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Status of Major Coffee Diseases of Coffea Arabica L. in Afromontane Rainforests of Ethiopia. A Review

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Abstract
Coffee berry disease (*Colletotrichum kahawae*), coffee wilt disease (*Gibberella xylarioides*) and coffee leaf rust (*Hemileia vastatrix*) were found prevalent in afromontane rainforest coffee areas (Harenna, Bonga, Berhan-Kontir and Yayu) of Ethiopia. The mean incidence and severity/intensity of coffee berry disease (CBD) ranged from 6.0 to 40.0% and from 2.0% to 17.9% at Berhan-Kontir and Bonga, respectively. The mean incidence of coffee wilt disease (CWD) varied from 2.4% at Berihan-Kontir to 16.9% at Yayu forest coffee areas. The mean incidence of coffee leaf rust (CLR) varied from 32.2% at Berihan-Kontir to 96% at Harenna. CLR also occurred in all field sites with annual variation in intensity. Investigation on morphological characteristics of uredinospores showed typical length and width with average sizes of 31.61 x 21.19 µm, Race specification indicated race II (v5) from Berhane-Kontir, race III (v1,5) and X (v1,4,5) from Bonga CLR collections. Recent investigation on *Hemileia vastatrix* hyperparasites has placed Ethiopian findings into *Verticillium lecani*. The results of assessments have revealed indicators to implement integrated management of major coffee diseases for sustainable conservation and wise use of forest coffee in afromontane rainforest of Ethiopia.
Keywords: Coffee, Coffee diseases, Ethiopia

1. Introduction

For Ethiopia, coffee is the most important export commodity, with a share of 20-25% of the total foreign exchange earnings. At least 15 million people also directly or indirectly rely on coffee for their livelihood. As the country of origin for crop, Ethiopia produces premium quality coffee. It is the leading producer in Africa, and the 5^{th} in the world, following Brazil, Vietnam, Colombia and Indonesia. If we consider Arabica alone, Ethiopia is the 3rd largest producer after Brazil and Colombia (Abu, 2015., Minten etal., 2015, ICO, 2015).

The average yield in the country is generally low (about 748 kg /ha) which is half of that achieved in Latin America and Asia. This is partly due to the limited use of improved technologies and best practices by most small-holder farmers, the widespread prevalence of insect pests, diseases and coffee weeds (Girma *et al*., 2009, Phiri *et al*., 2009, Esayas *et al.,* 2008, Tade*sse* E and Tesfu, 2015, Kifle *et al.,* 2015, Demelash and Ashenafi, 2017 ,Tamiru *et al.,* 2017). However, coffee suffers from a range of diseases including coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR) caused by *Colletotrichum kahawae, Gibberella xylarioides* and *Hemileia vastatrix*, respectively. Bacterial blight of coffee (BBC) and coffee thread blight which is caused by *Pseudomonas syringae pv garcae van Hall and Corticium koleroga* respectively becomes a major concern in Sidama and Gedeo Zone at Gera, Metu and Limmu Horizon coffee plantation.

In Ethiopia, there are four systems of coffee production viz. forest coffee, semi - forest coffee, garden coffee, and plantation coffee. Forest coffee is a wild coffee grown under the shade of natural forest trees with no management input and spontaneously regenerating natural population which accounts 10% and yield 250-300kg/ha (Figure 1). Forest coffees are found in southeastern and southwestern parts of the country (mainly in areas like Bale, Bench-Maji, Illubabor, Kafa, Jimma, Shaka, and West Wollega). The local communities living in and around the forest simply pick the wild coffee berries from naturally growing coffee plants and there is no management to improve coffee productivity. The floristic composition, diversity and structure is close to the natural situation, with little human intervention. The only management practice in the forest system is access clearing to allow movement in the forest during harvesting time (Gole et al. 2001).

Therefore, this paper attempts to review research findings on major coffee diseases, in Afromontane rainforest of Ethiopia.


Fig 1 Over view of the Yayo coffee forest(left) . Naturally grown coffee seedlings Yayo forest (right)

Research Findings

2. Coffee Berry Disease /CBD/ *Colletotrichum kahawae*

CBD was first detected in 1922 in Kenya around Mt. Elgon, west of the Rift Valley (waller, 2007). At the beginning, the disease was related to the fungus C. coffeanum described from Brazil by Noack causing leaf spots on Arabica coffee. But the new disease in Kenya produced anthracnose-like symptoms on green berries. Rayner called the pathogen C. coffeanum var. virulans to differentiate between leaf and berry symptoms. Morphological and pathogenicity research by several authors from the 1960s to 1990s finally resulted in the name C. kahawae, representing the Kiswahili word for coffee in the species name (Waller, 1993). Prior to that time, the pathogen was called either CBD-strain or *C. coffeanum* Noack sensu Hindorf. Intensive investigations on the *Colletotrichum* population in coffee were carried out by Hindorf and three distinct species occurring in association with CBD on coffee berries were described as (1) the CBD-causing species *C. coffeanum* growing with black colour on artificial Malt-Extract Agar, (2) *C. acutatum* with pink colour in vitro and (3) *C. gloeosporioides* producing symptoms only on ripe berries as the so-called late blight and a perfect stage of Glomerella cingulata (Hindorf, 1973). From Kenya the disease spread to Angola in 1930, Zaire in 1937, Cameroon between 1955 and 1957, Uganda in 1959, Tanzania in 1964, Ethiopia in 1971 and Malawi in 1985(Firman ID and Waller JM 1977). Until now the disease has been restricted to East, Central and South African coffee-growing regions. In Ethiopia the disease occurred much later than in neighboring Kenya. After its first appearance in Sidama and the first report by Mogk in 1971, the disease spread very quickly to nearly all growing coffee provinces until 1978 and caused remarkable losses. The pathogen can infect all organs of the host: flower buds, leaves, fruits and the maturing bark. Infection takes place either early during flower bud formation causing some losses in flowers or remains latent in the inflorescence until the berries start to expand in growth. The outbreak of the disease with visible symptoms occurs during the expanding stage of berry development, producing sunken, black, anthracnose-like lesions on the green pulp. High moisture or pulp wetness favors the production of conidia in black acervuli appearing in concentric rings and exuding pink masses of one-celled, straight or slightly curved hyaline conidia. The conidia are splash-borne or distributed by insects, coffee pickers or other vectors, but never by wind due to a sticky constellation in the pink masses. In the absence of buds and berries the pathogen survives in the maturing bark of secondary branches. The pathogen never attacks mature coffee beans; it remains in the pulp. The losses occur during early infestation by destroying the beans or by preventing proper wet and dry processing since the pulp cannot be removed completely, causing so-called ‘‘stinkers’’ in the crop and reducing the quality. An intensive progress of the disease in the expanding stage of the berry development finally produces mummified berries with no economic value at all.

Survey of CBD assessment was taken every 3-5 kilometer interval across the forest coffee by considering the existing field variation especially land gradients, and presence and absence of forest coffee. In each 100 meter x 100 meter plot, berry count and visual assessment was conducted to estimate disease severity and incidence. The frequency and intensity of CBD varied among and within forest coffee areas depending on environmental conditions and genetic diversity of forest arabica coffee. Coffee berry disease was observed in Yayu and Bonga forest coffee consistently. Survey results indicated that the disease incidence ranged from 0-50%, 20-60%, 0-20% and 0-50% and severity from 0-15%, 12.5-22.5%, 0-6.5% and 0-7.8% in forest coffee areas of Harenna, Bonga, Berhan-Kontir and Yayu, respectively. The mean incidence ranged between 6.0% at Sheko and 40.0% at Bonga where as the severity of the disease varied between 2.0 and 17.9% at Sheko and Bonga, respectively (Fig.1 and 2). High incidence of CBD may be explained by the particularly high rainfall found in relatively high altitudes of Bonga and to some extent in Yayu. Similarly, Cook (1975) explained that high rainfall, high humidity or wetness and relatively low temperatures persisting for long periods and favoring the CBD development exist at high altitudes, where these conditions generally prevail. In addition in Yayu the disease was also found at low altitudes (<1500 m.a.s.l) which ranged from 0 to 40% incidence and 0 to 5%

severity but reached up to 50% incidence and 7.8% severity in medium altitudes. This indicated that CBD is also important in lower altitudes where environmental factors are conducive for disease development. Previously there was no CBD information at bottom land of Harena (Majete) and Berhane-Kontir (Gizmeret) forest coffee areas. It is the first information to report in both areas for the existence of CBD infestations in pocket (limited parts) of Harena (Mekabaldo) and Sheko (Wesheka) forest and semi-forest coffee areas (Arega, 2008). Moreover, the result of coffee accessions which were collected from Bale, Bonga, Sheko and Yayo forests, and planted at Jima/Melko for preliminary evaluation of yield and coffee disease (CBD, CLR and branch dieback) revealed that, the level of CBD was found relatively higher on Yayo accessions as compared to other forest population. On the other hand high level of branch die back and CLR was recorded on Bale accessions (Table1).

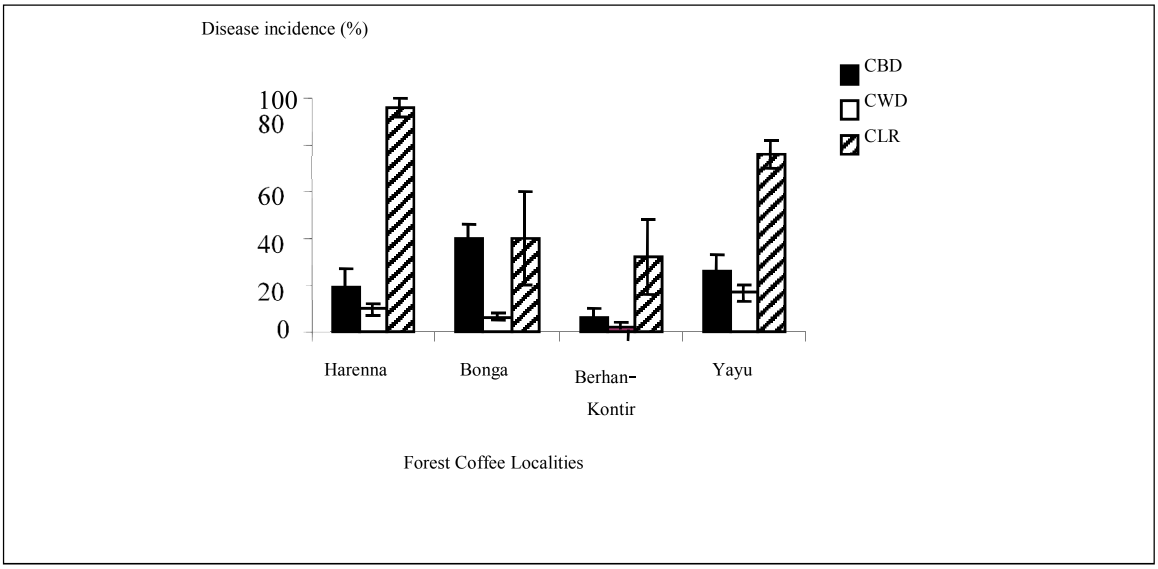

Fig. 1. Incidence of CBD, CWD and CLR in afromontane rainforest coffee areas of Ethiopia (error bars are standard errors).

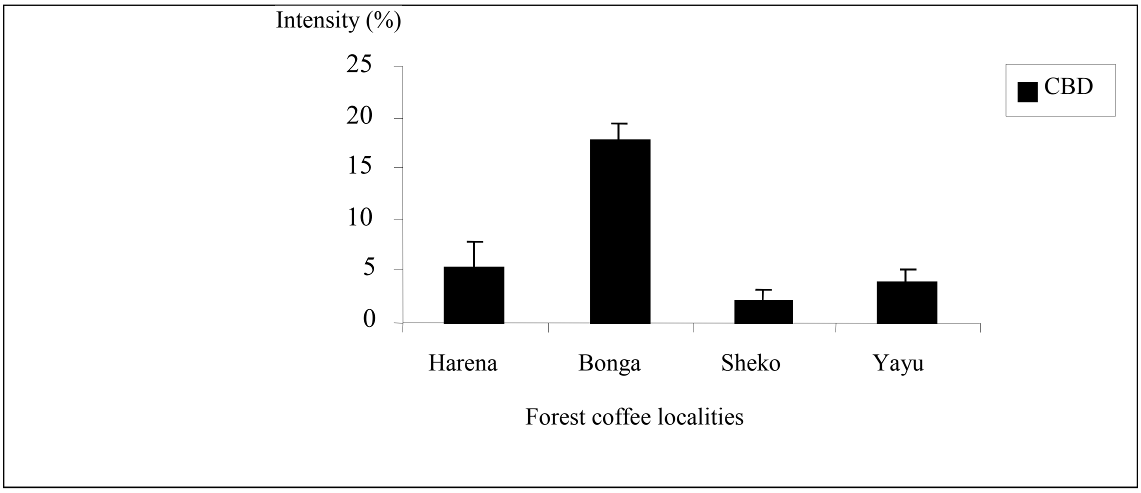

Fig. 2. Severity/intensity (%) of CBD in afromontane rainforest coffee areas of Ethiopia (error bars are standard errors).

Table 1. Reaction of forest coffee collections for Coffee berry disease, Coffee leaf rust and branch die back

Bale Collections				Bonga collection				Sheko Collections				Yayo Collections			
	Visual assessment (%)				Visual assessment (%				Visual disease records (%)				Visual assessment (%		
Acc.No	CBD	CLR	Incidence of branch Dieback	Acc.No	CBD	CLR	Incidence of branch Dieback	Acc.No	CBD	CLR	Incidence of branch Dieback	Acc.No	CBD	CLR	Incidence of branch Dieback
P1S1-1	10	19	90	P2S1-16	0.05	33	10	P3S1-31	0.00	4.5	0	P4S1-46	7.35	17	20
P1S1-2	0	16.2	80	P2S1-17	0.05	15.5	0	P3S1-32	0.00	9	0	P4S1-47	8.7	12.1	0
P1S1-3	0	21	80	P2S1-18	0.00	15.5	0	P3S1-33	0.00	4.2	0	P4S1-48	6.1	22.7	0
P1S1-4	0	26.25	30	P2S1-19	0.05	17.5	50	P3S1-34	0.00	5.9	20	P4S1-49	1.3	8.4	0
P1S1-5	0	14.5	50	P2S1-20	0.00	21.1	0	P3S1-35	0.00	6.9	0	P4S1-50	0.25	20.5	10
P1S2-6	0	30.7	50	P2S2-21	0.00	6.02	0	P3S2-36	0.00	4.1	0	P4S2-51	1.83	23.5	10
P1S2-7	0.15	19	30	P2S2-22	0.00	2.11	0	P3S2-37	0.00	2	0	P4S2-52	29.6	10.7	0
P1S2-8	0.2	23	40	P2S2-23	0.00	3.3	0	P3S2-38	0.00	3.2	0	P4S2-53	16.29	16.7	20
P1S2-9	0.05	32	10	P2S2-24	0.00	7.62	0	P3S2-39	0.00	3.3	0	P4S2-54	15.5	27	0
P1S2-10	0.15	27	10	P2S2-25	0.00	6.02	0	P3S2-40	0.00	2.7	0	P4S2-55	6.35	30	20
P1S3-11	0.15	26	40	P2S3-26	0.00	11.4	0	P3S3-41	0.28	3.8	0	P4S3-56	7.9	10.5	30
P1S3-12	0	22.78	50	P2S3-27	3.77	7.02	0	P3S3-42	0.00	2.4	0	P4S3-57	19.95	8.5	0
P1S3-13	0.15	23.5	80	P2S3-28	6.17	3.3	0	P3S3-43	0.00	11.1	0	P4S3-58	27	8.9	10
P1S3-14	0.05	22.5	60	P2S3-29	0.00	7.62	0	P3S3-44	0.17	12.7	10	P4S3-59	40	7.2	0
P1S3-15	0	29.5	40	P2S3-30	7.25	6.02	0	P3S3-45	0.00	6.9	0	P4S3-60	37.1	15.1	10
Mean	**0.7**	**24.1**	**46.8**		**1.2**	**9.3**	**3.6**		**0.03**	**5.5**	**2**		**15.1**	**15.9**	**8.7**
SD	**2.5**	**5.1**	**24.9**		**2.5**	**5.9**	**13.4**		**0.08**	**3.2**	**5.6**		**13**	**7.3**	**9.9**

3. Coffee Wilt Disease , *G. xylarioides* (*F. xylarioides*)

Coffee Wilt Disease (tracheomycosis) is a vascular disease caused by the fungal pathogen, *G. xylarioides (F. xylarioides)* and results in a total death of the infected coffee trees. The disease has been a serious problem to the production of Robusta coffee in DR Congo and Uganda since the 1990s killing hundreds of trees. The first appearance on Arabica coffee in Ethiopia was reported in 1958 by Lejeune, and a diagnostic confirmation was provided by Kranz and Mogk in 1973. Gibberella as the sexual or perfect stage producing wind-borne ascospores and Fusarium as the asexual or imperfect stage with splash-borne conidia. Infection mostly takes place at the imperfect stage penetrating through wounds into the base of the stem. The fungus blocks the water supply in the vascular system and causes a typical brown discoloration. In the field, black to violet perithecia of the perfect stage are formed on or beneath the bark at the base of the stem.

In each forest coffee, CWD assessment was taken every 2-4 kilometer distance between plots across the forest coffee area. Depending on the forest coffee, field sizes across each forest coffee area 5-8 plots were assessed. In each 100 meter x 100 meter plot, 30-50 trees were diagnosed diagonally and consecutively following the procedure of Girma *et al*. (2001) and CABI (2003). Healthy and diseased trees showing typical characteristic symptoms (internal and external) of the disease and/or sign of the pathogen were visually observed. Internal symptoms (black and/or brown strips) were observed after the diseased trees bark was slightly scratched off by knife to expose the wood. Then the numbers of healthy and diseased trees counted, and the incidence of CWD was computed as the number of diseased trees divided by the total number of observed coffee trees x 100.

Coffee wilt disease was found in all assessed forest coffee areas suffering considerably in coffee tree losses. Its incidence was varied from 0-16%, 0-10%, 0-6% and 0-30% in forest coffee areas of Harenna, Bonga, Berhan-Kontir and Yayu, respectively. The mean incidence varied between 2.4% at Berhan-Kontir and 16.9% at Yayu (Fig. 1). The national incidence and severity of the disease were 29.9 and 3 percent, respectively, and in monetary terms it caused loss of more than 3.7 million USD (Arega 2006, CABI, 2003).

4. Coffee Leaf Rust *(H. vastatrix)*

Coffee Leaf Rust (CLR) is one of the most important diseases of C. arabica in the world. It devastated Arabica coffee plantations in Ceylon at the end of the 19th century and was responsible for its replacement with tea plantations. Despite effective fungicides and resistant varieties developed to control rust, yield reductions of 20% or more in various countries are still caused by the pathogen (Waller, 1982). In Brazil, losses have been estimated to be about 30% and an annual loss of about 4500 tons of coffee was estimated in Kenya in the 1960s. The pathogen prefers a temperature range of 20–28 ^{o}C, needs a leaf wetness period only during spore germination and penetrates with the germination hyphae into the stomata of the host. The fungus tolerates longer seasons without rainfall and spores are wind-borne, only attacking leaves and needs no other host. Due to the fact that coffee is a perennial host with green leaves all through the year, the pathogen produces only uredinio- and teliospores with basidiospores. Coffee grown in lower altitudes is more predisposed to the disease and suffers more attacks. A heavy infestation of leaves not only reduces the assimilation area but also results in a complete defoliation diminishing the next year's crop tremendously. CLR was first reported in Ethiopia in 1934 by Sylvain , but the disease had existed for a long time without causing epidemics or eradications of certain varieties of C. arabica. The long-term coexistence of coffee and rust coupled with the high genetic diversity of coffee populations and a high level of horizontal resistance might have kept the rust at low levels. Other factors such as the low average productivity associated with shade and the existence of biological agents such as the hyperparasite *Verticillium lecanii*, were also believed to play an important role in maintaining CLR at low levels.

The assessments of CLR in the forest were carried out randomly on 100 trees for disease incidence (%) and the intensity (scale 1-4) of the disease within each 100 x 100 meter site. In all investigated forest coffee areas CLR was prevalent to a high extent (Fig.1). Result of the assessment showed more or less high incidence of CLR in all forest coffee areas varying from 32.2% at Berhan-Kontir to 96% at Harenna forest coffee (Fig. 1). The highest CLR incidence was occurred at Harenna followed by Yayu. Investigation on morphological characteristics like spore size of uredinospores, collected from forest coffee showed typical length and width with average sizes of 31.61x21.19 µm and has confirmed that the Ethiopian collections belong to the species *Hemileia vastatrix* (Ritschel, 2005). There was little emphasis on race-typing of Ethiopian rust samples until the beginning of the 1980s and the 1990s, Wondimu et al. 1987 observed that race III was the most frequent in forest coffee and race II in other areas. Other races were I, X and XV. In 2005 the first race-typing of CLR collections of indigenous coffee was carried out at the Centre of Coffee Leaf Rust Research (CIFC) in Oeiras, Portugal using their differentials. In this recent study the race specification identified race II at Berhane-Kontir and race III and X in Bonga with corresponding virulence genes v 1, 4 and 5 (Arega et al., 2008).

5. Conclusion and Recommendations

Coffee diseases such as CBD, CWD and CLR were assessed in afromontane rainforest coffee areas: Harenna, Berhane-Kontir, Bonga and Yayu. CBD incidence and severity varied from one forest coffee area to the other depending on environmental conditions and genetic diversity of Arabica coffee trees. The mean incidence and severity of CBD varied from 6% to 40%, and 2% to 17.9% at Berhane-Kontir and at Bonga, respectively. CWD was prevalent in all assessed forest coffee areas where it has been posing considerable coffee tree losses when its cumulative effect has been considered. Its mean incidence ranged from 2.4% at Berhan-Kontir forest area to 16.9% at Yayo forest coffee area with certain variations among sampled forest coffee field plots in each locality. These observations depicted that the integrated management of major coffee diseases should be given attention for sustainable conservation and wise use of forest coffee in afromontane rainforest of Ethiopia. This in turn could help to utilize the forest coffee genetic potential to improve the crop production and productivity in present and future research endeavors. Surveys in the forest coffee areas showed that there is a high diversity of coffee landraces which have the potential to develop a variety that can reduce the cost of production and offer environmentally better disease management approaches. The availability of high genetic diversity is fundamental for any crop improvement program for use by the plant breeders. In the absence of genetic diversity, any improvement endeavor is time consuming, expensive and with little success. Alike other crop species, the conservation of coffee genetic resources plays significant role as an economic potential, ecosystem conservation and survival capacity of the species. Because of this high genetic diversity, coffee breeding programs have been striving to identify disease tolerance, drought resistance, and low caffeine varieties. Therefore, a diverse coffee gene pool is of paramount importance for breeding. Particularly, cross breeding of cultivars and wild genetic material leads to results above average due to heterosis effects. In this regard, the Ethiopian wild coffee populations provide highly diverse genetic material for future coffee breeding and selection.

6. References

Abu Tefera (2015). Coffee Annual Report in Ethiopia. Grain Report Number ET 1514.

USDA Foreign Agricultural Service, Global Agricultural Network.

Arega Zeru. 2006. Diversity of Arabica coffee populations in Afromontane rainforests of Ethiopia in relation to *Colletotrichum kahawae* and *Gibberella xylarioides*. M.Sc. Thesis. Addis Ababa University, Ethiopia. 80 pp.

Arega Zeru , Fassil Assefa, H. Hindorf and A. Ritschel 2008. Occurrence of Major Coffee Diseases in Afromontane Rainforests of Ethiopia pp261-266. In: Girma Adugna, Bayetta Belachew, Tesfaye Shimber, Endale Taye and Taye Kufa (eds). Coffee diversity and knowledge. Proceedings of National Workshop Four Decades of Coffee Research and Development in Ethiopia. Addis Abeba, Ethiopia, 14-17 Augest 2007.

Cook, R.T.A. 975. Screening coffee plants for resistance to CBD. Coffee Research Foundation, Kenya. Annual Report 1973/4.

CABI. 2003. Surveys to assess the extent of coffee wilt disease in East and Central Africa. Final Technical Report. CABI Regional Center, Nairobi, Kenya. 49 pp.

Demelash Teferi and Ashenafi Ayano 2017. Assessment of commercially grown coffee types for their tolerance to bacterial blight of coffee (BBC) at Sidama and Gedeo Zones, Southern Ethiopia. Sky Journal of Agricultural Research Vol. 6(1), pp. 001 - 005,

Esayas Mendesil, Million Abebe and Chemeda Abdeta (2008). Review of research on coffee, Tea and Spices insect pests in Ethiopia. In: *increasing crop production through improved plant protection*. Vol. II (Abraham Tadesse ed.) 117-140 pp. PPSE and EIARO. Addis Ababa, Ethiopia.

Firman ID, Waller JM. Coffee berry disease and other Colletotrichum diseases of coffee. 4th ed. Kew, Surrey, England: Commonwealth Mycological Institute; 1977

Girma A., Million A., Hindorf H., Arega Z., Demelash T., and Chala Jefuka 2009. Coffee Wilt disease In Ethiopia PP 50-68. In: Flood Julie (Ed).Coffee Wilt Disease .CABI international, UK.

Girma Adugna, Mengistu Hulluka and Hindorf, H. 2001. Incidence of tracheomycosis, *Gibberella* xyilarioides

(*Fusarium xylarioides),* on Arabica coffee in Ethiopia. J. Plant Dis. and Pro. 108 (2): 136-142.
Gole, Teketay, D., Denich, M and Borsch, Th. 2001. Diversity of traditional coffee production systems in Ethiopia and their contribution for the conservation of coffee genetic diversity. In: Proceedings of the Conference on International Agricultural Research for Development, Deutscher Tropentag - Bonn, 9-11 October 2001. University of Bonn.
ICO 2015. Coffee Production Data. www.ico.org. Accessed on August 8, 2015: International Coffee Organization.
Hindorf H. Colletotrichum – population auf Coffea arabica L. in Kenya: II. Qualitative und quantitative Unterschiede in der Colletotrichum – population. Phytopathol Z 1973;77:216–34.
Kifle Belachew, Demelash Teferi and Legese Hagos. 2015. Coffee Thread Blight (*Corticium koleroga*): a Coming Threat for Ethiopian Coffee Production. Joranl of Plant Pathology and Micro-biology, 2015, 6(9): 1-6
Phiri N., Kimani M., Negussie E., Simons S. and Oduor G. 2009. Management of Coffee Wilt diseasepp.pp137-154 In: Flood Julie(ed).COFFEE WILT DISEASE: CABI, Uk.
Ritschel A. Monograph of the genus Hemileia (Uredinales). Borntraeger; 2005.
Tadesse E. and Tesfu K, 2015 Effect of Weed Management Methods on Yield and Physical Quality of Coffee at Gera, Jimma zone, South West Ethiopia. Journal of Resources Development and Management Vol.11.
Tamiru Shimales , Sisay Kidanu , Belay Abate and Demelash Teferi, 2017.Paper presented to Crop Research completed activity forum . 9^{th} 14^{th} Oct ,2017 Addis Abeba, In Press.
Rayner RW. Coffee berry disease: a survey of investigations carried out up to 1950. E Afr Agric J 1952;17:130–58
Minten, B., Dereje, M, Engida, E., and Kuma, T. 2015. Smallholders and upstream transformation in global value chains: The case of coffee producers in Ethiopia. IFRI/ EDRI, Addis Ababa
Waller JM. Coffee rust epidemiology and control. Crop Prot 1982;1(4):385–404.
Waller JM, Bridge PD, Black R, Hakiza G. Characterisation of the coffee berry disease pathogen, Colletotrichum kahawae sp. nov. Mycol Res 1993;97(8):989–94
Waller JM, Bigger M, Hillocks RJ. Coffee pests, diseases and their management. 1st ed. CABI; 2007.