Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.19, 2016

A Review on the Status of Coffee Berry Disease (Colletotrichum kahawae*)* in Ethiopia

Gabisa Giddisa

Summary
Ethiopia has served in the past and continues to serve as the source of germplasm for several economically important cultivated crops around the world. Coffee is a non-alcoholic and stimulant beverage crop, and belongs to the family Rubiaceae and the genus Coffea. This commercially as well as genetically valuable crop is attacked by a number of pre- and post-harvest diseases, and of these diseases, coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR) are the most important in Ethiopia. CBD is by far the most economically important disease causing up to 100% losses in some places.CBD is a major cause of crop loss of arabica coffee in Africa and a dangerous threat to production elsewhere. Prevalence of CBD was conducted in Oromiya Region and Southern Nations Nationalities and Peoples Region (SNNPR) and the result indicated 38.8 and 17.2% of mean percent prevalence of the disease, respectively (IAR, 1997). According to the result CBD pressure was very high at higher altitudes in the southwest region, while severe disease was recorded in valleys of Sidamo zone. In Amhara region where CBD occurs, survey result showed that an average CBD severity for the 1996/97-crop season was 38%.The occurrence and intensity of CBD varies from place to place and from one season to the other, depending largely on host susceptibility, pathogen aggressiveness and favorable weather conditions.. The disease is very severe and causes appreciable yield loss in areas where the temperature is relatively low and relative humidity is high, mainly in the rainy seasons.
Keywords: Coffee Berry Disease (Colletotrichum kahawae) Introduction

Ethiopia is the first in Africa and the seventh largest Arabica coffee producer in the world (ICO, 2005). The average annual production amounts to more than 200,000 tones and 90% of the produce is from garden, semi-forest and forest coffee systems by small-scale farmers, while nearly 10% of the produce comes from large-scale plantation coffee.

Coffee is by far the number one export crop and contributes decisively to the country's foreign currency income (Workafes and Kassu, 2000). In addition, the economic value of *C.arabica* genetic resources contained in Ethiopian highland rainforests was estimated to amount around USD 1458 million and USD 420 million at a 5 and10% respective discount rates (Hein and Gatzweiler, 2006).

Coffee production systems in Ethiopia are grouped into four broad categories namely, forest coffee, semi-forest coffee, garden coffee and coffee plantations (MCTD, 1992). They account 10, 34, 35 and 21% of the total production, respectively. The most important cultivation areas are southwestern and southern Ethiopia.

Ethiopia is the only country in the world where coffee grows wild as an under storey shrub or small tree in the Afro-mountain rainforests (Paulos and Demel , 2000). It is believed that forests harbor a large genetic pool of arabica coffee that represents a potential source to develop the crop for the benefit of present and future human generations in the world (Sylvian, 1958; Tefestewold , 1995). Many abiotic and biotic factors are the major constraints of coffee production in the country the most important of which are diseases caused by many etioletic agents, mainly the fungi. The crop is prone to a number of diseases that attack fruits, leaves, stems and roots, and reduce the yield and marketability (Eshetu , 1997).

This commercially as well as genetically valuable crop is attacked by a number of pre- and post-harvest diseases, and of these diseases, coffee berry disease (CBD), coffee wilt disease (CWD) and coffee leaf rust (CLR) are the most important in Ethiopia.CBD is by far the most economically important disease causing up to 100%losses in some places (Van der Graaff, 1981; Merdassa, 1986; Tefestewold and Mengistu, 1989; Eshetu and Girma, 1993).

Although the national average yield losses estimated between 25 and 30% (Tefesetewold, 1995; Eshetu *et al.,* 2000a).CBD was first detected in 1922 in Kenya around Mt. Elgon, west of the Rift Valley (Van der Graaff, 1981). Soon after detecting the disease, losses of up to 75% were reported. This brought the coffee cultivation west of the Rift Valley to a near end and tea plantations became predominant in the region. The dry Rift Valley stopped the spread to the major coffee-growing areas in the highlands of the Central Province for a long time. In 1951 a first appearance of CBD east of the Rift was reported by Rayner (1952). At the beginning, the disease was related to the fungus *C. coffeanum* described from Brazil by causing leaf spots on Arabica coffee. But the new disease in Kenya produced anthracnose-like symptoms on green berries. Rayner (1952) 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. Prior to that time, the pathogen was called either CBD-strain or *C. coffeanum* Noack sensu (Hindorf, 1975).

Intensive investigations on the *Colletotrichum* population in coffee were carried out by (Hindorf, 1975) 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*

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.

OBJECTIVES

- To Review on Coffee Berry Disease in Ethiopia.

2. Discussion

2.1 Occurrence and distribution of coffee berry disease (CBD)

In Ethiopia CBD first reported in 1971 (Mulinge, 1973; Van der Vossen and Walyaro, 1980). Then spread to all major coffee producing regions within very short period except to the lower altitude. Big plantations, garden and forest coffee, with and without shade all were infested alike (Tefestwold Biratu, 1995).

A few species of *Colletotrichum* invade almost all organs of coffee tree, some of which are common to the tropics. The most aggressive species causing the coffee berry disease is present only in East and Central Africa. The pathogenic organism on green coffee berries is *Colletotrichum kahawae* which colonizes berries of all stages, leaves and maturing bark of the branches, other strains have been identified as *C. gloesporioides* and in some instances *C. acutatum*. None of these latter strains are pathogenic on green coffee berries (Rodrigues *et al*., 1992; Tefestewold, 1995). Gassert (1979) studied occurrence of the CBD pathogen in different geographic, climatic and ecological conditions of Ethiopia. Non-CBD strains of *Colletotrichum* can be relieved easily from all coffee tissues and have been reported from all coffee growing areas. Many of them are able to cause a ripe berry anthracnose that also occurs in many coffee-growing regions.

Study of *Colletotrichum* population on *Coffea arabica* L. in Ethiopia and evaluation of the reactions of coffee germplasms showed the existence of 3 species: *C. kahawae*, *C.gloeosporioides* and *C. acutatum* in the population (Tefestewold, 1995). In most characters employed the pathogenic isolate manifested considerable similarities with *C. gloeosporioides.* Variation of a representative range of *Colletotrichum* isolates from diseased coffee berries was studied using morphological and pathological criteria and the result showed that both C. *kahawae* and *C. gloeosporioides* occur in diseased berries, probably as sequential colonizers of diseased tissues (Eshetu and Waller, 2003; Arega, 2006).

Infected berries are the major source of inoculum because CBD isolates are rarely recovered from tissues other than berries (Gassert, 1979; Mbogo, 1999).

3. Historical development of CBD

The disease is an anthracnose of green and ripe berries induced by *Colletotricum kahawae*. McDonald first detected CBD in 1922 in Kenya causing about 75% crop loss (Gibbs, 1969). Since then the disease was found in many estates of the Rift valley in Kenya. By the 1950s CBD had established in the east, the main coffee growing areas (Rodriguez *et al*., 1992).

Apparently, the free movement of coffee plant materials from CBD infected areas has been the main factor in distribution of this disease throughout all important Arabica growing areas in Africa. The disease was reported in Angola around 1930, Zaire in 1937, Cameroon 1955-1957,Uganda in 1959, Tanzania in 1964, Ethiopia 1971(Van der Graaff, 1981) and in Malawi in 1985(Lutzeyer *et al*., 1993). CBD was also confirmed in Malawi, Zimbabwe and Zambia in 1985(Masaba and Waller, 1992). It is not known outside of Africa, although a leaf spot and ripe berry anthracnose caused by related *Colletotrichum* species has been reported from Guatemala and Brazil (Griffiths *et al*., 1991).

Then spread to all major coffee producing regions within very short period except to the lower altitude. Big plantations, garden and forest coffee, with and without shade all were infested alike (Tefestwold, 1995). So environmental issues except low altitudes did not make much difference. Merdassa (1985) reported yield losses of 51% at Melko and 81% at Wondo Genet due to CBD.

CBD incidence and severity assessment in 10 zones and 31 Districts of Southern Nations Nationalities and Peoples Region (SNNPR), conducted in September 1998, resulted with 40% and 22.8% mean incidence and severity of the disease, respectively (Tesfaye and Sinedu , 2000).Losses due to CBD on individual farms vary considerably and in high rainfall and high altitude areas, losses may reach up to 100% (Van der Graaff, 1981). Resistant varieties play significant role in combating CBD.

4. Epidemiological studies

4.1 Coffee berry disease and climatic conditions

The occurrence and intensity of CBD varies from place to place and from one season to the other, depending largely on host susceptibility, pathogen aggressiveness and favorable weather conditions. The disease is very severe and causes appreciable yield loss in areas where the temperature is relatively low and relative humidity is high, mainly in the rainy seasons. A partial regression-correlation of disease parameters (severity and incidence of CBD) recorded for 10 years on the progenies of 13 released CBD resistant selections and a susceptible standard at Gera (CBD hotspot area) as dependent variables against major weather factors such as temperature

(maximum, minimum), rainfall (amount and number of rainy days) and relative humidity documented during disease development period as independent variables were analyzed. Among the meteorological parameters, the mean maximum temperature showed significantly negative correlation with CBD severity in berry count (r =-0.88) and visual assessment (r = -0.76), while the total number of rainy days = 0.72) and relative humidity (r = 0.71) exhibited significantly positive relationship (Girma, 1995).

The analysis demonstrated prevalence of low temperature accompanied by high rainfall extended over a longer period of time favored CBD development and increased the disease intensity (Girma, 1995) as indicated by Van der Graaff (1981). In southern and south eastern regions with bimodal rainfall pattern, CBD is a serious problem on local coffee landraces grown in valley bottoms where relative humidity is higher and moisture is sufficient to cause severe infection. Thus, although these condition sprevail at higher altitudes (> 1850 masl), it is not only elevation that detrimentally amplify CBD intensity rather the conducive weather conditions that occur even at lower altitudes. Van der Graaff (1981) indicated that low temperatures between 20 and 22 ^{o}C and relative humidity close to 100% or presence of water droplets at least for 5 hours should be maintained in growth room/chamber during CBD seedling hypocotyls inoculation test.

4.2. Biology of Colletotrichum kahawae (Synonymous- C. coffeanum)

C. kahawae can infect all stages of the crop from flowers to the ripe fruits and occasionally leaves, but maximum crop losses occur following infection of green berries with the formation of dark sunken lesions with sporulation. The perfect state for some species of *Colletotrichum*, occurring on coffee, has been proved to be the Ascomycota *Glomerella cingulata*. These fungi are generally polyphagous. In 1901 Noack detected for the first time *Colletotrichum acutatum* in Brazil causing leaf spots and dieback (branches) of *C. arabica* L. (Hindorf, 1975). But it was not pathogenic to green coffee berries.

Rayner (1952) had confirmed distinct forms that referred to *Colletotrichum coffeanum*, in the context of a fungus causing CBD, which was first detected by McDonald (1922).Gibbs (1969) and Hindorf (1970) tried to identify *Colletotrichum* species from various parts of coffee in Kenya.

Gibbs (1969) categorized the isolates (from coffee berries and bark) into four groups of which three were non-pathogenic and the fourth one invariably infected both wounded and unwounded berries and caused CBD.

Based on sporulating capacity (conidia production),shape and size of conidia, production of acervuli and pathogenicity on berries, who assigned and described the CBD pathogen isolate (‘var. virulans’) as slow growing, profuse grayish-black aerial mycelium, and conidia borne directly on hyphae. Hindorf (1970; 1973) classified the isolates using detailed cultural and morphological characteristics and relating his findings to Gibbs (1969). Hindorf (1970) grouped *Colletotrichum* isolates from Kenya coffee into 3, viz. *C. coffeanum* (now it is *C. kahawae*) as the only isolate causing CBD, *C. acutatum* (never causes serious damage to coffee but found on the host part damaged by biotic or abiotic factors) and *C. gloeosporioides* (causes anthracnose of leaves, dieback of branches, and brown blight of ripe berries). It was reported that *Glomerella cingulata* is the perfect form of *C. gloeosporioides* and never be for *C. kahawae* (which perhaps is a clone of *Glomerella cingulata* that fails to produce the perfect state in vitro).

The pathogenic fungus produced conidia that were variable in size and shapes, at the tip of solitary hyphae, never inacervuli. According to Sutton (1980) the fungus that cause CBD produces colonies of dense or floccose pale chocolate brown aerial mycelium, sometimes grayish with a lighter center, reverse greenish gray, lacking acervuli and sclerotia, and setae are usually absent. The germination of the one-celled, cylindrical and hyaline conidia of *C. kahawae* takes place only in the presence of free water (Hindorf, 1975).

Optimum temperature appears to be at 220C (18 230C *in vivo*, 15-250C *in vitro*). After germination, germ-tubes grow rather slowly, and 4 to 5hours later, dark brown thick-walled appressoria are formed at their tips. The appressoria stick strongly to the host cuticle and penetrate it by means of infection pegs. Inter-cellular mycelium is formed sparsely.

The incubation period lasts from 5 days to 3 weeks, average being around 8 days. Soon after a black necrotic lesion develops, the fungus produces fruiting bodies, the acervuli in which masses of pink conidia are formed.

C. kahawae and *C. gloeosporioides* were the only two species of fungus isolated from coffee tissue

samples collected from Habro and Kuni districts in Harerge region (Tefestewold and Mengistu , 1989). The absence of perithecia, its slow growth rate, and its pathogenic ability were the distinct characteristics of *C. kahawae*, while *C. gloeosporioides* produced fertile perithecia (perfect stage) and was unable to cause coffee berry disease.Tefestewold (1995) studied variations/similarities among *Colletotrichum* isolates collected from Harerge, Illubabor, Kaffa and Sidamo areas and found 3 spp. viz. *C. kahawae*, C.*gloesporioides* and *C. acutatum*. Variation of a representative range of *Colletotrichum* isolates from diseased coffee berries (collected from Yirgachefe, Gore, Gera and Limu garden coffee areas) was further studied using morphological and pathological criteria and the result showed that both *C. kahawae* and *C. gloeosporioides* occur in diseased berries, probably as sequential colonizers of diseased tissues (Eshetu and Waller, 2003). They indicated that *C. kahawae* isolates were pathogenic to hypocotyls of susceptible coffee cultivars where as *C.gloeosporioides* isolates were not pathogenic.

4.3 Dispersal of conidia and spread of CBD

Conidia are the asexual spores and major inoculums that can be dispersed easily from one place to other places. Dry spore masses require wetting before oxidation and spread can occur (Tefestewold, 1995). As a result, rain is a major environmental factor responsible for disease spread. Dew is generally not important for dispersal, but under certain conditions and only in tops of trees, enough dew formation can occur resulting in water movement and dispersal of inoculums. In either case, dispersal is mainly downward and in the form of water flow or droplets from diseased berries (Eshetu, 1997).

Therefore, treetops are extremely important as sources of inoculums. Windblown rain also results in local dispersal from tree to tree or over relatively short distances (Griffiths *et al*., 1991). Longer distance dispersal of CBD has apparently been by passive vectors such as man, vehicle, birds and insects that may carry viable spores or through the movement of diseased coffee materials such as unshelled coffee or young plants and other vegetative materials (Tefestewold, 1995).

4.4 Susceptible stages of berry, fungus invasion and symptoms of CBD

The fungus (*C. kahawae*) invades all parts of the coffee tree. The fast growing green berries are the most susceptible to the disease. After deposition on a plant surface, conidia and ascospores germinate to undergo complex differentiation to form appressoria. It is then firmly adhered to plant surfaces (Bailey *et al*., 1998). Adhesion of appressoria not only ensures that the pathogen remains in contact with the host for the time necessary for penetration of the surface to occur, but it also places the infection hyphae at a site where penetration can be achieved (Mulings, 1970). The most common means of penetration is by direct penetration of plant cuticles. Infection through wounds is not common (Tefestewold, 1995).

After infection, in a period of 5 days to 3 weeks, small, sunken, dark blackish lesions appear on the surface of the berry (Hindorf, 1975). These lesions expand rapidly and produce a large number of black acervuli extruding slimy pinkish masses of conidia on the lesions surface later on under conditions of high humidity (Hindorf, 1975; Omondi *et al*., 2000). The lesions deepen further beyond the pulp into the young bean, which becomes blackish and rotten; if infection occurs early and climatic conditions favor disease development; berry development is arrested and resulted in mummified berries on the fruiting branch (Hindorf, 1975; Tefestewold, 1995). Finally mummified berries remain on the tree or drop off. Under certain conditions, perhaps dryness or low temperatures, a second type of lesions develops (Hindorf, 1975). The second type of lesion is called scab. Such ‘scabs lesions’ are paler in color, not sunken, and produce concentric rings of acervuli. The deeper layer of the berries is not invaded. The lesions remain inactive for some time and under suitable weather conditions the ‘scab lesions’, however, becomes active again resulting in total destruction of the berries. A more resistant stage to CBD follows with the formation of the endosperm. The hard green endosperm of the berry between 25 and 30 weeks of growth remains completely free of new infections (Hindorf, 1975; Gassert, 1979).

Physiological changes of the ripening berry, however, affect a second susceptible stage. Fresh infections appear during ripening on a mild scale and such late infected berries can well be harvested but there is a loss in quality. On varieties showing resistance to CBD, scab lesions that are in active and only slightly sunken are often the only type developed and are an indication of host defense reaction (Van der Vossen and Walyaro, 1980; Glchuru, 1997). They are also produced at a higher frequency on susceptible varieties when conditions are unfavorable for disease development or when these varieties have not received fungicidal sprays during early berry development (Omandi, 1998). Although this fungus can attack leaves, stem, bark, twigs, and crop from flowers to ripe fruit, maximum incidence and crop loss occurs from infection of young expanding green berries (Bailey *et al*., 1992). Coffee berries are only susceptible to infection when they are expanding, 6-20 weeks after flowering and again at ripening, 30-36 weeks after flowering. Earlier berry stages or pinhead berries and the mature green beans are fairly resistant to infection (Tefestewold, 1995).

5. Assessment of coffee berry disease (CBD)

In each forest coffee area, CBD assessment was taken every 3-5 km interval across the forest coffee by considering the existing field variation especially land gradients, and presence and absence of forest coffee. In each 100 m x 100 m plot , two types of assessments were conducted on the same trees diagonally following procedures used by Tesfaye and Ibrahim (2000): (a) Berry counting- 10 trees/plot were randomly selected and each tree divided into 3 strata of branches (top, middle and bottom). From each stratum two branches were selected to calculate disease intensity. Depending on the forest coffee field sizes across each forest coffee area 5-7 plots were assessed. CBD damaged and healthy berries were counted and then percentage of diseased berries over total counted berries calculated. (b) Visual assessment of 10 trees per plot were randomly taken and diagnosed for presence and absence of the disease on each tree. Thereafter disease incidence was calculated as (number of diseased trees/total observed trees) x 100.

The prevalence of coffee berry disease was assessed in different regions of Ethiopia at various Times (Van der Graaff, 1981; Merdassa, 1986; Tefesetewold, 1995; Eshetu *et al.*, 2000a). In 1994, the mean CBD incidence was 38.8% in Oromia Regional State and 17.2% in Southern Nations Nationalities and Peoples Regional state (SNNPR) (JARC, 1997). The highest severity was recorded at Bedele (69%) followed by Gore (50%), while the lowest was at Mugi (17%) in Oromia. In SNNPR, the highest was recorded at Yirgachefe (34%) whereas the lowest was at Dilla (6%). The average severity of the disease in six zones of Oromia was about 31.1% in the year 2000, the highest being in Hararghe, and the least in Illubabor (Melaku and Samuel,Girma et al.2000). Similarly, CBD ranged between 22 and 63% in the major coffee growing zones of SNNPR (Tesfaye and Sinedu, 2000) (Table 1).

Tesfaye and Ibrahim (2000) studied disease status in Amhara, Gambella and BenishangulGumuz coffee growing areas and reported an estimated severity of over 38% in Amhara. The national average coffee yield loss attributed to CBD varied between 25 and 30% (Tefesetewold, 1995; Eshetu *et al.*, 2000). The earlier loss estimated by Merdassa (1986) was between 50 and 80%. The intensity of CBD was very high in all coffee growing areas of the country, especially at higher altitudes and in valley bottoms in many areas of the southern region.

Table1. Severity (%) of CBD in Oromyia and SNNPR (1997-1998).

Oromia			**SNNPR**		
Zone	**Wereda (n)**	**Mean (%)**	**Zone**	**Wereda (n)**	**Mean (%)**
Jimma	7	32.0	Sidama	5	22.0
Illubabor	7	19.0	Gedeo	4	32.5
West wollega	8	22.6	N.Omo	6	39.6
East Hararge	2	41.0	Hadiya	3	52.7
West Hararge	5	42.0	Gurage	4	63.0
Borena	2	30.0	Amaro	2	38.0
Mean		**31.1**	**Mean**		**41.3**

Source: (Melaku and Samuel, 2000, Tesfaye and Sinedu, 2000)

6. Pathogenicity of CBD isolates

Tefesetewold (1995) distinguished the CBD pathogen from other *Colletotrichum* spp. associated with Arabica coffee in Ethiopia based on thorough analyses of cultural, morphological, biochemical and physiological characteristics. However, he failed to support the new species name *Colletotrichum kahawae* introduced by Waller *et al*. (1993) that the first nomenclature of *C. coffeanum* Noack (sensu Hindorf) was based on berry samples taken from Brazil where the disease does not exist. The results of two independent studies evidenced no host specialization (physiologic races) in the CBD pathogen populations in Ethiopia (Tefesetewold, 1995; Arega, 2006).Tefesetewold (1995) tested 6 isolates sampled in Keffa, Sidamo and Hararghe on 3 CBD Resistant cultivars (741, 744 and 74110) and a landrace from Sidamo (Kurme) and found significant variations in aggressiveness among the isolates.

Table 2. Pathogenicity of 6 *Colletotrichum kahawae* isolates on seedlings of 4 coffee selections 23 days after inoculation in growth chambers (after Tefesetewold, 1995).

Coffee	***Colletotrichum kahawae* isolates**					
Cultivars	**H# Harar**	**H#37**	**S#104**	**S#1152**	**K#46**	**K#Kaffa**
741	0.0g	0.0g	0.0g	0.0g	0.0g	0.0g
744	36.8 e	26.7 ef	0.0 g	14.6 fg	0.0 g	0.0 g
74110	93.7 ab	95.8 ab	79.6 bc	89.9 abc	98.0 ab	89.6 abc
Kurme	100 a	70.8 cd	55.3 d	79.2 bc	60.0 d	83.3 abc

Source; (Arega, 2006).

Coffee cultivar 741, 744, and 74110 were released CBD resistant selections, Kurme represented Sidamo local land races. Codes H, S and K refer respectively to isolates from Hararghe, Sidamo and Kaffa.

Means followed by the same letters are not significantly different from each other (DMRT) LSD value = 17.48; SD = 6.14.

Similarly, 12 *C. kahawae* isolates sampled from four afromontane rainforest sites (Harenna, Bonga, Sheko and Yayu) and in seedlings of three widely grown CBD resistant cultivars and a susceptible check indicated significant differences in aggressiveness (Table 2) (Arega, 2006).

Table 3. Pathogenicity of 12 *C. kahawae* isolates collected from afromontane rain forest coffee areas inoculated with seedlings of three CBD resistant and susceptible cultivars in growth room

	Coffea arabica cultivar				
Isolate[1]	741	754	74110	370	Mean[2]
H40	14.0 gh	20.3 g	88.7 b-d	100 a	55.8 AB
H41	12.7 gh	17.8 gh	85.3 b-e	100 a	54.0 A-C
H43	14.2 gh	15.4 gh	78.3 d-f	98.0 a	51.5 CD
B52	20.2 g	17.9 gh	89.5 bc	100 a	56.9 A
B53	16.5 gh	13.8 gh	86.6 b-e	100 a	54.2 A-C
B55	17.7 gh	18.9 gh	77.8 d-f	98.3 a	53.2 B-D
S60	12.3 gh	13.7 gh	80.3 c-f	100 a	51.6 B-D
S61	10.7 gh	14.3 gh	76.9 ef	97.6 a	49.9 D
Y70	9.0 h	15.0 gh	79.0 d-f	100 a	50.8 CD
Y73	14.6 gh	18.5 gh	92.7 b	98.3 a	56.0 AB
Y75	16.0 gh	10.8 gh	21.0 g	70.3 f	29.5 E
G81	21.8 g	9.3 h	79.3 d-f	98.3 a	52.2 B-D
Mean[2]	15.0 L	15.5 L	78.0 K	96.7 J	

Source: Arega (2006).

Colletotrichum kahawae isolates coded with 'H, B, S, Y and G were collected, respectively from Harenna (Bale), Bonga, Sheko, Yayu and Gera. 3 Coffee cultivar 741, 7454 and 74110 are CBD resistant cultivars, 370 was CBD susceptible check. 3Means followed with the same letter(s) are not significantly different according to DMRT. Least significant difference (LSD) values (P = 0.05) for the cultivars, the isolates and the interactions comparisons are 2.1, 3.7 and 7.3, respectively. CV = 9.5%.6.1. Testing of indigenous coffee germplasms for resistance to CBD Attached berry test (ABT) and seedling inoculation test were conducted in field and in laboratory conditions, respectively to evaluate differences in resistance among forest coffee germplasms.

6.2. Attached berry test (ABT)

Attached berry test was conducted following methods and procedures used by Van der Graaff (1981). ABT was not conducted on selected indigenous forest coffee trees in Sheko and Harena because there was no CBD occurrence in or near the selected sites, but occurred only in pocket areas very far from the selected coffee trees. The test was conducted at the sites of Bonga and Yayu on selected indigenous forest coffee trees in August 2005. Three branches of the selected coffee trees (1 from top, 1 from middle, 1 from bottom) were marked bearing healthy berries of the same age. In order to obtain the inoculum for further infections, green CBD infected berries with active black lesions were collected from the respective sites. Then diseased berries were wetted slightly with distilled sterilized water and incubated in closed plastic boxes for 24-48 hours to produce a reasonable sporulation. After incubation, a suspension of conidia was prepared by rinsing the berries in sterile water and the conidia density was determined by means of haemocytometer. The berries in the expanding stage on marked branches were inoculated with a suspension of 2 x 106 conidia/ml using a hand sprayer. Each branch was then being kept moist and warm over night for 12 hours in a plastic 'sleeve'. The plastic sleeve was covered with paper bag to avoid high temperature due to insulation. Individual branches of a tree were used as replications. Number of healthy and diseased berries was recorded 21 days after inoculation. The disease index (DI) was calculated as the ratio of diseased to total (healthy plus diseased) berries and the fractions were analyzed after angular transformation.

6.3. Seedling inoculation test

Seeds were collected from 75 different indigenous forest coffee trees, described under 4.1, from all forest coffee areas to check their abilities for susceptibility or resistance to CBD. Seedling tests were conducted following the same methods and procedures described under 4.4.4.2. Isolate G81 from Gera was used as the inoculum source. Resistant (741, 754, 75227) and susceptible (370) cultivars were included as standard checks (Bayetta et al., 2000; Bayetta , 2001). The experiment was arranged in randomized complete block design and replicated three times.

7. Average Yield loss due to coffee berry disease

The overall national average loss due to coffee berry disease is estimated to range 25-30%, which amounts to well over 600 million Ethiopian Birr (ETB) or 73.6 million USD (1 USD=8.15 ETB) per annum (Eshetu ,1997; Eshetu et al., 2000). CBD can be controlled by the use of resistant coffee varieties, spraying fungicides or by cultural practices. Development of resistant varieties save the nation's valuable foreign exchange spent on fungicides, fuel and spray machinery and further avoids the hazardous effect of pesticide pollution of the environment. The exhaustive testing of selecting materials for resistance to CBD in the mother trees and their progenies in the laboratory and in locations, where the epidemic is not only severe but also regularly present, is very vital (Eshetu, 2000). Resistance to CBD in coffee arabica most probably is horizontal/quantitative (Robinson, 1974; Van der Graaff, 1984) in nature and controlled by 3-5 recessive genes (Mesfin and Bayetta, 1984).

8. Host resistance

8.1. Development of CBD resistant cultivars

Merdassa (1986) reviewed the ever successful crash program of CBD resistant selection and appraisal program that ultimately resulted in the release of more than 15 resistant coffee cultivars in the shortest time in Ethiopia. Since then great efforts have been made adopting similar selection scheme and testing procedures in search for CBD resistant coffee within the heterogeneous populations. As a major component of origin-specific coffee landrace development program, selecting CBD resistant mother trees and testing their progenies have been in progress.

The selection methodologies and testing procedures have been optimized in that the *ex situ* detached berry test was replaced by the *in situ* attached berry test jointly supported by intensive seedling test under controlled growth room conditions for efficient screening and appraisal of CBD resistance (Girma and Chala, 2008).More than 1308 coffee mother trees were selected from Hararghe (348), Limmu(280), Sidamo (373) and Wollega (307) between 1985 and 2005.Coffee progenies of outstanding performance have already been advanced to verification plots in the fields at Haru and Mugi (West Wollega), Micheta and Mechara (West Hararghe), and Konga and Korkie (Sidamo).

Eight coffee selections viz. 7418, 74153, 7514, 7516, 7576, 75129, 8136 and 827, which are as resistant as the standard checks (741 and 75227) were identified and recommended for release (Girma and Chala, 2008). Of these, five selections have been recently approved for production in southwestern Ethiopia. To date, about 20 Released CBD resistant cultivars are in production in major coffee growing areas of the country except in Hararghe. Advances in coffee disease research. The nature of resistance to CBD is believed to be horizontal (Van der Graaff1981; Mesfin and Bayetta, 1984; Bayetta, 2001), and the inheritance of the resistance is controlled by recessive genes. Disease susceptibility showed partial to complete dominance over resistance.

The inheritance mechanism is nonetheless a debatable issue between the Ethiopian (Mesfin and Bayetta, 1984; Bayetta, 2001) and Kenyan breeders (Van der Vossen and Walyaro, 1980; Vander Vossen, 2007). This situation apparently limited resistance breeding and use of coffee hybrids for CBD control.

Table4. CBD resistant selections of coffee mother trees and their progenies promoted to verifications between 1985 and 2005.

Region	**Selection years**	**No of tested selections**	**No of promising progenies**
Hararghe	1985, 1998, 2002 – 2	348	14
Limmu	1985, 2001, 2003 – 2005	280	0
Sidamo	1985, 1994 – 1997	373	14
Wollega	1998 – 2001	307	14
Total		**1308**	**42**

Source: Coffee Proceeding, 2000

9. Management of CBD

9.1. Cultural and biological controls

In these methods very few efforts had been made in Ethiopia. There are some reports those that promote good aeration and rapid drying of the canopy, such as adequate pruning and wide spacing can reduce disease incidence. Eshetu reported 1988, in his visit to the former Yeju Awraja (North Wollo), there was no CBD incidence observed and this was attributed to the use of irrigation by coffee farmers in the area, which shifted the susceptible stage of berry development (Tesfaye and Ibrahim, 2000).

The use of fungicides against CBD has been shown to induce greater level of disease under some circumstances. Some farms that had never used fungicides did not have high levels of CBD, and when used intermittently fungicides can make the disease worse (Eshetu *et al*., 2000). The negative effects of fungicides can

be attributed to the removal of microorganisms antagonistic to the pathogen and subsequent loss of a natural biological control mechanism. This effect was studied in more detail by Masaba (1991) who found that there was a large difference between the micro flora on sprayed and unsprayed coffee. A number of organisms showing significant antagonism towards the CBD pathogen (filamentous fungi, yeasts and bacteria) were present on unsprayed coffee and elements of the micro-biota were shown to have a natural bio control effect on the disease. These all indicate the hope for using antagonistic microorganism for CBD management.

9.2. Chemical control

Fungicides screening program was started one year after the occurrence of CBD in 1972 (Critchett and Merdasa, 1984). They indicated a shot summary of results of chemical screening over the period 1972 to 1981 in that Captafol (Orthodifolaton) 80% WP was recommended as effective fungicides to control CBD and Daconil and Delan were also considered as promising fungicides. According to Eshetu *et al.* (2000) Captafol 80% WP was withdrawn from use in 1987 due to its carcinogenic effect. Some of the previously recommended fungicides such as Delan, Dyrene, and Octave were also withdrawn from use due to their negative impact on plant, animal and human life (Eshetu *et al.*, 2000; Tsegaye *et al*., 2000).

Further screening programs have been continued to provide coffee growers with ample choice of effective fungicides, economically cheap and safe to users and the environment. Twenty-one fungicides were tested against the disease from 1987 to 1997 at Gera (CBD hot spot area). From the result six fungicides, viz. Daconil '2787' 75% WP, Daconil 75% WDG, Shirlan 50% SC, Nordox 50% WP, Octave super 50% WP and a tank mixture of Daconil '2787' and Nordox were recommended to control CBD in Ethiopia (Eshetu *et al*., 2000).

Their formulations, application rate and spray intervals in Ethiopia have been recommended (Table 5).The key appeared to the protection of the immature crop throughout the rainy season. Thus, timely application and appropriate volume spray provides effective control (Eshetu *et al*., 1995). Time and frequency of fungicide applications depends on epidemiology of the pathogen. In Ethiopia fungicide spray against CBD starts six week after main flowering for six rounds at 4 weeks (28 days) interval in a crop season was recommended (Eshetu *et al*., 2000). Farmers could waste money if they apply one or two sprays and then have stopped the schedule (Tsegaye *et al*., 2000). Such sprays are not only in effective against CBD, may result in high levels of the disease. So, timely application should be done to avoid this disease.

In areas where shortage of water does not occur, high volume of 750-1000 ml per tree can be used depending on size of the tree (Eshetu *et al*., 2000). The regions where water is scarce for spraying, low volume application, 200-250 ml per tree, using motorized knapsack sprayer was effective in controlling CBD.

It is also advisable to repeat spraying if heavy rains (>10 mm) fall immediately within six hour after spraying since the initial fungicide deposit could be washed away from the tree (Eshetu *et al*., 2000).

Table 5.Recommended fungicides for controlling CBD (Institute of Agricultural research, 1996)

Common name	**Trade name**	**Formulations****	**Rate (kg/ha)**	**Spray interval (weeks)**
Chlorothalonil	Daconil	75% WDG	4.4	4
Chlorothalonil	Daconil '2787'	75% WP	**4.4**	**4**
Fluazinam	Shirlan	50% SC	1.1	4
Cuprous oxide	Nordox	50 %WP	7.7	4
Chlorothalonil + *	Daconil '2787' +	75% WP +	7.0 +	4
Copper	Octave super	+50% WP	2.0	4

** WDG- Water dispersible granule; WP- Wettable powder; SC- suspension concentrate

* Tank mixture

Source: Eshetu *et al.* (2000).

9.3. Resistant varieties

Resistance variety is the best option to protect the crop from damage due to biotic factors. It is only the use of cultivars with durable resistance that provides a permanent solution and guarantees stable cash income to the growers, realizing these circumstances a breeding program was launched by Ethiopian Institute of Agricultural Research, Jimma Agricultural Research Center.

Since Ethiopia is the center of origin and genetic diversity for *Coffea arabica* L., coffee population provides immense opportunities to make selections for any desirable trait for example high yielding and diseases resistant varieties. The CBD resistant selection program in Ethiopia was designed by Robinson (1973) that basically consisted of four steps; mother tree selection, testing of mother trees, multiplication and progeny testing. From 1973 to 1982 seven hundred eighty six mother trees were identified from previously Keffa, Illubabor, Sidamo, Shewa and Harerghe administrative regions, and 15 CBD resistant progenies were released after thorough field and laboratory evaluation of mother trees and their progenies (Merdasa, 1985). Since then, following the program; mother trees selection, testing of mother trees, multiplication and progenies testing have been continued to develop resistant varieties. Resistant *C. arabica* types to the disease which were developed by Van der Graaff (1981) through selection of mother coffee trees and their progenies have been used as standard checks for continuous screening of coffee germplasms. It was realized that planting of local types in each locality to avoid spoilage of quality due to blending effects of coffee from different origins (Bayeta *et al*., 2000). As a result the coffee research program has been re-oriented to develop CBD resistant and high yielding cultivars for each locality using coffee materials from the respective areas.

Search for individual trees within coffee population was made from each locality, viz. from 1985 to 1997 in Sidama and Gedeo areas, from 1999 to 2005 in Limu, from 1999 to 2001 Wollega area, and from 2004 to 2005 in Harerge area. During the years 235 mother trees (from Sidama and Gedeo), 196 mother trees (from Limu), 165 mother trees (from Wollega), and 57 mother trees (from Harerge) were selected (IAR, 1996; IAR, 1997; EARO, 1999; EIAR, 2005).

Visually selected mother trees were assessed through regular field observations, field inoculation tests, and seedling inoculation tests in the field and laboratory to reselect within selected mother trees. After visual selection, using combined field observations, attached berry test (ABT) and seedling inoculation tests unsatisfactory mother trees were discarded. Mother trees were also observed for coffee leaf rust, leaf blight, brown eye spot and yield status.

Among the selections most have been being under evaluations, some discarded after appropriate evaluations, some mother trees' progenies were established for further tests in their respective locality. After evaluating promising progenies some verified cultivars have been released in different years. Since the inception of CBD resistant selection and breeding program at Jimma Agricultural Research Center (JARC), 19 CBD resistant selections having reasonable yield and resistance to other diseases and pests were released to growers (Bayetta *et al*., 2000). Based on regular field observations on the farms, 6 of them were withdrawn from production from time to time due to their manifestation of either high CBD, rust , or wilt diseases and/or low yield performance.

Gaps and challenges

There is always shift in the status of diseases because of selection pressure imposed by planting new coffee varieties and improving practices from traditional to modern production systems. There would also be alteration in the host-pathogen-environment interactions and resurgence in the existing populations or introduction of new pathogen owing to poor quarantine both at national and international levels. (Girma et al.2000).

CBD is still the leading disease of Arabica coffee significantly affecting yield in all coffee growing regions of the country, while more than 90% of the coffee population is vulnerable to CBD. On the other hand, chemical control is constrained by lack of subsidy for fungicide and sprayer purchase; and above all challenged by the present tendency towards organic coffee production. CBD is more severe in highlands. In lowlands, it occurs when the weather is favorable for it to attack moderately resistant cultivars and hybrids.

It has been experienced that a moderately resistant coffee variety known as 'Dessu' (F59)succumb to CBD at middle altitudes areas (1750 m) during the years with favorable weather conditions. Arega (2006) recorded up to 40% CBD incidence in forest coffee populations in lowland areas of Bonga, Bale, Sheko and Yayu (< 1500 m). CBD pathogen isolates collected from these localities were proved as aggressive as those isolates obtained from highlands of Gera. Therefore, recommending less tolerant but high yielding pure lines and hybrids based merely on altitudinal domain is rather challenging. The inheritance mechanism of CBD resistance is known to be governed by recessive genes and exploitation of hybrids possessing resistant trait and high yield needs repeated and painstaking backcrossing activities. Furthermore, large-scale multiplication of hybrid coffee via seeds is perhaps tedious and propagation by cutting and tissue culture techniques seems expensive. Thus, development of CBD resistant cultivars through selections and intensive testing of mother trees and their progenies from each landrace populations are indisputable. Besides, selecting resistant cultivars from one specific locality and introducing into new coffee growing areas has a number of drawbacks.

The adaptation problems as practically realized in Hararghe, genetic erosion and/or mix up of potential landraces in terms of valuable traits for quality, yield and disease/insect pest resistance have their own biodiversity and market brand risks. Harar coffee, for instance, is highly susceptible to most diseases including CBD, although it is known to fetch premium price for its best quality profile, nevertheless farmers prefer growing alternative cash crop Chat (*Catha edulis*) to planting coffee.

10. Concussion

Coffee diseases such that CBD and CWD, the two important coffee diseases were found associated with coffee growing in afromontane rainforest of Harena (Bale), Berahane-Kontir (Sheko), Bonga and Yayu. CBD incidence and severity varied from one forest coffee area to other depending on environmental condition and genetic diversity of forest arabica coffee. It is apparent for these surveys that CBD was wide spread in Bonga forest coffee areas and followed by Yayu. The mean percent incidence of CBD was 40, 26.3, 18.6 and 6% for Bonga, Yayu, Harena and Berhan-Kontir (Sheko), respectively.

The estimated mean percent severity was 17.9, 4.0, 5.4 and 2% for Bonga, Yayu, Harena and Sheko, respectively. There was no CBD occurrence at bottom land of Harena (around Majete) and Berhan-Kontir (around 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 (around Mekabaldo) and Sheko (around Wesheka) forest and semi-forest coffee areas. Similarly, Bayetta Belachew (2001) explained high CBD occurrence related with high humidity with high altitude around Gera. 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. As Cook (1975) explained that high rainfall, high humidity or wetness, and relatively low temperatures that persist for long periods favour CBD development and the disease is invariably severe at higher altitudes where these conditions generally prevail. The incidence and the intensity of the disease varied from one forest coffee area to other. Similarly, the variation in intensity and incidence of CBD in other coffee production systems also reported by many authors. In 1994 crop season, prevalence of CBD was conducted in Oromiya Region and Southern Nations Nationalities and Peoples Region (SNNPR) and the result indicated 38.8 and 17.2% of mean percent prevalence of the disease, respectively (IAR, 1997). According to the result CBD pressure was very high at higher altitudes in the southwest region, while severe disease was recorded in valleys of Sidamo zone.

According to Tefestewold (1995) CBD severity varied from year to year and among districts and regions. In Amhara region where CBD occurs, survey result showed that an average CBD severity for the 1996/97-crop season was 38% (Tesfaye and Ibrahim, 2000). Survey conducted in 1997 and 1998 in six major coffee growing zones (in 32 districts) of Oromiya region showed an average of 31% and 32% disease severity for the respective years (Melaku and Samuel, 2000). CBD incidence and severity assessment in 10 zones and 31 of Southern districts Nations Nationalities and Peoples Region (SNNPR), conducted in September 1998, resulted with 40% and 22.8% mean incidence and severity of the disease, respectively (Tesfaye and Sinedu , 2000).

11. Recommendation

Coffee berry disease management by growing resistant cultivars leads to sustainable, environmentally-friendly organic coffee that fetch premium price, thus primarily developing resistant coffee cultivars for each ecological niche in the major coffee growing regions of the country should get the highest priority.

This strategic approach will enable to maintain ecologically adapted coffee landraces securing undiluted quality profile of special interest (specialty coffee) in the world market. Secondly, effective and selective fungicides should continuously be screened and made available to coffee farmers at affordable price. Thirdly, bio pesticides derived from microbial agents and botanical extracts against CBD pathogen needs to be investigated. The 'CBD escape 'mechanism through changing the cropping pattern by using irrigation and inducing early flowering and berry growth before disease outbreak in a season should be exploited. Moreover, farmers' indigenous knowledge need to be explored; and ultimately all practices should be incorporated to develop integrated disease management (IDM) program in coffee.

12. References

1. Abraham T. (2006). A study on ochratoxin A and ochratoxigenic fungi in coffee. M.Sc thesis. School of Graduate Studies, Department of Biology, Addis Ababa University, Ethiopia. Pp. 75.
2. Arega Z. (2006). Diversity of Arabica coffee populations in afromontane rainforests ofEthiopia in relation to *Colletotrichum kahawae* and *Gibberella xylarioides* M.Sc. thesis. School of Graduate Studies, Department of Biology, Addis Ababa University, Ethiopia. Pp.80.
3. Bayetta B. (2001). Arabica coffee breeding for yield and resistance to coffee berrydisease (*Colletotrichum kahawae* sp. nov). Dissertation, Imperial College at Wye,University of London. Pp. 232.
4. CSA (2002). *Annual Statistical Abstract.* Addis Ababa, Ethiopia.
5. Eshetu Derso and Waller, J.M. (2003). Variation among *Colletotrichum* isolates from 70diseased coffee berries in Ethiopia. *Elsevier Science crop protection*. 22: 561-565.
6. Eshetu Derso and Girma A. (1993). Determining level of coffee berry disease resistance on 1982 selections using detached berry test. *In*: Proceedings of the joint Conference of Ethiopian Phytopathological Committee and Committee of Ethiopian Entomologist. 5 – 6 March, 1992. Addis Ababa, Ethiopia. CPSE, Addis Ababa, Ethiopia.P. 50 (abstract).

7. Eshetu D. et al. (2000a). Control of coffee berry disease by fungicides in Ethiopia. *In*: Proceedings of the workshop on control of coffee berrydisease (CBD) in Ethiopia. 13 – 15 August 1999, Addis Ababa, Ethiopia. Pp. 35 – 46.
8. Eshetu D. et al. (2000b). Significance of minor diseasesof *Coffea arabica* L. in Ethiopia: A review. *In*: Proceedings of the workshop on control of coffee berry disease (CBD) in Ethiopia. 13 – 15 August 1999, Addis Ababa, Ethiopia. Pp.58 – 65.
9. Gibbs, J. N. (1969). Inoculum sources for coffee berry disease. *Ann. Appl. Biol*. **64**: 515-522.
10. Girma Adugna and Chala J. (2008). Resistance levels of Arabica coffee cultivars to coffee berry disease, coffee wilt and leaf rust diseases in Ethiopia. *In:* Sebil vol. 12.Proceedings of the 12th Crop Science Society of Ethiopia (CSSE), 22 – 24 May 2006, Addis Ababa, Ethiopia. Pp 92 – 103.
11. Girma A. (1995). The influence of climatic conditions on the resistance levels of released coffee types to coffee berry disease (CBD). *In*: Proceedings of the 2nd annual conference of Crop Protection Society of Ethiopia (CPSE): 26-27 April 1994. Addis Ababa, Ethiopia. CPSE, Addis Ababa, Ethiopia. Pp. 32 (abstract).
12. Griffiths, E.et al. (1991). Control of coffee berry disease. *Ann. of Appl.Biol*. **67**: 45-74.
13. Hein, L.; and Gatzweiler, F.(2006).The economic value of coffee (*Coffea arabica*) genetic resources. Ecological Economics. 60: 176 – 185.
14. Hindorf, H. (1970). *Colletotrichum* spp. isolated from *Coffea arabica* in Kenya. *Z.*71 *Pflanzenkrh. Pflanzenschutz*. **77**: 328-331.
15. Hindorf, H. (1973). *Colletotrichum*-population on *Coffea arabica* L. in Kenya: II.Qualitative and quantitative differences in the *Colletotrichum*-population.*Phytopath. Z.* **77**: 216-234.
16. Hindorf, H. (1975). *Colletotrichum* occurring on *Coffea arabica*: A Review. *J. Coffee Res.* **5**(3/3): 43-56.
17. IAR.(19970). Jimma National Coffee Research Center progress report for the period 1994(Part 1 Coffee). Melko.
18. Jimma Agricultural Research Center (JARC). (1997). Progress report for the period 1996.Jimma, Ethiopia. pp. 37 – 42.
19. Lutzeyer, H.et al. (1993). Neue Erkenntnisseuber pflanzenschutz in plantagenkulturen darjestellt am beispiel kaffee. Weltforumverlag, koln.
20. International Coffee Organization (ICO). (2005). Coffee market report. London, UK. Pp. 8.
21. Masaba, D.M. and Waller, J.M. (1992). Coffee berry disease: the current status. In:*Colletrotrichum: Biology, pathology and Control,* pp. 237-249, (Bailey, J.A. and Jeger, M.J., eds). CAB International, Wallingford, UK.
22. Melaku Jirata and Samuel A. (2000). The status of coffee berry disease in Oromia. *In*:Proceedings of the workshop on control of coffee berry disease (CBD) in Ethiopia. 13 – 15August 1999, Addis Ababa, Ethiopia. Pp. 18 – 28.
23. Merdassa E. (1985). A review of coffee diseases and their control in Ethiopia.In: *Proceedings of the first Ethiopian crop protection symposium,* PP. 179-195.
24. Merdassa E. (1986). A review of coffee diseases and their control in Ethiopia. *In*:Proceedings of the First Ethiopian Crop Protection Symposium. 4-7 February 1986. IAR,Addis Ababa, Ethiopia. (Tsedeke Abate, ed.). Pp. 187 – 195.
25. Mesfin Ameha and Bayetta B. (1984). Resistance of the F1 hybrids to coffee berry disease in six parent diallel crosses in coffee. *In*: Proceedings of the first regional workshop on coffee berry disease, 19 – 23 July 1982, Addis Ababa, Ethiopia. Pp. 167 – 177.
26. Mesfin A. (1991). General introduction: An overview on the status of coffee, tea and spice In Ethiopia. In: *Proceedings of the First Workshop on Production Constraints Assessment of Coffee, Tea and Spices,* 15-17 September, Jimma, Ethiopia.
27. Mulinge, S. K. (1973). Outbreaks and new records. Ethiopia, coffee berry disease. *FAO Plant Protection Bulletin*. **21**: 85-86.
28 . Paulos Dubale and Demel T. (2000). Coffee production systems in Ethiopia. **In**: *Proceedings of the workshop on control of coffee berry disease (CBD) in Ethiopia,* pp 99- 107. 3 15 August 1999, Addis Ababa, Ethiopia.
29. Rodrigues, C.J., Varzea, V.M. and Mederios, E.F. (1992). Evidence for the existence of physiological races of *Colletotrichum coffeanum* Nock sensu Hindorf. *Kenya coffee***57**: 1417-1420.
30. Tesfaye Alemu and Ibrahim. (2000). The status of coffee berry disease in minor coffee growing regions. *In*: Proceedings of the workshop on control of coffee berry disease (CBD)in Ethiopia. 13 – 15 August 1999, Addis Ababa, Ethiopia. Pp. 29 – 34.
31. Tesfaye Negash and Sinedu A. (2000). Status of CBD in SNNP. *In*: Proceedings of theworkshop on control of coffee berry disease (CBD) in Ethiopia. 13 – 15 August 1999,Addis Ababa, Ethiopia. Pp. 18 – 28.
32. Tefesetewold B. (1995). Studies of *Colletotrichum* population on *Coffea arabica* L. inEthiopia and evaluations of the reactions of coffee germplasm. PhD Dissertation,University of Bonn, Germany. Pp. 231.
33 . Tefestewold Biratu and Mengistu H. (1989). *Colletotrichum* species associated with coffee berry disease in

Hararghe. Eth. J. Agri. Sci. 11: 1 – 6.
34. Van der Graaff, N. A. (1981). Selection of Arabica coffee types resistance to coffee berry disease in Ethiopia. Meded. Landbouwhogesch. Wageningen, 81–11: Pp 110.
35. Van der Vossen, H. A. M. (2007). State-of-the-Art of developing Arabica coffee cultivars with durable resistance to coffee berry disease (*Colletotrichum kahawae*). *In*: Proceedings of 21st International Scientific Conference on Coffee Science (ASIC), 11-15 September2006, and Montpellier, France. Pp. 794 – 801.
36. Van der Vossen, H. A. M. and Walyaro, D. J. (1980). Breeding for resistance to coffee berry disease in *Coffea arabica* L. II. Inheritance of the resistance. Euphytica 29: 777 – 791.
37. Waller, J. M.; Bridge, P. D.; Black, R.L.; Hakiza, G. (1993). Characterization of the coffeeberry disease pathogen, *Colletotrichum kahawae* sp. Nov. Mycol. Res. 97: 989 – 994.
38 . Workafes Woldetsadik and K. (2000). Coffee production systems in Ethiopia.*In*: Proceedings of the workshop on control of coffee berry disease (CBD) in Ethiopia. 13 –15 August 1999, Addis Ababa, Ethiopia. Pp. 99 – 106.