Global Research in Environment and Sustainability
August 2023, Vol. 1, No. 6, pp. 37-45.

Evaluation of Coffee Hybrid Varieties Against Major Coffee Insect Pests at Teppi, Southwestern, Ethiopia

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Abstract:
Coffee, originated in Ethiopia is utilized in a number of ways. It is grown in more than 50 countries around the world. With cultivation, marketing, export and processing of the crop a million of people depends on for livelihood. Insect pest is the major challenge of coffee production in Ethiopia. The insect pest evaluation of coffee hybrid variety trial was under taken during the year 2013 (2005 E.C) for the objective evaluation of coffee hybrid variety trial for insect pest tolerant at Teppi, Southwestern Ethiopia. From the evaluation, we understand that there is a correlation between insect pest attack, canopy width and number of primary branches. The other all vegetative parameters had no relationship with insect pest occurrence. Geisha is highly infected with Coffee blotch leaf minor. Geisha was susceptible to coffee serpentine leaf minor in addition to coffee blotch leaf minor. For the next coffee hybridization study the following hybrid parents were not suitable for insect tolerance: HC-1, HC-3, HC-4, HC-5, HC-7 and HC-13. For the future study, in addition to morphological parameters, the biochemical content of the leaf responsible for insect pest attraction need attention.

Keywords: Hybrid, insect pests, vegetative parameters, Teppi

INTRODUCTION

Ethiopia is the main producer of coffee in the African continent, and the fifth largest exporter of Arabica coffee globally (International Coffee Organization, 2019). Coffee is the backbone of the Ethiopian economy, accounting for 70% of the foreign exchange earnings and 10% of the government revenue while employing 25% of the domestic labor force (Yilma *et al.*, 1999). Four coffee production systems are used in Ethiopia: coffee gardens tended by smallholder farmers near their residences (70%), semi-forest and forest coffee (25%), and modern plantations (5%) (Woldemariam *et al.*, 2008).

Smallholder producers account for 95% of production, while state-owned plantations and investor plantations account for 4.4% and 0.6% of production, respectively (FDRE, 2003).Arabica coffee originated in Ethiopia, and only grows in its wild form in Ethiopia, Uganda, and Kenya (Koebler *et al.*, 2013). The top coffee-producing districts in Ethiopia are Oromia, South Nations, Nationalities, and Peoples Regional State (James *et al.*, 2015). The major constraints to coffee production in Ethiopia include diseases, insect pests, a lack of access to market information, lack of physical infrastructure, poor extension services, limited farm management, low soil fertility, and changes in climatic conditions (Tadesse *et al.*, 2020).

Ethiopian originated coffee (*Coffea arabica* L.) production is challenged by different insect pests in its home of origin. Efforts were made by researchers to increase the productivity and production of coffee (World Coffee Research, 2022). The two species of coffee with economic importance are the Robusta coffee (*Coffea canephora* Pierre) and Arabica coffee (*Coffea arabica* Linnaeus). Arabica coffee has relatively higher demand (over 70% of the world coffee market)

due to its higher beverage quality (Vegro *et al*., 2020). The incidence and spread of pests and disease are also likely to increase and affect crop yields and quality (Jaramillo, 2011). Thirteen arthropod pests and five non-arthropod vertebrate pest species were found to depend on coffee regardless of the landrace type at Gedeo zone (Fekadu *et al*., 2016).

In Africa, as elsewhere, coffee farmers are continuously threatened by a range of pest and disease problems. Many of these are minor in terms of the damage they cause and their effect on yield and quality. However, some, such as coffee berry disease, coffee leaf rust and coffee wilt disease (*tracheomycosis*), can be very serious indeed and can have a major impact not only on individual farmers but on the economy of countries or regions heavily dependent on coffee for foreign exchange earnings (Mike A. Rutherford and Noah Phiri, 2006).

Timor hybrid: this is a naturally occurring hybrid from the island of Timor in Southeast Asia. This is a cross between the local Arabica and Robusta varieties, and has been widely cultivated due to its resistance to coffee leaf rust. Jember: this coffee was developed by Indian breeders in the 1940's and was introduced to Indonesian farmers, which is where it tends to be grown to this day. It is named after the Jember Indonesian coffee and cacao research institute who first introduced it as a commercial plant. F1 hybrids: these are new hybrid coffees that researchers have been developing in labs over the last few years in an attempt to cultivate varieties that are asdisease resistant as possible, while still tasting amazing (Specialty Coffee Association, 2021). Ascoffee rust resistance genes are dominant, when hybrids are derived from a cross between a rust- resistant Catimor parent and an Ethiopian accession, they will have the same level of resistanceas the Catimor parent (Bertrand *et al*., 2011). There is high chance to exploit host plant resistancefor the management of coffee berry borer in Ethiopia (Chemeda Abedeta Garbaba and Weyessa Garedew, 2019).

Resistant coffee plants have been obtained through the transfer of resistance genes from *C. racemosa* to the susceptible *C. arabica* cultivars (Guerreiro-Filho, 2006). However, homogeneous and stable populations, sexually propagated, have not been obtained yet, suggesting that resistance inheritance is more complex than the control by two dominant and complementary genes (Guerreiro-Filho *et al*., 1999).

Thus, the cloning of resistant coffee plants with desirable agronomic traits may represent a viable alternative to be explored by different methods of vegetative propagation, such as the cutting of orthotropic branches, or the somatic embryogenesis through in vitro culture of leaf tissue (Bertrand *et al*., 2011). Basic knowledge about the biology of this insect, the damage it causes to the plants, the identification of sources of resistance, the development of efficient selection methods and knowledge about the genetics of resistance have contributed to the efficiency of the ongoing genetic improvement programs. Recently, coffee genomics studies have also promoted an improvement in the efficiency of the development of cultivars resistant to this insect (Ramiro DA *et al*., 2006).

Researchers will evaluate and select the best-performing crosses, focusing on key traits of interest identified by local breeders and experts. Priority targets include: Disease and Insect resistance/tolerance, Productivity, Traits linked to climate resilience (e.g., yield stability), Traits linked to harvest (e.g., uniform ripening time), and Traits linked to production efficiency (e.g., dwarf/tall) and Tolerance to abiotic stresses (drought, heat) (World Coffee Research, 2022). So

the objective of this study is to evaluate coffee hybrid varieties for insect pest tolerance at Teppi, Southwestern, Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

Teppi is located at Southwestern parts of Ethiopia at 35°08'E longitude and 7°08'N latitude and at an altitude of 1200 m.a.s.l. It is situated at 600km from the capital city (Addis Ababa) of Ethiopia. The average annual rain fall of the area is 1630mm and the mean minimum and maximum temperature of the area are 15°c and 30°c, respectively.

Materials and Design Used for the Study

Fifteen coffee promising hybrids were used for the study with already released coffee hybrid checks Ababuna and Geisha. The design used was RCBD with three replications.

Methods Used for the Study

Three coffee trees were taken per plot for each insect and each coffee tree branches were taken from the upper, middle and bottom to record the insect pest attack on each branches leaf. From the upper, middle and bottom branches, three representative branches were taken and all the leaves were counted. From the total leaf counted, infected leaves with insect pests were recorded.Sixteen coffee trees per plot with two rows were used for the study.

Morphological and Insect Pest Data's Taken

About six morphological parameters were taken for the evaluation of coffee morphological parameters with insect pest attack. The six morphological parameters taken for the evaluations are Height, no of nodes, no of primary branch, Height up to the first primary branch, Girth and Canopy width. The insect pests' data taken were coffee blotch leaf minor, coffee serpentine leaf minor and coffee leaf skeletonize.

Data Analysis

Finally, the collected data and information from the experiments were recorded, tabulated and subjected to the analysis using an appropriate computer software program, the SAS® Statistical Analysis Software (Release 9.4 for Windows). The Fishers protected Least Significant Difference (LSD) values were used ($P<0.05$) to separate means of different treatments.

RESULTS

Table 1. Effect of Coffee canopy density to the attack of insect pests

Plot No.	Variety	No. of primary branches			mean	Canopy width in cm			mean
		Replication				Replication			
		I	II	III		I	II	III	
1	HC-1	61.8	60.8	69	63.9	1.56	1.61	1.63	1.6
2	HC-2	56.8	82.4	86.4	75.2	1.536	1.54	1.82	1.63
3	HC-3	55.8	65.8	73.4	65	1.648	1.72	1.56	1.64
4	HC-4	61	62.6	90	71.2	1.7	1.8	1.74	1.75
5	HC-5	67.2	68.8	74.2	70.1	1.82	1.95	1.76	1.84
6	HC-6	62.2	50.6	72.2	61.7	1.562	1.67	1.7	1.64
7	HC-7	72	69.8	80	73.9	1.81	1.68	1.68	1.72
8	HC-8	60.4	67	69	65.5	1.65	1.56	1.7	1.64

9	HC-9	69.2	61.8	92.6	74.5	1.86	1.78	1.79	1.81
10	HC-10	57.6	81.8	74.8	71.4	1.66	1.65	1.68	1.66
11	HC-11	49.8	75.2	93	72.7	1.58	1.62	1.61	1.6
12	HC-12	50.4	48.8	82.8	60.7	1.76	1.64	1.67	1.69
13	HC-13	62.4	79.2	75.8	72.5	1.8	1.57	1.49	1.62
14	HC-14	59.6	71.6	80.6	70.6	1.76	1.48	1.63	1.62
15	HC-15	52.8	74.8	76.4	68	1.7	1.6	1.72	1.67
16	Ababuna(C_1)	42.6	50	64	52.2	1.74	1.7	1.68	1.71
17	Geisha(C_2)	60.6	74.6	75.6	70.3	1.46	1.52	1.34	1.44

Source: Wakjira Getachew, 2005 E.C

Table 2. Effect of different Coffee morphological parameters to the attack of insect pests

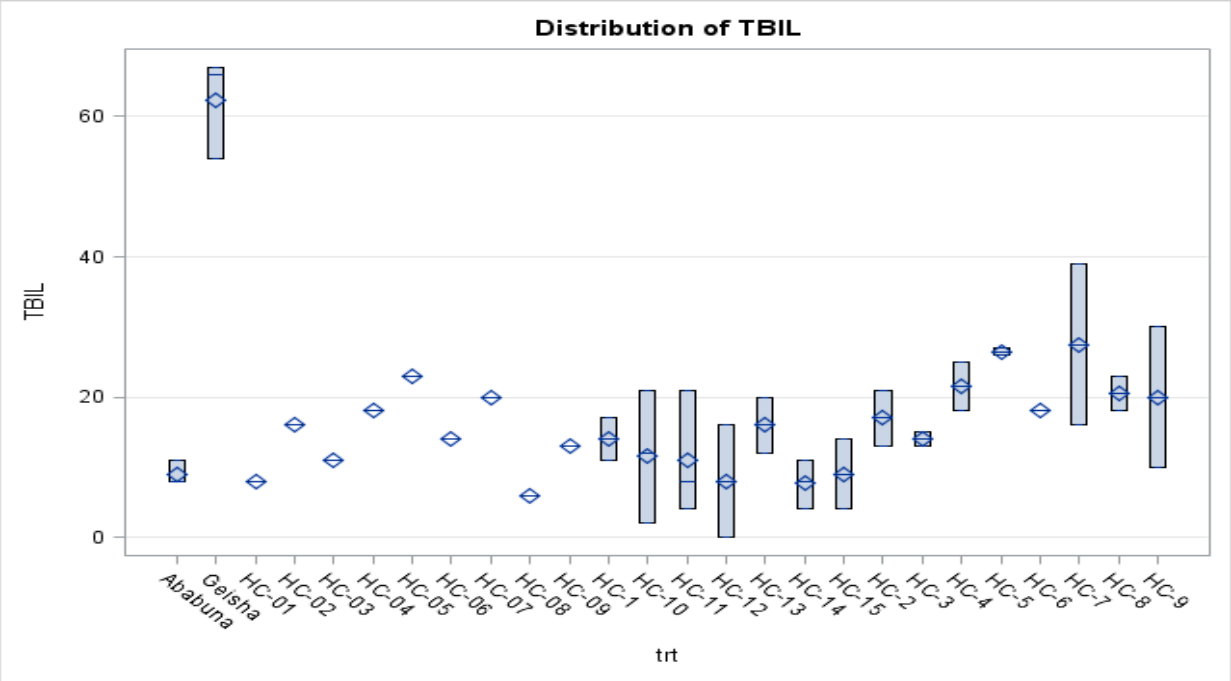
Plot No.	Variety	Height in cm			mean	No. of nodes/tree			mean	Height up to first primary branches			mean	Girth in cm			mean
		Replication				**Replication**				**Replication**				**Replication**			
		I	II	III		I	II	III		I	II	III		I	II	III	
1	HC-1	259	293	295	282	33.6	51	33.4	39.3	33.6	37	34	34.9	2.92	2.94	2.88	2.91
2	HC-2	278	344	356	326	36.6	32.6	40.6	36.6	35	30.2	35.2	33.5	3.5	3.32	2.98	3.27
3	HC-3	283	294	294	290	37.4	32.6	33.4	34.5	34.4	34	34	34.1	3.36	3.04	2.68	3.03
4	HC-4	294	323	376	331	38.8	35	42	38.6	34.2	37	39.6	36.9	3.78	3.54	3.6	3.64
5	HC-5	313	320	331	321	45	51.4	35.2	43.9	38.2	35.4	37.2	36.9	3.54	3.44	2.96	3.31
6	HC-6	305	287	340	311	46.6	47.4	36	43.3	34	33.8	32.6	33.5	2.74	2.86	2.78	2.79
7	HC-7	372	344	298	338	60.2	32.4	36.8	43.1	40.4	37	42	39.8	3.78	3.9	3.48	3.72
8	HC-8	302	310	320	311	37	30.4	34.2	33.9	27.6	29	28.6	28.4	3.16	3.24	2.7	3.03
9	HC-9	316	305	367	329	42.6	50.4	42.2	45.1	39.6	38.6	38	38.7	3.3	3.6	3.22	3.37
10	HC-10	346	351	363	353	45	37.4	39	40.5	37.8	41	37.8	38.9	3.18	3.04	2.8	3.01
11	HC-11	304	356	380	347	43.4	41.6	44.6	43.2	33.8	35	39.4	36.1	3	3.46	2.9	3.12
12	HC-12	304	310	331	315	44.8	50	39.4	44.7	34	36.8	43	37.9	3.06	2.86	2.9	2.94
13	HC-13	303	333	285	307	44.4	37.8	35.6	39.3	30.4	29	35.8	31.7	3.1	3.2	2.56	2.95
14	HC-14	350	316	358	341	52.2	35.4	39	42.2	36.2	36	39	37.1	4.42	2.84	3.14	3.47
15	HC-15	335	358	332	342	46.8	32.4	37.6	38.9	35.4	39	37.8	37.4	3.2	3.26	2.92	3.13
16	Ababuna(C_1)	288	318	328	311	40.2	43.4	33.2	38.9	33.6	39.8	38	37.1	2.86	2.96	3	2.94
17	Geisha(C_2)	226	252	276	251	45.8	32.6	37.4	38.6	23.4	25	29.4	25.9	2.64	3.04	2.6	2.76

Source: Wakjira Getachew, 2005 E.C

Table 3. Evaluation of coffee hybrid variety trial for blotch leaf minor at Teppi

Coffee blotch leaf minor						
Plot	Trt	R1	R2	R3	Total	Rank
1	HC-01	8	11	17	36	11
2	HC-02	16	21	13	50	7
3	HC-03	11	13	15	39	10
4	HC-04	18	18	25	61	4
5	HC-05	23	26	27	76	2
6	HC-06	14	18	18	50	7
7	HC-07	20	16	39	75	3
8	HC-08	6	18	23	47	9
9	HC-09	13	10	30	53	5
10	HC-10	21	2	12	35	12
11	HC-11	21	4	8	33	13
12	HC-12	8	16	0	24	15
13	HC-13	20	16	12	48	8
14	HC-14	11	4	8	23	16
15	HC-15	9	4	14	27	14
16	Ababuna	8	8	11	27	14
17	Geisha	66	67	54	187	1

Source: Wakjira Getachew, 2005 E.C

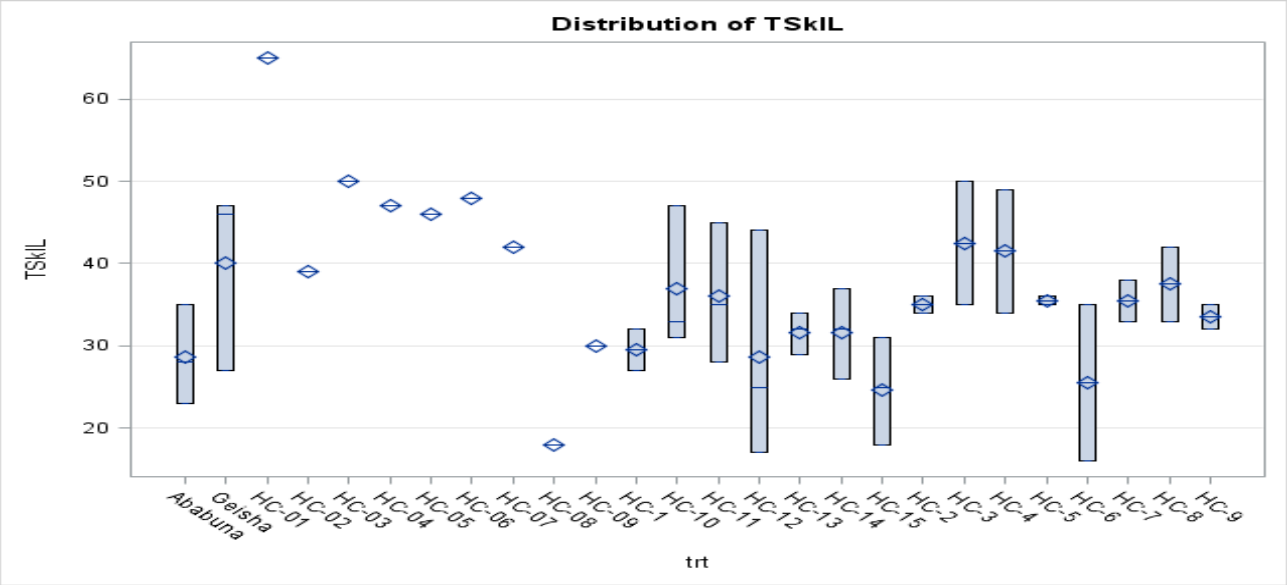


TBIL= Total blotch infected leaf

Table 4. Evaluation of coffee hybrid variety trial for Leaf Skeletonizer at Teppi

Coffee leaf skeletonizer						
Plot	Trt	R1	R2	R3	Total	Rank
1	HC-01	65	32	27	**124**	**3**
2	HC-02	39	34	36	**109**	**8**
3	HC-03	50	50	35	**135**	**1**
4	HC-04	47	49	34	**130**	**2**
5	HC-05	46	35	36	**117**	**5**
6	HC-06	48	35	16	**99**	**10**
7	HC-07	42	38	33	**113**	**6**
8	HC-08	18	42	33	**93**	**13**
9	HC-09	30	35	32	**97**	**11**
10	HC-10	47	31	33	**111**	**7**
11	HC-11	35	45	28	**108**	**9**
12	HC-12	25	44	17	**86**	**14**
13	HC-13	29	32	34	**95**	**12**
14	HC-14	32	26	37	**95**	**12**
15	HC-15	18	31	25	**74**	**15**
16	Ababuna	35	28	23	**86**	**14**
17	Geisha	47	46	27	**120**	**4**

Source: Wakjira Getachew, 2005 E.C

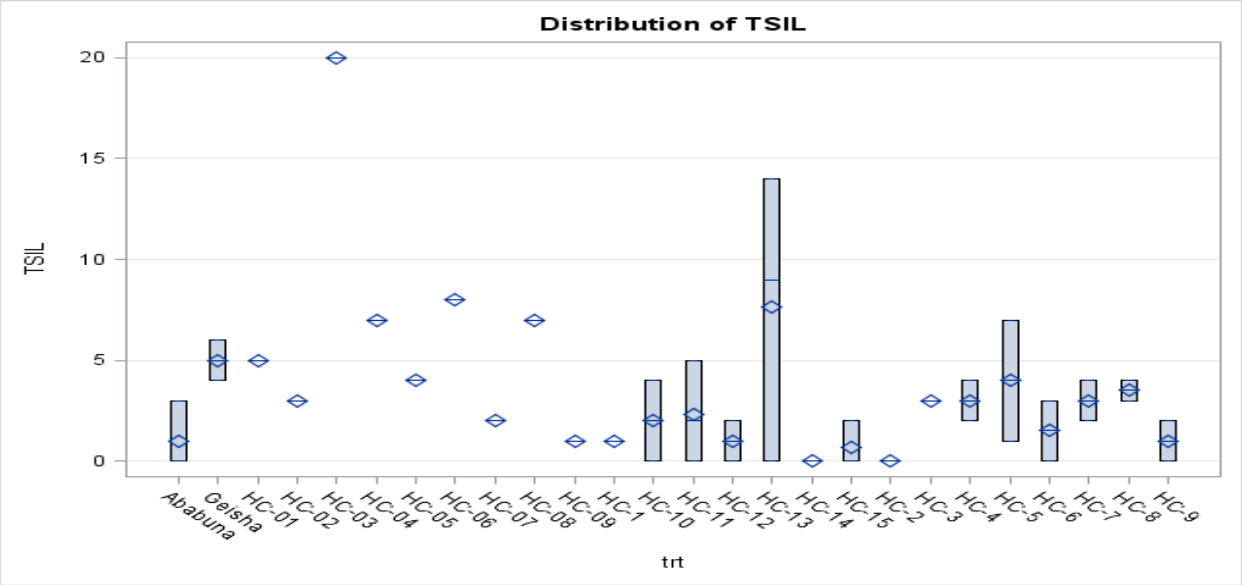


TSkIL=Total skeletonizer infected leaf

Table 5. Evaluation of coffee hybrid variety trial for Serpentine Leaf Minor at Teppi

Coffee serpentine leaf minor						
Plot	Trt	R1	R2	R3	Total	Rank
1	HC-01	5	1	1	7	**9**
2	HC-02	3	0	0	3	**11**
3	HC-03	20	3	3	26	**1**
4	HC-04	7	4	2	13	**5**
5	HC-05	4	1	7	12	**6**
6	HC-06	8	0	3	11	**7**
7	HC-07	2	2	4	8	**8**
8	HC-08	7	4	3	14	**4**
9	HC-09	1	2	0	3	**11**
10	HC-10	0	2	4	6	**10**
11	HC-11	5	2	0	7	**9**
12	HC-12	0	2	1	3	**11**
13	HC-13	9	14	0	23	**2**
14	HC-14	0	0	0	0	**13**
15	HC-15	0	0	2	2	**12**
16	Ababuna	0	3	0	3	**11**
17	Geisha	5	6	4	15	**3**

Source: Wakjira Getachew, 2005 E.C



TSIL=Total serpentine infected leaf

DISCUSSIONS

From the above result, two vegetative parameters: canopy width and no of primary branches were related with insect pest infestation. The highest the number of primary branch and the more compact, it's affected by insect pests. Insect pest infestation has no relationship with the other parameters. For the evaluation of coffee blotch leaf minor Geisha is the first coffee variety attacked with this insect pest and also in line with specialty coffee association, 2021 Geisha coffee is susceptible to leaf rust. Different types and degrees of resistance illustrate the relationship between the coffee plant and the leaf miner. The great variation in the growth of lesions due to coffee leaf miners in leaves of the species *C. racemosa, C. setenophylla, C. kapakata*, among others (Guerreiro-Filho *et al.*, 1991), is probably due to phytochemicals that interfere in the normal development of the caterpillars and it is a clear example of antibiosis (Ramiro DA *et al.*, 2006). HC-5 and HC-7 are the second and the third respectively. For the evaluation of coffee leaf skeletonizes HC-3 is the first attacked by this insect. HC-4 and HC-1 are the second and the third respectively. For the evaluation of coffee serpentine leaf minor HC-3is the first attacked by this insect. HC-13 and Geisha are the second and the third respectively.

CONCLUSIONS

To increase the yield of coffee with hybridization, insect pest and disease tolerance quality of the coffee must take attention for sustainable coffee yield increment. More compact coffee variety had more insects to hide. Geisha coffee was seriously attacked by blotch leaf minor from all the treatments. The leaf of Geisha coffee is broad and deep green. According to Mercon Specialty, 2019, the best way to prevent pests is through good farm management. Choice of variety, shade management, selective pesticide use, and plant nutrition management are important considerations.

RECOMMENDATIONS

Therefore, the coffee tree must be pruned regularly for more air circulation to reduce insect pest attack on coffee. The coffee leaf content and insect pest attack relation of Geisha coffee variety need great attentionin the future to study. HC-3 was susceptible to coffee leaf skeletonizes and coffee serpentine leaf minor from all the treatments used for the study and needs care in the future of coffee variety development for coffee insect pest tolerance.

ACKNOWLEDGEMENTS

The authors are grateful to Ethiopian Institute of Agricultural Research and Jimma Agricultural Research Center for providing and approving fund for this study, respectively. We are thankful to all the staff of Teppi Agricultural Research Center for their direct and indirect help throughout the study period.

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