Adaptability study of released CBD resistant coffee (Coffea arabica L.) variety in Guangua District, Northwestern Ethiopia

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Abstract – Yield and productivity of coffee in Ethiopia has been far below other coffee growing countries partly due to poor management practice, lack of high yielder variety. Thus, a field experiment was conducted at Guangua fruit and vegetable nursery site during 2010-2016 growing season to test the adaptability of released CBD resistance lowland coffee variety in Guangua conditions, Northwestern Ethiopia. The treatments consisted of six released CBD resistance coffee variety and three local check that were laid out in randomized complete block design with two replications. Results of this study revealed that yield were significantly ($P<0.05$) influenced by variety. Maximum yield (9.62 and 9.0 Q/ha) recorded from local check wen 27/09 and wen 18/09 and the minimum yield (3.24, 3.43 and 3.47 Q/ha) recorded from released variety 76/98,105/98 and 78/84, respectively. Accordingly, local check wen 27/09 and wen 18/09 and released variety 7440 and w 4/98 are the most suitable cultivars specifically in the study area.

Keywords: Adaptability, Coffee, yield

1. Introduction

Coffee is the most prevalent soft drink in the world. Over 2.25 billion cups are consumed every day (Tadesse Woldemariam Gole 2015). Its popularity and volume of consumption are growing every year, and coffee shops are the fastest growing part of the restaurant commerce. Today, coffee is both a part of our communal experiences as well as an accepted norm for doing business. Many business managers, scientists, politicians, and people of all walks of life relax having a cup of coffee during breaks in between conferences, busy research works and routine daily activities. Economically, coffee is the second most exported commodity after oil, and employs over 100 million people worldwide (Tadesse Woldemariam Gole 2015).

Ethiopia is the birthplace and center of genetic diversity of Arabica coffee (*Coffea arabica* L.). Mesfin Amaha (1991) suggests that Ethiopia is not only the native home of Arabica coffee but also the country that has shown the use of coffee to the world. Coffee has been used in Ethiopia as a food and beverage for many hundreds, if not thousands, of years. Thus, Ethiopia can be considered as the biological and cultural home of coffee (Moat et al., 2017). Arabica coffee is the most widely consumed, dominating over 70% in volume of production and over 90% of traded value globally (Tadesse Woldemariam Gole 2015). More than 80 developing countries mainly earn their foreign currency from coffee. For Ethiopia, coffee is the most important export commodity, with a share of 20-25% of the total foreign exchange earnings (Moat et al., 2017). Coffee production is important to the Ethiopian economy with about 15 million people directly or indirectly deriving their livelihoods from coffee (Tefera and Tefera, 2013). According to FAO statistics (www.faostat3.fao.org), global coffee production area covered around 10,975,184 ha in 2016 and 653,909.76 ha in Ethiopia in 2016 on small holder farmers field (CSA 2016).

The main coffee growing areas are found within Oromia Region and Southern Nations, Nationalities, and Peoples' Region (SNNPR), with modest production in Amhara Region and minor output in Benishangul-Gumuz Region (Moat *et al.*, 2017). Ethiopia has huge potential to increase coffee production as it is endowed with suitable elevation, temperature, soil fertility, indigenous quality planting materials, and sufficient rainfall in coffee growing belts of the country. According to the second Growth and Transformation Plan (GTP II), the government is eager to more than double current coffee production to reach around 1.0 million metric tons by 2019/20 (Francom and Counselor 2017). Despite Ethiopia's immense potential for increasing coffee production, average per hectare yield remains very low at 0.72 MT per hectare (Tefera and Tefera, 2013). Three major factors cause low coffee production are shifting coffee cultivation by Khat (*Cata edulis*), the Ethiopian coffee farm management system and the agronomic practices are traditional and extension services provided to small holder farmers are inadequate, the government of Ethiopia doesn't have a specialized institution that provides extension support for coffee production. Considering the existing production situation, achieving this goal is not expected within such a short timeframe.

In Amhara region, coffee grows as homestead with known landraces planted in high densities (up to 4100 trees/ha) and intercropped with banana, orange and hops/gesho/ and somewhere with khat and eucalyptus with a very low productivity. In order to boost coffee yields, greater investment and resources need to be devoted to developing and distributing improved varieties, extension support, better inputs (e.g. fertilizer and irrigation), and improved tree management practices. In the study area there are certain problems that needs research interventions including lack of adaptable lowland improved coffee varieties with disease resistance (major coffee diseases like coffee berry disease, coffee wilt disease and coffee leaf rust), good quality and better yield accompanied by good management practices. Therefore, this study was designed to see the adaptability of released coffee varieties with better yield, their response to the prevailing environmental condition and to popularize released coffee varieties for end users.

2. Material and Methods

Description of the Study Site: The experiment was conducted at Chagni nursery site which is located at north-western part of Ethiopia. It is 50 km far from Injibara and 505 km away from Addis Ababa. Chagni is located at latitudinal of 10°57' N and longitudinal 36°30'E with an altitude of 1670 meter above sea level. The mean annual rainfall of the area is 1606 mm with an average maximum and minimum air temperatures of 30.4°C and 12.4°C, respectively. The site has the textural class of clay soil type.

Planting Materials: Six released CBD resistant coffee variety and three local checks were used for this experiment and the seeds of released variety were taken from Jimma Agricultural Research Center and three local checks material harvested from wonbera area during the main season of 2009 from farmer's field as described in Table 1. The harvested seeds planted in a pot to produce a seedling in Chagni nursery site.

Experimental Design and Management: The trial carried out from 2010 to 2016 cropping seasons in randomized complete block design (RCBD) with two replications. The plot consists one row with seven trees per row and the planting space is 2m x 2m between row and between plants. All field management practices were delivered properly and timely as per the recommendation of the area uniformly. Mean agronomic and yield parameters of the last three years of cropping seasons were used for data analysis.

Table 1 Experimental materials

Treatment	Variety Name	Released by
1	7440	JARC
2	wen 05/09	Local check
3	66/98	JARC
4	78/84	JARC
5	105/98	JARC
6	76/98	JARC
7	wen 27/09	Local check
8	w 4/98	JARC
9	wen 18/09	Local check

JARC= Jimma Agricultural Research Center

Data collections: During the time of this study, the following growth characters and yield related data recorded based on their standard procedures.

Number of main stem nodes: total number of nodes per plant counted at the main season of the year

Canopy diameter (cm): average length of tree canopy measure twice, east-west and north-south, from the widest portion of the tree canopy measured from randomly selected three plants.

Plant height (cm): total height of the tree from the ground level to the tip of the main stem of the plant measured by measuring tip.

First branch height (cm): height of the tree from the ground level to the first primary branch of the main stem of the plant

Number of primary branches: is total number of primary branches count per plant

Average inter node length of main stem (cm): by computing per tree as (TH-HFPB)/TNN-1, where TH=total plant height, HFPB=height up to first primary branch, TNN=total number of main stem nodes

Stem diameter (cm): measured as a diameter of the main stem at five cm above the ground level

Yield (gm): Cherries were picked at red ripe stage and weighted per plot base at harvesting season and fresh cherry in gram per plot converted in to clean coffee quintal per hectare.

Data analysis

The data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) of the Statistical Analysis System computer software and the mean values were compared using the procedure of Least Significant Difference (LSD) test at 5% probability level.

3. Results and Discussion

3.1. Growth parameters

The statistical result for growth parameters showed non-significant difference among all materials used in this study. Even if it was non-significant difference between all treatments maximum plant height recorded (232.75cm) from local check **wen 27/09** and the minimum recorded (196.75cm) from variety **76/98**. Maximum first branch height recorded (38cm) from **wen 05/09** and **66/98** and the minimum (24.5cm) also recorded from **wen 27/09**. The maximum canopy diameters (E-W 226.25 and N-S 221.5cm) recorded from **wen 27/09** and the minimum diameter (E-W 169.5 and N-S 166 cm) recorded from **wen 18/09**. The longest internode length (9.01cm) recorded from **wen 18/09** and the minimum (7.1cm) recorded from released variety **78/84**. The maximum and minimum primary branch number (55.5 & 45.25) recorded from **wen 05/09** and **7440**, respectively (Table 2). Those growth parameters are very important to deliver the necessary management practice since coffee production highly affected by poor management practice mainly in the study area. Farmers grow coffee too much populated plants per unit area less than one meter distance between plant for those local cultivars that can cover more than 2.3 m canopy diameter in the study area (Table 2).

Table 2 Mean values for vegetative parameters

Treatment	PHT(cm)	FBHT	STD (cm)	MSTN	Canopy Diameter (cm)		INL (cm)	PBRN
					E-W	N-S		
7440	202	27.75	4.92	25.75	171.25	177.25	7.14	45.25
wen 05/09	229	38	5.45	25	196.25	219.5	8.19	55.5
66/98	210	38	5.1	25.75	198.0	190.5	6.79	49.0

78/84	221.75	35.75	5.75	28	189.25	205.5	7.1	47.75
105/98	200.75	26.25	4.2	22.75	182.25	186.5	8.39	46.5
76/98	196.75	31.5	4.97	23.25	199.25	203.25	8.07	52.25
wen 27/09	232.75	24.5	5.75	29.5	226.25	221.5	7.3	51.5
w 4/98	210	35.75	5.35	27	205.5	222.75	7.47	50.5
wen 18/09	224	33.75	5.12	22.75	169.5	166	9.01	48
CV (%)	8.22	18.86	7.34	13.18	9.96	10.83	10.72	16.25
LSD (5 %)	40.59	14.08	0.87	7.76	44.36	49.77	1.9	18.58

Mean values which does not have letters are not statistically significant, PHT= plant height, FBHT= first branch height, STD= stem diameter, MSTN= main stem node, E-W= canopy diameter in east west direction, N-S= canopy diameter in north to south direction, INL= internode length, PBRN= primary branch number

3.2. Yield parameters

The result indicated that there were significant ($P<0.05$) variation between treatments on yield of coffee in all growing season. The maximum yield (12.06 and 10.28 Q/ha) clean coffee recorded from local check **wen 18/09** and **wen 27/09**, respectively during 2014 cropping season (Table 3). The minimum yield of coffee (1.36, 1.84 and 2.04 Q/ha) recorded from released coffee varieties of **105/98**, **78/84** and **76/98**, respectively. During 2015 the maximum and minimum yield (6.4 and 3.28 Q/ha) recorded from local check **wen 05/09** and **105/98,** respectively. The maximum and the minimum yield (12.8 and 3.33 Q/ha) recorded from **wen 27/09** and **78/84**, respectively in 2016. Over the year the maximum yield (9.62 and 9.0 Q/ha) recorded from **wen 27/09** and **wen 18/09**, respectively which gave statistically similar results and significantly different over the other treatments. Accordingly results are above the national average productivity of 7.48 Q/ha green coffee yield (Kufa, 2018). Local check **wen 05/09**, released variety **7440** and **w 4/98** gave 5.72, 5.71 and 5.69 clean coffee Q/ha, respectively which are statistically at par and significantly

Table 3 Mean coffee yield data

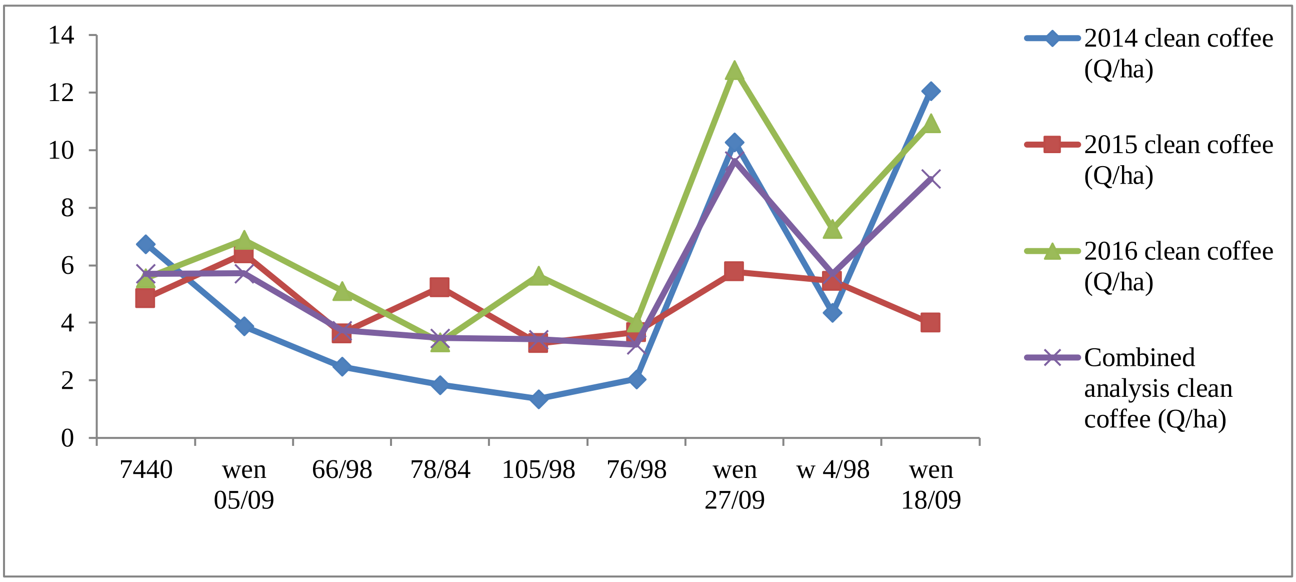
Treatment	2014		2015		2016		Combined analysis	
	yield gm/tree	clean coffee (Q/ha)	yield gm/tree	clean coffee (Q/ha)	yield gm/tree	clean coffee (Q/ha)	yield gm/tree	clean coffee (Q/ha)
7440	1614.8^{bc}	6.74^{bc}	1163.7^{ab}	4.85^{ab}	1331.4^{c}	5.55^{c}	1369.9^{b}	5.71^{b}
wen 05/09	932.3^{dc}	3.88^{dc}	1534.3^{a}	6.4^{a}	1651.9^{bc}	6.89^{bc}	1372.8^{b}	5.72^{b}
66/98	595.8^{dc}	2.48^{dc}	869.1^{b}	3.62^{b}	1229.1^{c}	5.12^{c}	898.0^{bc}	3.74^{bc}
78/84	443.2^{d}	1.84^{d}	1255.4^{ab}	5.23^{ab}	800.0^{c}	3.33^{c}	832.9^{c}	3.47^{c}
105/98	326.4^{d}	1.36^{d}	787.8^{b}	3.28^{b}	1354.2^{c}	5.64^{c}	822.8^{c}	3.43^{c}
76/98	488.8^{d}	2.04^{d}	880.3^{b}	3.67^{b}	964.9^{c}	4.02^{c}	778.0^{c}	3.24^{c}
wen 27/09	2465.8^{ab}	10.28^{ab}	1384.4^{ab}	5.77^{ab}	3072.9^{a}	12.8^{a}	2307.7^{a}	9.62^{a}

w 4/98	1042.6dc	4.35dc	1307ab	5.45ab	1744bc	7.27bc	1364.5b	5.69b
wen 18/09	2893.4a	12.06a	958.8ab	3.99ab	2622.8ab	10.94ab	2158.3a	9.0a
CV (%)	40.38	40.35	23.46	23.49	31.04	31.05	31.97	31.97
LSD (5 %)	1117.8	4.65	609.7	2.54	1174.8	4.9	501.92	2.09

Means followed by the same letter in the same columns are not statistically significant, Q/ha= a measuring unit of weight as 100 kg/ha, CV= coefficient of variation, LSD= list significant difference

different over the rest treatments. The lowest yield (3.24, 3.43 and 3.47 Q/ha clean coffee) recorded from released variety **76/98**, **105/98** and **78/84**, respectively which are statistically at par compared with each other. The reason for lowest yield in the study area for thus released variety may be due to difference soil type, soil fertility level, vary in temperature and rain fall. Even if it gives below the national average that is better in yield, cup quality and disease resistance compared with local landraces which mainly cultivated in the study area. Coffee yield and canopy diameter significantly increased and optimum population density decrease with increasing number of bearing heads (Tesfaye *et al.*, 1998; Tesfaye *et al.*, 2001). Taking into account the morphological nature of coffee trees and pruning systems to be used, optimum spacing, and the corresponding population density has been recommended for each canopy classes.

Clean coffee yield trend analysis



4. Conclusion and Recommendation

In Ethiopia in general and in the study area in particular the aforementioned potential coffee growing areas the local utilization of coffee motivates to produce coffee at large come into view. Currently large number of people engaged in serving boiled coffee with its ceremony. This massively materialized activity specially in creating job opportunity for women being strong income source for the livelihood of family. Thus this call technology generation, support and enhancing of coffee production in those areas where coffee is not produced as major crop having production potential and thus is a good opportunity to produce coffee at large for commercial farms as well as small holder farmers. The local checks are quit superior in both vegetative and yield parameters and thus suggest that further variety development is important to acquire high yielder, better in cup quality and to develop disease resistance variety. Therefore local check **wen 27/09** and **wen 18/09** and released variety **7440** and **w 4/98** and are more productive in the study area.

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