sensitive to field management such as; shade, water stress, nutrient and seasonal temperature variation than the open varieties especially at medium altitude namely; Jimma.

To evaluate the exhaustion of coffee tree productive center, four indicator parameters are identified; namely dead, non-bearing, bearing and new branch. These parameters are grouped in to two, the first two are unproductive and the later are potentially productive. By considering the indicators parameters at both location and for the whole varietymean value depict that, the dead branch part reached from 67- 75%, the non- bearing branch 3 -4%, the bearing portion range 18 - 25% and the new and future potential branch part range 2 -4% on different tree management practices (Table 1-4) after 15 years. This indicates that the tree is no more

having potential bearing portion in the future because of the new branch part is almost fewer than 5%which is the following season's crop or future productive zone.The bearing portion also became to unproductive zone on the tree for the next cropping season (Table 1-4). Similar to this finding, another investigators like; Arcila-Pulgarín et al. (2002) and Rena et al. (1994) also reported that, without new growth, coffee trees do not produce fruit since flower buds are only produced once on specific segments of plagiotropic branches This indicates that if the coffee tree losses about 70% (dead plus non- bearing) of the productive center, needs rehabilitation to give a new lease of life for the coffee plant.

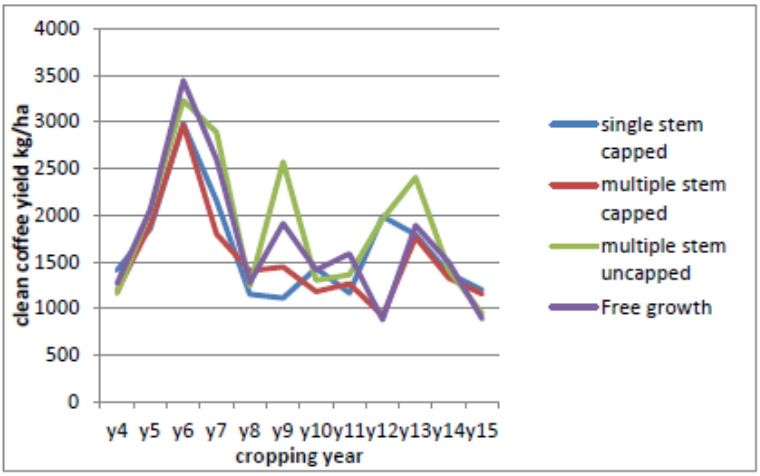

Fig1. *Coffee tree management and yield response trend on compact variety at Gera*

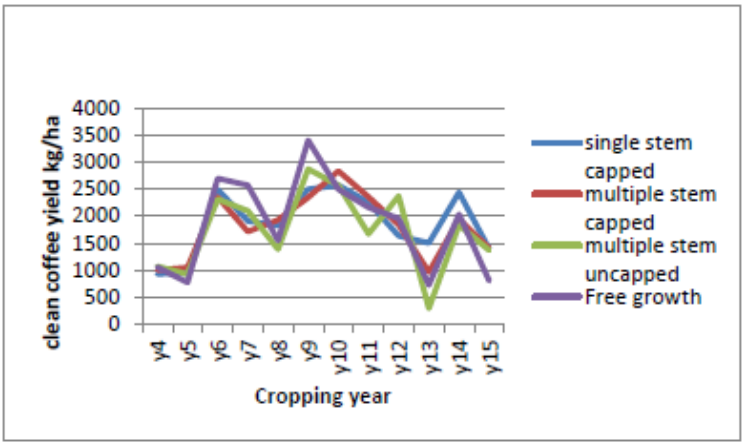

Fig2. *Coffee tree management and yield response trend on open variety at Gera*

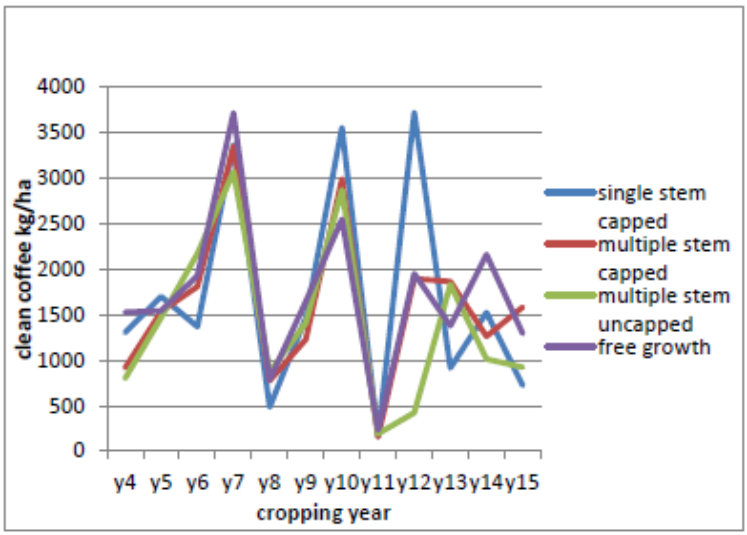

Fig3. *Coffee tree management and yield response trend on compact variety at Jimma*

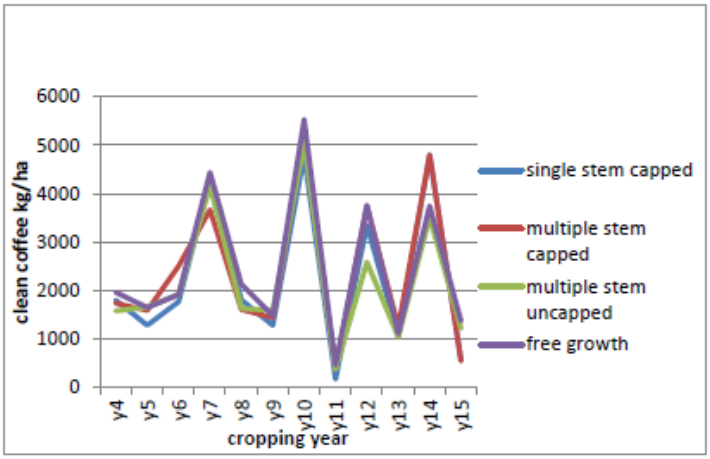

Fig4. *Coffee tree management and yield response trend on open variety at Jimma*

Table1. *Productive center potential of compact coffee type (75227) after twelvecropping seasons at Gera.*

Tree Management Practice	Branch (%)			
	Unproductive		Productive	
	Dead	Non bearing	Bearing	New
Single stem capped	64.12	5.21a	28.01	2.67b
Multiple stem capped	66.84	4.28a	26.0	3.02b
Multiple stem uncapped	70.41	1.47b	23.06	5.07a
Mean value	67.12	3.65	25.69	3.58
LSd (5%)	NS	1.52	NS	1.24
C.V (%)	6.04	18.41	13.68	15.31

Table2. *Productive center potential of compact coffee type (74165) after twelve cropping seasons at Gera.*

Tree Management Practice	Branch (%)			
	Unproductive		Productive	
	Dead	Non Bearing	Bearing	New
Single stem capped	68.40	2.46b	27.49	1.65b
Multiple stem capped	64.99	5.51a	25.13	4.42a
Multiple stem uncapped	70.24	4.58a	20.05	5.17a
Mean value	67.87	4.18	24.23	3.75
LSd (5%)	NS	1.55	NS	0.87
C.V (%)	2.87	16.38	14.11	10.19

Table3. *Productive center potential of compact coffee type (75227) after twelve cropping seasons at Jimma.*

Tree Management Practice	Branch (%)			
	Unproductive		Productive	
	Dead	Non Bearing	Bearing	New
Single stem capped	63.22b	3.36b	31.0a	2.42b
Multiple stem capped	72.08a	2.14b	24.02b	1.80c
Multiple stem uncapped	72.74a	5.58a	16.08c	5.66a
Mean value	69.35	3.69	23.7	3.29
LSd (5%)	7.59	174	5.88	0.59
C.V (%)	4.83	20.75	10.94	8.0

Table4. *Productive center potential of compact coffee type (74110) after twelve cropping seasons at Jimma.*

Tree Management Practice	Branch (%)			
	Unproductive		Productive	
	Dead	Non Bearing	Bearing	New
Single stem capped	73.78	2.09b	22.18a	1.95b
Multiple stem capped	77.09	2.33b	18.19b	2.52ab
Multiple stem uncapped	73.96	8.52a	14.83c	2.69a
Mean value	74.94	4.31	18.40	2.39
LSd (5%)	NS	1.6	3.16	0.67
C.V (%)	2.19	16.35	7.57	12.26

On free growth of coffee tree management, the newly emergingsuckers or bearing verticals are more contributing to yield contrary to other training and pruning practices which depend on the new branches and length of plagiotropic growth. The verticals growing nature on free growth described as primary (main stem), secondary and tertiary verticals which grow one on the other. As the age of the coffee tree increase, the contribution of the main stem verticals (primary) decrease slowly and gradually substituted by secondary and tertiary verticals (bearing heads). Secondary verticals initiated anywhere of the lignified part of the stem, while the tertiary verticals sprout from the chest height to the top part of the secondary vertical where they harvest enough sun light for flower initiation. Mean value of 8 secondary and 17 tertiary and 9fourth and 2 fifth verticalswhich have different age were observed on 15 years coffee tree on free growth plot. Therefore, on free growth coffee tree, there are a lot of verticals or bearing heads with different age can find through time which contribute to sustain the coffee yield as most of the small scale farmers are applying this practice.

The raw quality of coffee measured using bean size screener and the result showed, maximum amount of coffee beans were found under screen no. 16 which is medium bean size and this accounts for about55% of the sample coffee bean. The larger bean size is found under screen no.17 and 18 and counted for about 19%, and the smaller bean size on the screen size no. 14 is accounted for about 18% of the total sample. Less amount of sample counted from screen no. 20 which is the very large bean size and counted 1.55% of the total sample (Table 5).Therefore, as the coffee tree became older, the size of the beans became smaller due to the exhaustion of the source to supply to the sink.According to the results of study by Vaast P. et al., (2005) tree physiology, plant age, and period of picking all interact to produce the final characteristics of the product. Indeed, it was found that tree age, location of the fruits within the tree (Alemsged et.al. 1997.), and fruits-to-leaves ratio had a strong influence on the green beans size and chemical content. However, there is no statistically significant variation on bean size among coffee tree management practice.

Table5. *Mean value of bean size on tree management practice and variety under two contrasting agro ecology*

Grade classification	Bean size screen no.	Location and coffee variety (%)				Tree management, Location and varietyMean(%)	Grade Classification, location and variety(%)
		Gera		Jimma			
		74165	75227	74110	75227		
Very large	20	0.51	2.38	0.82	2.07	1.5	1.5
large	18	1.97	8.63	1.83	9.47	5.48	19.06
	17	6.75	16.54	11.26	19.79	13.59	
medium	16	26.45	31.52	40.6	29.19	31.94	55.16
	15	30.03	21.07	24.81	17	23.23	
small	14	25.99	16.14	15.7	15.82	18.41	18.41
shell	12	7.42	3.03	4.42	5.01	4.97	5.58
	Underscreen	0.8	0.28	0.59	0.77	0.61	

At Jimma, most cup quality parameters showed no significant difference except shape and make and cup total attributes of variety 75227, and acidity and flavor of variety 74110. Whereas at Gera, there was no significant difference for almost all cup quality parameters, except cup total attribute of variety 74165. The overall cup total range of the two location and varieties were ranged from 77% -88%, which indicate that when coffee tree becoming older the taste of the coffee beans and standard becoming below the specialty level.

Table6. *Quality evaluation of different tree management on 15 years old coffee tree at Jimma and Gera*

location	variety	Training and pruning	shape and make (15%)	Color (15 %)	odor (10 %)	Aromatic intensity (5%)	Aromatic quality (5%)	Acidity (10%)	Astringency (5%)	Bitterness (5%)	Body (10 %)	Flavor (10 %)	Overall cup quality (10%)	Cup total (100 %)
Jimma	**75227**	single stem topped	14a	14.33	10	4.17	4.5	8	4.33	4.33	7.83	8	8	88.67 a

		multiple stem topped	14a	13.67	10	3.83	3.83	7.5	4.17	4.17	7.5	7.5	7.5	83.33 b
		multiple stem untopped	13.33 ab	14	9.83	3.83	3.83	7.5	4	4	7.67	7.5	7.56	81.08 b
		Free growth	12.67 b	13.33	10	3.83	3.67	7.5	4.33	4.33	7.33	7.33	7.5	82.33 b
		P≤ (5%)	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
		CV (%)	2.76	3.41	1.45	7.37	10.1	4.23	6.57	6.57	5.27	3.81	4.45	2.41
		LSD	0.75											4.04
	74110	single stem topped	13	13	10	4	4.33	7.83a	4.67	4.33	7.67	8a	7.83	85
		multiple stem topped	13	12.67	10	4.3	4.33	7.83a	4.67	4.43	7.67	8a	7.83	84.77
		multiple stem untopped	13	13.17	10	3.83	3.67	7.33b	4.17	4.17	7.5	7.5b	7.5	82.17
		Free growth	13	12.83	10	3.83	3.83	7.5b	4	4	7.33	7.33 b	7.33	80.67
		P≤(5%)	NS	NS	NS	NS	NS	*	NS	NS	NS	*	NS	NS
		CV (%)	0	2.89	0	9.55	10.1	0.83	13.6	6.31	5.3	1.87	3.28	2.81
		LSD						0.283				0.289		
Gera	**75227**	single stem topped	13.33	12.83	10	4.33	4.33	7.5	4.33	4.33	7.33	7.33	7.33	83
		multiple stem topped	13.33	13.17	10	3.67	3.67	7.5	4.6	3.67	7.33	7.33	7.33	81
		multiple stem untopped	13	12.33	10	4	4	7.5	4.33	4.33	7.17	7.5	7.33	81.5
		Free growth	12.5	12.5	10	4.17	4.33	7.53	4.17	4.17	7.67	7.67	7.67	82.33
		P≤ (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
		CV (%)	3.89	2.7	0	8.5	8.41	6.31	6.57	7.28	8.13	8.13	8.02	3.06
		LSD												
	74165	single stem topped	12.83	12.5	10	4.33	4.5	8ab	4.67	4.07	7.5	7.67	7.67	84.33 a
		multiple stem topped	12.67	12.17	10	4	4	7.5bc	4	4	7.17	7.5	7.5	80.5a b
		multiple stem untopped	12.33	12	10	3.83	3.83	6.83c	4	3.67	7.17	6.83	6.93	77.17 b
		Free growth	12.33	12.3	10	4.5	4.5	8.5a	4.5	4.5	7.83	8.17	8.16	85.67 a
		P≤ (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*
		CV (%)	4.46	3.52	0	10	9.07	5.62	13.87	13.86	5.39	5.95	5.93	3.97
		LSD						0.87						6.495

CONCLUSION AND RECOMMENDATION

Losing the coffee tree productive center more than 70% invite to rehabilitate the coffee tree. For medium and higher altitude agro ecology like Jimma and Gera, coffee tree can be more productiveonly for 12cropping years after intensively applied all management practice starting at nursery and in all cropping year at field level. As the coffee tree became older up to 15 years, the bean size also became more of medium to small size and cup quality below the specialty standard. In general, the coffee should be rejuvenate after 15 years by considering the first three years of vegetative growth stage and twelve cropping yearswhen progressive yield decline begins.

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