Global Scientific JOURNALS

GSJ: Volume 6, Issue 1, January 2018, Online: ISSN 2320-9186
www.globalscientificjournal.com

EVALUATION OF BALE 2007 COFFEE COLLECTIONS AGAINST MAJOR COFFEE DISEASES AT JIMMA, SOUTHWESTERN ETHIOPIA

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Abstract

With the objectives of developing disease resistant landrace coffee varieties and boost the yield with their intrinsic cup quality, a multidisciplinary research program have been designed and implemented at Jimma agricultural research center. Towards such over all goals, local land race development program has been implemented for Bale coffee producing areas. To meet this goal, local land race development program of Bale 2007 coffee collections were started in 2007 and 326 coffee accessions were collected and planted in 2008 at Gera research sub centre. Accordingly 199 coffee accessions were evaluated for their resistance to CBD, CWD and CLR using visual assessment and laboratory inoculation test. There were significant differences among the Bale coffee collections evaluated for resistance to coffee berry disease. The range was from 0% (B321/07) – 95% (B261/07) most of Bale coffee accessions show resistant reaction for CBD but some of the accessions show high susceptibility. Coffee collections were also evaluated for their resistance to coffee leaf rust under field condition at Jimma research center. There existed highly significant difference among coffee cultivars in percent coffee leaf rust severity. Coffee leaf rust disease severity varied between 0.5% (B299/07) – 63.3% (B195/07). There existed highly significant difference among cultivars both in percent wilt seedlings and incubation period. Disease severity and incubation period on Bale 2007 coffee collections varied between 0.00 % (B320/07) - 100% (B126/07) and 86.6 -171.5 days respectively. Based on over all detailed analysis of field evaluation and greenhouse test investigation for major diseases.

Keywords: Bale Coffee Collections, Disease resistant, Colletotrichum kahawae, Gibberella xylarioides, Hemileia vastatrix

1. Introduction

Coffee is the most important agricultural commodity upon which more than 50 countries including Ethiopia are dependent for their economy, especially foreign exchange earnings. Coffee has for centuries played an important role in the Ethiopian economy and represents the main cash crop cultivated by small-scale farmers for social, economic, political and ecological sustainability. The estimated coffee production area in Ethiopia is 561,761 ha (CSA, 2015). In Ethiopia, coffee berry disease (CBD), coffee wilt disease and coffee leaf rust (CLR) are foremost factors in reducing the quantity and quality of coffee in the country. Production of land race coffee varieties adaptable to specific agro-ecological niches allows farmers to supply high quality coffee at premium prices. Based on the extreme demand for coffee quality to the character of those origins (types): Harar, Yirgacheffee and Sidama brands are now internationally recognized and registered as property right to Ethiopia with their distinct character/flavour and taste (IPO, 2008). In the past, the interest of coffee improvement program was to develop varieties that have a wider adaptation and distribute them to all coffee growing areas. It was however, lately realized that distribution of such limited varieties to all coffee growing agro-ecologies adulterate the typical quality of each specific locality or region, manifested poor adaptation and less preferred by local coffee farmers compared to their respective local cultivars.

Jimma Agricultural Research Center (JARC) was privileged in location specificity of Arabica coffee under defined agro-ecology, growing demand for land race coffee in the international market, and existence of genetic diversity in major coffee growing areas to gear our coffee research system towards specialty coffee variety development for each agro-ecological niche of the country. The development of disease resistant land race coffee varieties addressing quality issues was started at Bale land race coffee 10 years back in southeastern Ethiopia. The coffee varieties were originally selected and/or collected from forest and farmers' coffee fields in semi-forest or garden production systems of Bale area and intensively evaluated and tested for their reaction to economically important diseases in the country and assessed for yield potential and quality. In this manuscript, screening of coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR) resistant coffee collections in Bale coffee producing areas of southeastern Ethiopia, pertaining to pathological investigations are reported.

2. Material and Methods

2.1 Description of the study area

The laboratory, greenhouse/growth room and field studies were undertaken at Jimma Agricultural Research Center (JARC). JARC is found in Oromiya regional state in Jimma zone 360 Km southwest of Addis Ababa. It is located around 07°46'N latitude and 36°47'E longitude coordinate and at an elevation of 1753 m.a.s.l. It represents the medium agro ecological zones which receives annual rainfall of 1572mm. Its mean minimum and maximum temperature is 11.6^0c and 26.3 ^{0}C respectively. The major soil type of the center is chromic nitosol and cambiosl of upland and fluvisol of bottom land (JARC, 2004).

2.2. Treatments and Design Used

Screening of Bale 2007 coffee landrace collections were conducted on 199 coffee accessions which were collected in 2007 from Bale coffee growing areas of south-eastern, Ethiopia. The laboratory, greenhouse or growth room and the field studies were conducted at Jimma Agricultural Research Center (JARC) south-west, Ethiopia since the year of 2008. Coffee collections were screened for CBD, CWD and CLR following the standard procedures for each disease. The treatments were outlined using single observation plot with six trees per plot per accession with 2m x 2m spacing at Jimma Agricultural Research centre. The laboratory and greenhouse or growth room studies were conducted using completely randomized design (RCBD) using standard procedures.

2.2. Testing for CBD Resistance

2.2.1. Attached berry test and disease assessment in the field

Attached berry test (ABT) was used to verify their levels of resistance by inoculating good number of growing berries on three branches (top, middle and bottom canopies) of a sample coffee tree (3-5 trees/plot) with inoculum suspension of 2 x 10^6 conidia/ml at field. These inoculated branches were covered with plastic sleeves with paper bags over night to favour infection. After three weeks, the number of healthy and CBD infected berries per branch were recorded and then percentage infected berries was calculated. Besides, visual estimation of per cent CBD infection was assessed on tree base for four years.

2.3. Testing for resistance to Coffee Wilt Disease

Coffee accessions were tested for their reaction to coffee wilt. The seedlings (20/box) were inoculated at fully opened cotyledon stage (8-10 weeks old) with viable conidial suspension of the CWD pathogen (*G. xylarioid*es) isolate by stem nicking technique (Pieters and Van der Graaff 1980; Girma and Mengistu, 2000). The number of wilting seedlings per box (based on external symptoms) and days to the first symptom appearance were recorded fortnightly for 6 months, and finally percentages of dead seedlings and incubation periods (day) were used for analyses.

2.4. Testing for resistance to Coffee Leaf Rust

Six trees per accessions were considered for field CLR disease assessment using visual method. Recording was started on pick time of CLR disease appearance in the field using visual assessment methods for three consecutive years.

All the datas' were finally transformed to angular values as necessary and analyzed using SAS statistical software (SAS, 2000).

3. Results and Discussion

3.1. Testing for Coffee Berry Diseases (CBD)

There were significant differences among the Bale coffee collections evaluated for resistance to coffee berry disease (*Colletotrichum kahawae*) at Jimma. In visual assessment the average severity was 15.74 percent and the range was from 0% (B321/07) – 95% (B261/07) some of the accessions show highest severity which is greater than 50 percent of coffee berry diseases. From these B261/07, B126/07, B287/07, B22/07, B232/07, B128/07, B114/07, B04/07, B10/07, B171/07 and B144/07 which exhibited 95, 90, 88.3, 86.7, 73.3, 62.5, 62, 60, 57.5, 52.5 and 52.5 respectively.

Most of the accessions showed significantly lower disease severity (< 5%) namely, B321/07, B286/07, B278/07, B300/07, B299/07, B273/07, B109/07, B267/07, B144/07, B276/07, B292/07, B110/07, B104/07, B39/07, B325/07, B311/07 and B128/07 indicating higher CBD resistance (Table 1).

Table 1. Reaction of Bale 2007 Coffee Collections for Coffee Leaf Rust and Berry Diseases at Jimma (Mean of three years Data)

Accs	CLR	CBD	Accs	CLR	CBD	Accs	CLR	CBD	Accs	CLR	CBD	Accs	CLR	CBD
B327/07	3.0	0.0	B46 /07	15.0	2.5	B207/07	48.0	3.0	B45 / 07	38.8	40.0	B302/07	11.3	18.8
B326/07	12.0	0.0	B 47/07	20.0	31.3	B203/07	32.5	26.7	B22/07	50.0	86.7	B301/07	2.6	1.0
B4/07	12.5	60.0	B48 /07	27.5	7.5	B199/07	32.5	0.0	B67 /07	58.3	41.7	B299/07	0.5	0.0
B7/07	5.0	20.0	B51/07	27.5	42.5	B100/07	12.5	47.5	B144 / 07	27.5	52.5	B293/07	6.2	5.0
B325/07	7.5	7.5	B285/07	10.0	0.0	B101/07	48.3	45.0	B176 / 07	35.0	25.0	B292/07	10.0	30.0
B324/07	5.0	8.3	B53/07	20.0	5.0	B102/07	35.0	30.0	B158 / 07	27.5	3.8	B291/07	12.5	15.0
B 10/07	5.0	57.5	B54/07	47.5	2.5	B109/07	3.7	5.0	B179/07	4.0	12.5	B37/07	10.3	0.0
B323/07	18.0	15.0	B281/07	3.7	3.3	B114/07	11.0	62.0	B160/07	20.0	0.0	B290/07	9.0	6.0
B 322/7	10.0	5.0	B280/07	13.3	0.0	B121/07	30.0	5.0	B 183/07	5.0	0.0	B 39 /07	20.0	0.0
75227	10.0	0.0	B278/07	6.5	0.0	B126/07	7.5	90.0	B171/07	21.7	52.5	B289/07	8.3	0.0
B321/07	2.3	0.0	B58 /07	27.5	5.0	B128/07	42.5	62.5	B189/07	50.0	0.0	B288/07	7.2	4.0
B320/07	10.0	3.0	B276/07	5.3	0.0	B144/07	13.0	1.0	B195/07	63.3	33.3	B287/07	8.3	88.3
B319/07	4.0	0.0	B273/07	15.0	1.0	B131/07	32.5	40.0	B194/07	35.0	43.3	B 43/07	5.3	0.0
B318/07	27.0	0.0	B61/07	25.0	5.0	B134/07	11.3	16.7	B211/07	33.8	7.5	B44 /07	40.0	25.0
B316/07	15.0	8.3	B 63/07	11.0	0.0	B145/07	31.3	21.3	B221/07	10.0	0.0	B261/07	35.0	95.0
B311/07	5.0	0.0	B272/07	11.0	0.0	B146/07	25.0	2.5	B198 / 07	5.3	2.5	B76 /07	25.0	0.0
B310/07	10.2	0.0	B271/07	8.0	0.0	B147/07	21.7	2.5	B219/ 07	27.5	40.0	B77 /07	40.0	13.3
B309/07	11.7	0.0	B270/07	27.0	0.0	B150/07	15.0	10.0	B202/ 07	45.0	31.7	B78 /07	37.5	2.5
B308/07	13.7	0.0	B269/07	13.3	1.7	B155/07	20.0	0.0	74110	30.0	0.0	B286/07	21.3	36.3
B307/07	2.8	0.0	B68/07	15.0	10.0	B156/07	25.0	10.0	B300/07	26.3	1.7	B110 / 07	5.0	0.0
B306/07	15.0	5.0	B268/07	16.7	1.7	B157/07	33.0	20.0	B236/ 07	10.0	0.0	B104 / 07	60.0	10.0
B 25/07	6.8	0.0	B70 /07	11.3	1.3	B159/07	15.0	0.0	B226 / 07	32.5	47.5	B243/07	7.5	0
B305/07	11.7	0.0	B267/07	25.0	0.0	B162/07	45.0	0.0	B242/ 07	35.0	37.5	B232/07	28.8	73.3
Mean													**20.17**	**15.74**
Stdev													**14.47**	**23.01**

3.2. Testing for Coffee Leaf Rust (CLR)

Three years Bale 2007 coffee collections were evaluated for their resistance to coffee leaf rust under field condition at Jimma Research Center. There existed highly significant difference among coffee cultivars in percent coffee leaf rust severity (Table 1). Coffee leaf rust disease severity varied between 0.5% (B299/07) – 63.3% (B195/07).

Accessions B299/07, B321/07, B301/07, B307/07, B327/07, B281/07, B109/07, B319/07, B179/07, B07/07, B324/07, B10/07, B311/07, B183/07 and B110/07 resulted low percentage (<5%) CLR severity i.e 0.5, 2.3, 2.6, 2.8, 3.0, 3.7, 3.7, 4.0 and 5 % respectively showing highly resistance reaction. Coffee cultivar B276/07, B198/07, B43/07, B293/07, B278/07, B25/07, B288/07, B325/07, B126/07, B243/07, B271/07, B289/07, B325/07, B126/07, B243/07, B271/07, B289/07, B287/07 and B290/07, shows resistant reaction (<10%) i.e. 5.3, 6.2, 6.5, 6.8, 7.2, 7.5, 8, 8.3 and 9 % coffee leaf rust severity (Table 1). Coffee cultivars B44/07, B77/07, B128/07, B162/07, B202/07, B54/07, B207/07, B101/07, B22/07, B189/07 and B67/07 exhibited moderately susceptible reaction (>40 %) with CLR severity value of 58.3, 50, 48.3, 48, 47.5, 45, 42.5, 40 and 40 % respectively. However, very few accessions show susceptible reaction namely B104/07 and B195/07 exhibited 60.0 and 63.3 % (Table 1).

3.3. Testing for Coffee Wilt Diseases (CWD)

There existed highly significant difference among Bale 2007 coffee cultivars both in percent wilt seedlings and incubation period (Table 2). Disease severity and incubation period on Bale 2007 coffee collections varied between 0.00 % (B320/07) - 100% (B126/07) and 86.6 -171.5 days respectively. Accessions B101/07, B118/07, B61/07, B243/07, B207/07, B107/07, B178/07, B126/07, B276/07, B234/07, B232/07, B25/07, B138/07, B108/07 and B254/07 resulted highest percentage (> 98%) seedling death i.e 100, 98.7, 98.6, 98.5 and 98.3 with short incubation period of 87, 101, 86.4, 101, 101, 115, 101, 115, 129, 101, 87, 101, 101, 101, 129, 115, 115, 101, 87, 115 and 87 respectively (Table 2). Coffee accessions B307/07, B325/07, B321/07, B55/07 and B196/07 shows resistant reaction with severity percent of 11.7, 12.7, 14.7, 22.6, 22.8 and incubation period of 164.5, 143, 135.4, 147 and 154 days. However, coffee accessions B265/07, B10/07 and B305/07 shows moderately susceptible with severity of 31.9, 36.7, 38.7 and 45.3% and incubation period of 114.4, 119, 143 and 115 days (Table 2).

Coffee cultivar B320/07, B319/07, B293/07, B292/07, B285/07, B323/07 and B298/07 shows highly resistance reaction i.e. 0, 3.2, 3.3, 3.4, 5.3, 7.3, 9.4 % seedling death and incubation period of 0, 0, 147, 143.5, 171.5, 136 and 126 days respectively (Table 2).

Table 2. Reaction of Bale 2007 Coffee Collections for Coffee Wilt Disease Under greenhouse Condition at Jimma, 2014

	Seld Rate (%)		IP		Seld Rate (%)		IP		Seld Rate (%)		IP		Seld Death Rate (%)		IP
Accs	Actu	Ang	(Days)	Accs	Actu	Ang	(Days)	Accs	Actu	Ang	(Days)	Accs	Actu	Ang	(Days)
B-320/07	0.0	0.0	0.0	B-274/07	82.0	65.3	108.0	B-166/07	94.7	76.9	101.0	B-307/07	11.7	16.1	164.5
B-317/07	62.4	52.3	114.4	B-24/07	68.3	56.0	143.0	B-25/07	98.7	86.2	101.0	B-174/07	90.0	75.1	119.0
B-293/07	3.3	6.1	147.0	B-269/07	74.5	60.1	129.0	B-327/07	72.0	58.5	115.0	B-55/07	22.6	28.4	147.0
B-134/07	82.7	66.2	105.0	B-108/07	98.5	85.9	115.0	B-297/07	94.7	79.1	115.0	B-111/07	95.7	80.2	105.0
B-39/07	66.2	54.5	114.4	B-245/07	74.1	59.6	143.0	B-126/07	100.0	90.0	115.0	B-196/07	22.8	28.5	154.0
B-298/07	9.4	14.7	126.0	B-138/07	98.6	86.1	129.0	B-305/07	45.3	42.3	115.0	B-285/07	5.3	10.5	171.5
B-277/07	60.4	51.1	105.0	B-154/07	91.9	73.5	143.0	B-232/07	98.7	86.2	101.0	B-61/07	100.0	90.0	86.4
B-146/07	71.1	57.8	137.7	B276/07	100.0	90.0	129.0	B-73/07	74.7	61.3	115.0	B-28/07	78.6	64.3	114.4
B-319/07	3.2	6.0	0	B-151/07	97.1	82.0	136.0	B-178/07	100.0	90.0	101.0	B-197/07	93.3	81.1	86.4
B-97/07	90.5	75.2	100.4	B-282/07	64.3	53.4	115.0	B-80/07	97.3	82.2	87.0	B-139/07	98.7	86.2	87.0
B-292/07	3.4	8.7	143.5	B-254/07	98.3	85.7	115.0	B-246/07	97.3	84.5	115.0	B-118/07	100.0	90.0	101.0
B-78/07	75.8	66.2	95.7	B-182/07	68.7	56.0	129.0	B-137/07	97.2	84.4	115.0	B-128/07	91.8	76.3	115.0
B-46/07	86.0	68.3	109.7	B-153/07	95.8	78.1	115.0	B-107/07	100.0	90.0	115.0	B-27/07	95.9	80.6	101.0
B-58/07	93.2	75.3	105.0	B-173/07	50.2	44.9	157.0	B-92/07	90.6	72.7	101.0	B-48/07	92.0	77.3	101.0
B-68/07	75.7	60.4	86.3	B-184/07	86.7	76.9	143.0	B-69/07	87.8	69.6	101.0	B-101/07	100.0	90.0	87.0
B-265/07	36.7	37.0	119.0	B-37/07	89.0	70.7	101.0	B-74/07	76.2	61.0	115.0	B-270/07	63.9	53.4	129.0
B-321/07	14.7	22.2	135.4	B-281/07	92.0	80.2	101.0	B-158/07	98.7	86.2	101.0	B-234/07	98.7	86.2	101.0
B-06/07	93.4	78.3	105.0	B-323/07	7.3	12.8	136.0	B-207/04	100.0	90.0	101.0	B-67/07	97.3	82.3	101.0
B-289/07	80.0	63.5	119.0	B-10/07	38.7	38.4	143.0	B-243/07	100.0	90.0	101.0	370	19.21	25.50	133.0
B-223/07	97.0	81.9	114.4	B-325/07	12.7	17.0	143.0	B-199/07	97.3	84.5	87.0	971	2.78	5.60	0.00
B-291/07	31.9	34.0	114.4	B-309/07	50.1	45.1	129.0	B-49/07	95.9	80.6	101.0	974	12.37	16.96	133
Mean													72.1	62.4	114.0
CV (%)														12.40	10.29
LSD (0.05)														13.80	28.14

From Bale 2007 collections, 18 accessions were selected based on overall mean percentage of CBD, CLR and field survival rate. The promising cultivars which were promoted to coordinated variety and verification trial tested for CBD and CLR infection was consistently lower (<5 %). In addition to coffee berry disease resistant and yield advantage the selected coffee genotypes satisfied the quality standard demanded for Bale coffee production area (Table 3).

Table 3. Promising Bale 2007 coffee collections based on their major coffee diseases resistant

	CBD					Survival Rate (%)
ACC No	2014	2015	2016	Mean	CLR	
B325/07	7.5	0.0	0.0	2.5	3.5	100
B 321/07	0.0	0.0	0.0	0.0	3.3	60
B 311/07	8.3	0.0	0.0	2.8	3.3	80
B299/07	1.0	0.0	0.0	0.3	1.5	100
B292/07	5.0	0.0	0.0	1.7	3.4	100
B39/07	6.0	0.0	0.0	2.0	2.0	100
B286/07	0.0	0.0	0.0	0.0	3.3	80
B278/07	0.0	0.0	0.0	0.0	2.0	100
B273/07	1.0	0.0	0.0	0.3	2.8	100
B267/07	1.7	0.0	0.0	0.6	3.0	60
B203/07	5.0	2.2	10.0	5.7	3.0	80
B109/07	1.3	0.0	0.0	0.4	2.0	80
B128/07	5.0	3.2	2.5	3.6	2.0	60
B300 /07	0.0	0.0	0.0	0.0	3.2	100
B110/07	0.0	0.0	5.0	1.7	2.5	100
B144/07	1.7	0.2	0.0	0.6	2.0	75
B276/07	2.5	0.0	0.0	0.8	2.0	100
B 104 /07	5.0	0.0	0.0	1.7	2.0	100
74110	0.0	0.0	0.0	0.0	2.5	40
75227	0.0	0.0	0.0	0.0	2.5	80
Mean	2.4	0.29	0.9	1.2	2.6	84.8
Stdev	2.78	0.85	2.47	1.51	0.62	2.78

[1]Mean=values are means of 3 years data; Survival rate= Tree survival at field level against CWD; Stdev=standard deviation

4. Summary and Conclusion

Ethiopia is the centre of origin and diversity of Arabica coffee. The country is ecologically very diverse and coffees grown under these environments are different in quality, disease resistance, yield potential and many other traits. A new breeding strategy, known as '*Local Coffee Landrace variety Development Program*', was designed with main objective to develop high yielding and disease resistant cultivars with good quality for the major coffee growing areas of Ethiopia (Bayetta and Labousie, 2006). Local land race variety development program of Bale 2007 coffee collections were started in 2007 and 326 coffee accessions were collected from Bale zones of Ginir , Gololcha and Nensebo Woredas in 2007 and planted in 2008 at Gera research sub centre. Most of the coffee accessions were not established well at Gera due to the disease known as brown eye spot of which is caused by *Cercospora cofficola*. Reestablishment was planned to save and utilize the accession for further breeding program thus as a result seeds were collected from existing 201 coffee accessions and planted at Jimma in July 2010 in single observation plots. Accordingly 199 coffee accessions were evaluated for their resistance to Coffee Berry Disease Coffee wilt disease and Coffee leaf Rust using visual assessment and laboratory inoculation method.

There were significant differences among the Bale coffee collections evaluated for resistance to coffee berry disease (*Colletotrichum kahawae*) at Jimma. In visual assessment the average severity was 15.74 percent and the rage was from 0% (B321/07) – 95% (B261/07) some of the accessions show highest severity which is greater than 50 percent of coffee berry diseases. Three years Bale 2007 coffee collections were evaluated for their resistance to coffee leaf rust under field condition at Jimma research center. There existed highly significant difference among coffee cultivars in percent coffee leaf rust severity (Table 1). Coffee leaf rust disease severity varied between 0.5% (B299/07) – 63.3% (B195/07). There existed highly significant difference among Bale 2007 coffee cultivars both in percent wilt seedlings and incubation period (Table 2). Disease severity and incubation period on Bale 2007 coffee collections varied between 0.00 % (B320/07) - 100% (B126/07) and 86.6 -171.5 days respectively. Based on over all detailed analysis of field evaluation and greenhouse investigation some of Bale 2007 coffee accessions are promising for release pretending that they have other required traits like yield and good cup quality.

ACKNOWLEDGEMENTS

The Authors would like to acknowledge Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center for providing fund, laboratory and greenhouse facilities. Moreover, authors acknowledge all staffs of plant pathology research laboratory. We thank Mr. Sisay Tesfaye, Mr. Mamo Abye and Mr. Wondimu Bekele for their technical support throughout the experiment.

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