



Research Article

Hybrid Coffee Variety Verification Trial for Yield and Yield Components for Mid- and Low-Lands of Southwest Coffee Growing Areas

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Article History: Received: February 15, 2019 Revised: July 23, 2019 Accepted: August 12, 2019

ABSTRACT

Once the presence of heterosis in crosses among indigenous arabica coffee cultivars was noticed, the next step was to investigate as to how to maximize the observed level of heterosis and make use of the available enormous genetic potential. A total of 15 F₁ hybrids were selected and advanced to verification based on their high yielding ability and resistance to diseases (CBD and CLR) at mid-to low-land South Western parts and planted at Melko and Tepi with the objective of developing high yielding, typical quality, hybrid coffee varieties for mid and low land coffee producing areas of South West Ethiopia. yield data, growth parameters, survival rate and quality data was taken and analyzed using SAS version 9.2 and mean was separated using LSD at 5% level of significance. Based on the evaluation made there was significance difference between hybrids for parameters under consideration and three Crosses 7455 X 7530, F-59 X H13 & F-59*Dr1 gave mean over-location and over-years yield of 20.9, 19.3 & 20.1 qt/ha clean coffee respectively. Their survival rate was also higher 93.8, 89.6 & 79.2 respectively. The mean Heterosis of the three crosses 7455X7530, F-59XH-13 & F-59XDr1 were 27.6, 18.1-20.8 & 33.0 over hybrid check, and 53.1, 41.7-50.6 & 65.8 over pure line check/s respectively under their best performed coffee Arabica growing areas. These three hybrids showed better growth performances as indicated. These crosses have been evaluated, registered & officially released by variety release committee and named EIAR50/CH, Melko-Ibsitu & TepiHC5, respectively.

Key words: Arabica Coffee, Hybrid coffee, Heterosis

INTRODUCTION

Ethiopia is the primary center of origin and diversity for Arabica coffee, (*Coffea arabica* L.). It grows on different soil types; PH, altitudes, and rain fall (Onwueme and Sinha, 1991). These environmental variations have greatly favoured the evolution of wide genetic variation within the arabica coffee population in Ethiopia (Meyer, 1968), which could provide immense possibility to improve yield, quality and other desirable traits of the crop. Despite the presence of wide genetic variation for improvement, the average national yield is low (7.48 quintal per hectare) CSA (2015). To overcome this productivity constraint, coffee hybridization was started in 1978 to develop hybrids for the country.

The presence of high level of heterosis in crosses among elite indigenous coffee (*Coffea arabica* L.) cultivars has been well determined. This was noted from different set of crosses that exhibited better parent heterosis ranging from 60% to 120% for yield (Mesfin and Bayetta, 1983;

Bayetta, 2001). Once the presence of heterosis in crosses among indigenous arabica coffee cultivars was noticed, the next step was to investigate as to how to maximize the observed level of heterosis and make use of the available enormous genetic potential. A series of hybridization experiments were conducted and succeeded in releasing three commercial hybrids. As a continuation of the hybrid variety development, 105 hybrids were evaluated under seven sets of trials.

A total of 27 F₁ hybrids were selected and advanced to verification based on their high yielding ability and resistance to diseases (CBD and CLR). Among hybrids advanced to verification, 15 of them which selected from Melko, Mettu and Bebeke were recommended for verification at mid-to low-land southwestern parts and planted at Melko and Tepi.

Objective/s: Keeping this in view, the present study was conducted to verify and develop high yielding, typical quality, hybrid coffee varieties for mid and low land coffee producing areas of South West Ethiopia.

Cite This Article as: Ayano A, K Nasiro, T Benti and N Mekonnen, 2019. Hybrid coffee variety verification trial for yield and yield components for mid- and low-lands of southwest coffee growing areas. Inter J Agri Biosci, 8(5): 237-241. www.ijagbio.com (©2019 IJAB. All rights reserved)

MATERIALS AND METHODS

A total of 15 hybrid coffees promoted from previous hybridization trials and two standard checks (Ababuna and Dessu at Melko and Ababuna and Geisha at Tepi) were planted at Jimma and Tepi in 2008 in RCB designs using three replications at 2.0 m x 2.0 m spacing between rows and plants. All cultural practices for nursery and field planted coffee trees such as slashing, application of fertilizer at recommended rate; weeding, herbicide application, pruning, etc and other activities were done properly and timely as per the recommendation (IAR, 1996; Endale *et al.*, 2008). Meanwhile initial evaluations were made on all selections for yield and yield components.

Yield data recording was conducted by harvesting fresh red ripe cherry and recording in every picking in gm/plot. In late harvest, buni (dried coffee) harvested from the tree and the ground and converted to fresh cherry yield in gram /plot by multiplying by 2.6 (Conversion factor). Fresh cherry yield in gm/plot was converted to fresh cherry yield in gm/ bearing tree for mean comparison. This was in turn converted to yield in clean coffee Qt/ha by multiplying 0.00417. On top of yield data growth parameters (total height, height up to first primary branch, girth, number of first primary branch, number of nodes on the main stem, number of primary branch, inter-node length on the main stem, canopy diameter) were recorded. In addition to these, percent survival rate also recorded. On the other hand disease records and quality evaluation were made by respective disciplines.

RESULTS AND DISCUSSION

Yield and yield components

The three Crosses 7455 X 7530, F-59 X H13 & F-59*Dr1 gave higher mean yield of 26.8, 23.4 & 21.6 qt/ha clean coffee at Melko respectively. Their survival rate was also higher 93.8, 89.6 & 79.2 respectively (Table 1). They gave higher mean yield of 15.7, 15.1 & 18.5 qt/ha clean

coffee at Tepi respectively. All the three hybrid survival rate was 100% (Table 2). The mean Heterosis of the three crosses 7455X7530, F-59XH-13 & F-59XDr1 were 27.6, 18.1-20.8 & 33.0 over hybrid check, and 53.1, 41.7-50.6 & 65.8 over pure line check/s respectively under their best performed coffee Arabica growing areas (Table 4). They gave mean over-location and over-years yield of 20.9, 19.3 & 20.1 qt/ha clean coffee respectively (Table 3). These three hybrids showed better growth performances as indicated (Table 5).

Quality of the hybrids

7455 X 7530 –The overall quality standard of this hybrid is good and acceptable scored (80.9 out of 100). And have best acceptable range of export standard screen size (97%).

F59 X H13 –The overall quality standard of this hybrid is good and acceptable scored (82.71 out of 100). And have best acceptable range of export standard screen size (98%). F59 X Dr1 –The overall quality standard of this hybrid is good and acceptable scored (78.02 out of 100). And have best acceptable range of export standard screen size (99%) (Table 6).

Conclusion and recommendations

The three Crosses (7455 X 7530), (F-59 X H13) & (F-59 X Dr1) gave higher mean yield of 26.8, 24.0 & 23.4 qt/ha clean coffee, respectively. These crosses have been evaluated, registered & officially released by variety release committee and named EIAR50/CH, Melko-Ibsitu & TepiHC5, respectively. All the three candidate hybrids are suitable to medium to low altitude (1750- 1200 masl) coffee growing environments of Southwest Ethiopia coffee growing areas. All the three hybrid varieties require proper application of NPK fertilizers as per Research recommendation of rate and method of application. These new hybrids are highly suitable for both large scale and small scale farming systems provided the environment qualifies the recommendation.

Table 1: Mean Yield clean coffee (Qt/ha) and survival rate of candidate hybrids and their checks under Hybrid Verification at Melko

Crosses	2011/12	2012/13	2013/14	2014/15	Mean	Survival rate (%)
74165*Dr1	10.4	17.6	35.7	20.3	21.0	83.3
74140*Dr1	6.5	22.7	41.0	25.8	24.0	87.5
75227*Dr1	6.5	16.6	38.7	20.2	20.5	97.9
F-59*H15	6.1	22.0	31.8	18.9	19.7	91.7
F-59*Dr1	7.4	15.2	41.3	22.6	21.6	79.2
741*7455	7.1	23.0	40.6	27.0	24.4	62.5
F-59*H13	6.5	27.5	33.6	26.2	23.4	89.6
7455*7530	5.1	19.9	46.1	33.1	26.1	93.8
221A71*1377	10.1	17.9	35.8	22.4	21.6	95.8
74110*1377	6.1	17.0	32.2	27.9	20.8	93.8
74158*1377	4.4	21.1	32.9	34.8	23.3	93.8
74158*1577	7.3	18.8	29.1	18.6	18.5	91.7
74158*221A71	4.1	21.7	39.1	18.3	20.8	95.8
74110*20071	6.9	12.4	34.8	25.2	19.8	93.8
20071*1577	5.9	14.7	30.1	29.0	19.9	79.2
ABABUNA	8.2	17.9	34.2	13.6	18.5	95.8
F-59	4.7	14.9	27.5	15.0	15.5	81.3
Mean	6.8	18.9	35	23.5	21.1	
f-test	N	*	*	N	*	
LSD(5%)	4.4	7.2	9.2	14.8	5.3	
CV	39.9	22.9	15.5	37.8	31.2	

Table 2: Mean yield clean coffee (Qt/ha) and survival rate of candidate hybrids and their checks under Hybrid Verification at Tepi

Treatments	2010/11	2011/12	2013/14	Mean (Q/ha)	Survival rate (%)
74165*Dr1	3.5	14.0	21.4	13.0	100
74140*Dr1	5.0	16.7	21.5	14.4	98
75227*Dr1	2.9	16.2	20.9	13.4	98
F-59*H15	5.7	17.4	19.2	14.1	100
F-59*Dr1	3.7	20.9	30.9	18.5	100
741*7455	3.8	13.6	20.6	12.7	85
F-59*H13	7.6	12.6	24.9	15.1	100
7455*7530	3.5	12.7	30.7	15.7	100
221A71*1377	4.2	15.9	22.8	14.3	100
74110*1377	3.0	15.6	21.0	13.2	94
74158*1377	3.5	16.7	22.0	14.0	94
74158*1577	2.6	13.9	15.4	10.6	92
74158*221A71	2.4	18.4	17.7	12.8	96
74110*20071	2.7	15.5	29.1	15.7	96
20071*1577	2.6	14.2	22.5	13.1	73
ABABUNA	2.7	17.1	24.0	14.6	98
Geisha	4.6	8.6	22.8	12.0	100
Mean	3.8	15.3	22.8	14.0	
F-test	*	*	N	N	
LSD(5%)	2.1	5.1	13.0	4.7	
CV	33.6	20.1	34.3	35.9	

Table 3: Mean Yield clean coffee (Qt/ha) of candidate hybrids and their checks under Hybrid Verification trial plot at Melko and Tepi

Crosses and parents	Yield in Q/ha clean coffee/ over years over locations											
	Melko						Tepi					
	2011/12	2012/13	2013/14	2014/15	Mean	SD	2010/11	2011/12	2013/14	Mean	SD	OLM
74165*Dr1	10.4	17.6	35.7	20.3	21.0	10.65	3.5	14.0	21.4	13.0	9.00	17.0
74140*Dr1	6.5	22.7	41.0	25.8	24.0	11.70	5.0	16.7	21.5	14.4	8.50	19.2
75227*Dr1	6.5	16.6	38.7	20.2	20.5	11.72	2.9	16.2	20.9	13.4	8.00	17.0
F-59*H15	6.1	22.0	31.8	18.9	19.7	11.14	5.7	17.4	19.2	14.1	7.31	16.9
F-59*Dr1	7.4	15.2	41.3	22.6	21.6	11.46	3.7	20.9	30.9	18.5	8.81	20.1
741*7455	7.1	23.0	40.6	27.0	24.4	13.79	3.8	13.6	20.6	12.7	8.49	18.6
F-59*H13	6.5	27.5	33.6	26.2	23.4	11.87	7.6	12.6	24.9	15.1	8.90	19.3
7455*7530	5.1	19.9	46.1	33.1	26.1	13.24	3.5	12.7	30.7	15.7	10.41	20.9
221A71*1377	10.1	17.9	35.8	22.4	21.6	12.39	4.2	15.9	22.8	14.3	9.49	18.0
74110*1377	6.1	17.0	32.2	27.9	20.8	12.02	3.0	15.6	21.0	13.2	9.04	17.0
74158*1377	4.4	21.1	32.9	34.8	23.3	13.98	3.5	16.7	22.0	14.0	8.79	18.7
74158*1577	7.3	18.8	29.1	18.6	18.5	11.16	2.6	13.9	15.4	10.6	7.00	14.6
74158*221A71	4.1	21.7	39.1	18.3	20.8	11.65	2.4	18.4	17.7	12.8	9.04	16.8
74110*20071	6.9	12.4	34.8	25.2	19.8	11.46	2.7	15.5	29.1	15.7	13.20	17.8
20071*1577	5.9	14.7	30.1	29.0	19.9	11.20	2.6	14.2	22.5	13.1	10.00	16.5
ABABUNA	8.2	17.9	34.2	13.6	18.5	11.21	2.7	17.1	24.0	14.6	10.87	16.6
F-59 /Geisha [#]	4.7	14.9	27.5	15.0	15.5	9.68	4.6	8.6	22.8	12.0	9.56	13.8
Mean	6.8	18.9	35	23.5	21.1	10.03	3.8	15.3	22.8	14.0	9.57	17.5
F-test	N	*	*	N	*		*	*	N	N		N
LSD(5%)	4.4	7.2	9.2	14.8	5.3		2.1	5.1	13.0	4.7		4.1
CV	39.9	22.9	15.5	37.8	31.2		33.6	20.1	34.3	35.9		20.2

[#]The pure line/ checks F-59 & Geisha varieties were used at Melko & Tepi respectively. OLM: Over location mean**Table 4:** Summary of Heterosis over Commercially released varieties (Hybrid & pure-line)

Genotypes	Melko		Tepi		GXE(means)	
	Over Ababuna	Over Dessu	Over Ababuna	Over Geisha	Over Ababuna	Over Dessu/Geisha
20071*1577	-18.6	-2.3	-28.4	-10.8	-23.2	-6.6
221A71*1377	2.9	23.4	-21.8	-2.5	-8.9	10.8
741*7455	3.8	24.6	-22.3	-3.2	-8.4	11.4
74110*1377	-5.2	13.7	-22.3	-3.2	-13.3	5.4
74110*20071	-4.8	14.3	-16.2	4.4	-9.9	9.6
74140*Dr1	10.5	32.6	-22.8	-3.8	-5.4	15.0
74158*1377	9.0	30.9	-21.8	-2.5	-5.9	14.4
74158*1577	-2.4	17.1	-19.3	0.6	-10.3	9.0
74158*221A71	11.9	34.3	-24.4	-5.7	-5.4	15.0
74165*Dr1	-14.8	2.3	-11.7	10.1	-13.3	5.4
7455*7530	27.6	53.1	-12.7	8.9	8.4	31.7
75227*Dr1	6.2	27.4	-19.8	0.0	-6.4	13.8
F-59*Dr1	1.9	22.3	33.0	65.8	17.2	42.5
F-59*H13	18.1	41.7	20.8	50.6	19.7	45.5
F-59*H15	7.1	28.6	12.7	40.5	10.3	34.1

Table 5: Mean growth characteristics of hybrid verification trial (Yield Component means)

Genotypes	Internode Length		Length of 1 st 1 ^o branch(cm)		Number of of 1 st 1 ^o branch(number)		Number of Stem Node	
	Melko	Tepi	Melko	Tepi	Melko	Tepi	Melko	Tepi
20071*1577	6.7	6.9	119.0	69.7	79	63	41	42
221A71*1377	6.3	6.8	125.5	72.4	86	82	46	47
741*7455	5.9	7.1	104.8	58.8	79	77	43	48
74110*1377	6.1	7.0	117.7	71.3	88	66	46	43
74110*20071	6.3	6.4	117.6	69.0	86	66	45	42
74140*Dr1	5.4	5.7	110.0	62.6	90	71	48	45
74158*1377	6.1	6.7	119.0	64.5	85	72	47	45
74158*1577	6.3	6.7	116.8	61.1	83	65	46	44
74158*221A71	5.4	6.3	120.7	68.2	87	69	47	43
74165*Dr1	5.5	6.0	103.0	65.6	78	70	44	42
7455*7530	6.0	6.9	108.0	59.5	73	65	39	41
75227*Dr1	6.1	5.8	114.8	73.7	81	60	42	41
F-59*Dr1	6.2	6.6	119.6	71.3	77	74	43	48
F-59*H13	7.4	7.0	122.1	70.7	76	65	40	43
Ababuna	6.6	6.9	128.2	67.2	79	60	45	40
F-59	6.0	6.5	111.8	59.3	75	71	42	43
F-59*H15	6.8	5.6	122.0	77.0	77	74	40	46
Mean	6.1	6.5	116.8	67.16	81.2	68.3	43.9	43.6
CV	5.8	12.8	6.7	9.7	7.6	8.7	5.2	7.4
Heritability	0.8366	0.0466	0.5670	0.5473	0.5224	0.6747	0.7722	0.4369

Table5: Continued.....

Genotypes	Canopy(cm)		Girth(mm)		Plant height(cm)	
	Melko	Tepi	Melko	Tepi	Melko	Tepi
20071*1577	201.8	221.9	59.0	73.9	298.0	324.0
221A71*1377	224.6	221.9	62.2	78.0	314.3	335.6
741*7455	195.7	221.9	55.6	68.0	272.0	327.2
74110*1377	192.3	221.9	59.5	69.0	305.0	322.5
74110*20071	194.9	221.9	56.8	72.9	305.3	337.9
74140*Dr1	196.5	221.9	59.8	69.8	278.5	338.0
74158*1377	200.1	221.9	59.0	67.8	312.7	353.4
74158*1577	199.6	221.9	56.5	67.8	310.8	333.8
74158*221A71	207.0	221.9	58.3	65.7	272.2	321.3
74165*Dr1	191.6	221.9	56.5	67.2	259.6	317.5
7455*7530	198.1	221.9	60.4	66.0	254.9	316.2
75227*Dr1	208.9	221.9	61.1	63.5	272.3	297.3
F-59*Dr1	218.3	221.9	64.3	76.8	284.4	342.5
F-59*H13	217.7	221.9	67.8	80.4	321.3	330.6
F-59*H15	224.9	221.9	64.1	76.0	290.7	359.7
Ababuna	212.9	221.9	59.1	74.0	319.3	306.5
F-59	201.6	221.9	58.3	62.2	279.3	266.1
Mean	205.5	195.6	60.1	70.5	292.0	325.3
CV	4.0	5.5	3.97	2.96	8.2	4.8
Heritability	0.8134	0.8797	0.8157	0.9497	0.5846	0.8345

Attributes of the released hybrids

ELAR50/CH (7455*7530) -This hybrid variety is among top yielding varieties under hybrid variety trial at Bebeke and Goma-II. It is also top yielder and stand establishment at hybrid verification plot at Melko and Tepi with relatively large number of bearing trees during the study years. It has also a very good survival rate both at Tepi and Melko 100% and 94% respectively. This candidate hybrid has also showed very high field resistance for coffee berry disease (CBD) at Melko and also showed very good resistance in attached berry test (ABT) very low coffee leaf rust infection at Tepi. The overall quality of the candidate hybrid is among the top (81.08 out of 100) this is very acceptable quality standard (Table 6). The variety is highly Vigorous having good stand best adapt to medium to low altitude coffee growing areas of southwest Ethiopia. It is characterized by good growth habit with large number of primary branches, green tipped, medium growth habit and manageable sized tree and erect stem.

Melko-Ibsitu (F-59*H13) -This hybrid variety is among top yielding varieties under hybrid variety trial at Bebeke. It has also good performance and stand establishment at hybrid verification plot at Melko and Tepi with relatively large number of bearing trees during the study years. It has also a very good survival rate both at Tepi and Melko 100% and 90% respectively. This candidate hybrid has also showed very good field resistance for coffee berry disease (CBD) at Melko and very low coffee leaf rust infection at Tepi. The overall quality of the candidate hybrid is among the best (81.08 out of 100) this is very acceptable quality standard (Table 6). The variety is highly Vigorous having good stand best adapt to medium to low altitude coffee growing areas of southwest Ethiopia. It is characterized by good growth habit with large number of primary branches, bronze tipped, open growth habit, highly Vigorous erect stem.

Table 6: Raw and cup quality of candidate cultivars and their checks under Hybrid Verification trial plot at Melko and Tepi

Coffee code	Above Screen size 14 (in percentage)	Raw quality (40%)		Cup quality (60%)		Overall Quality (100%)
	Melko	Melko	Tepi	Melko	Tepi	over locations
F59x H15	98.50	35.50	34.75	46.04	47.69	82.85
F59xH13	98.50	36.83	34.50	44.25	46.88	82.71
Dessu/ Geisha**	97.50	36.17	35.25	43.50	47.38	81.75
74165x Dr1	99.00	35.67	32.25	45.92	46.13	81.04
7455x7530	97.90	35.83	35.00	45.63	42.75	80.90
74140x Dr1	99.00	35.42	31.50	45.21	44.75	79.40
74158x221A71	95.00	32.67	29.50	47.38	45.94	78.85
Ababuna	98.00	35.67	33.25	42.58	45.25	78.79
75227x Dr1	98.00	35.17	30.00	43.58	46.13	78.63
74110x20071	98.00	35.17	31.25	46.04	44.13	78.44
74158x1577	99.00	35.83	31.75	44.83	43.38	78.08
F59xDr1	99.00	35.50	31.25	43.54	44.00	78.02
74110x1377	98.50	34.17	31.50	44.58	43.88	77.63
74158x1377	98.50	33.83	32.50	42.79	43.25	76.98
20071x1577	98.00	34.67	34.50	45.58	38.00	76.88
741x7455	99.00	35.17	31.75	45.71	40.81	76.73
221A71x1377	94.50	33.50	29.75	50.04	37.38	76.02
LSD(5%)		1.87	2.64	3.41	6.01	4.39
CV		3.22	5.75	4.56	9.63	3.35

**F59 and Geisha were used as released pure line checks at Melko and Tepi respectively.

TepiHC5 (F-59*DR1)-This hybrid variety is among top yielding varieties under hybrid variety trial at Bebeke and Goma-II. It has also good performance and stand establishment at hybrid verification plot at Melko and Tepi with relatively large number of bearing trees during the study years. It has also a very good survival rate at Tepi (100%) and also at Melko survived 79.2 %. This candidate hybrid has also showed very good field resistance for coffee berry disease (CBD) at Melko and very low coffee leaf rust infection at Tepi. The overall quality of the candidate hybrid is good (78.02 out of 100) this is very acceptable quality standard. The variety is Vigorous having good stand best adapt to medium to low altitude coffee growing areas of southwest Ethiopia. It is characterized by good growth habit with large number of primary branch, light bronze tipped, medium growth habit and manageable sized trees and flexible stem.

Acknowledgements

Authors acknowledge Ethiopian Institute of Agricultural Research (EIAR)/ Jimma Agricultural Research Center (JARC) for sponsoring to execute the experiment. Authors also acknowledge technical assistants and field assistants who took pertinent data through the study period.

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