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# CURRENT STATUS ON COFFEE LEAF RUST (*HEMILEIA VASTATRIX*) IN SIDAMA AND GEDEO ZONE, SOUTHERN ETHIOPIA

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**ABSTRACT**

Coffee is the most important and second traded commodity next to oil in the world. In Ethiopia, coffee leaf rust caused by *Hemileia vastatrix* is one of the third most economically important diseases of Coffee Arabica. The current status of coffee leaf rust was intensively assessed and examined in 189 sample coffee farms from six districts across major coffee growing areas of the Southern Ethiopia. At each farm, ten randomly selected trees on a diagonal transect across the farm were assessed for disease incidence and severity. The survey data showed that coffee leaf rust was present in all assessed district varying in magnitude and extent of damage. The highest overall mean of rust incidence (38.6%) and severity (13.80%) was recorded at Dilla zuria while the lowest incidence (10.52%) and severity (1.38%) was at Yergachaffee district. The highest altitude range was obtained at Yergachaffee (1838-2056) while the lowest was at Dilla zuria (1434-1825) district. Overall mean severity and incidence result indicate that, there was statistical (p = 0.058 for severity, p = 0.044 for incidence) and negative correlation between intensity and altitude (severity, r= -0.80 and incidence, r= -0.82). The linear regression equation of severity and incidence obtained from the data was Y= -0.036X+73.16 and Y = -0.074X +158.9 (where Y= percentage CLR severity and incidence, respectively and X= altitude). This regression equation implies that, in higher elevation areas the rust intensity was low as compare to the lower elevation. Finally, the disease was remarkably increasing from time to time in all assessed coffee farms. Therefore, appropriate measurement like farmers' awareness creation and training on how to control disease as well as appropriate agronomic managements has to be seriously undertaken. In addition, development of coffee leaf rust resistant varieties to southern Ethiopia through resistant breeding has to be set high priority.

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## INTRODUCTION

Coffee is the most popular soft drink in the world and the second traded commodity next to oil. It is a source of income for more than 12 million farms worldwide, a quarter of which are operated by women. It provides direct employment to more than 25 million families in producing countries. Coffee remains an export commodity (International Coffee Organization, 2019). Ethiopia is the primary center of origin and genetic diversity of C.arabica L. and coffee is well known being the pillar of Ethiopian economy. It accounts for 29 % of the total export and 37% of agricultural export earnings of the nation; 4.7 million small-holders directly involved in producing coffee and about 25 million people directly or indirectly depends on coffee sector for their livelihoods (EIAR, 2017). Ethiopia is the leading producer in Africa, and the 5th in the world, following Brazil, Vietnam, Colombia and Indonesia and produces premium quality coffee. It is tenth coffee exporter with 4.79 percent share of the world total (Bellachew, 2015). If we consider Arabica coffee alone, Ethiopia is the 3rd largest producer after Brazil and Colombia (International Coffee Organization, 2019).

According to CSA (2015), the total productive coffee area in Ethiopia is estimated at 561,761.82 hectares with annual average production of 419,980 tons and productivity of 748 kg/ha. According to ICO statistics, the production of Ethiopian coffee has been constantly increasing since 2000/01 harvest season. The annual production stood at the highest level of 8.10 million bags (= 486 thousand tons) in 2012/13 compared to 3.11 million bags (= 186.6 thousand tons) in 2000/01 cropping season. The productivity has also reportedly reached 748 kg/ha in 2014 compared to only less than 300 – 500 kg/ha before a decade (CSA, 2015).

Despite the largest share in production and economic contribution, C. arabica is threatened by several coffee diseases which remain among the major constraints to reduced production and productivity in many parts of Ethiopia. About fourteen fungal diseases and one bacterial disease have been reported to attack the crop (Eshetu et al., 2000). Out of the above fourteen fungal and one bacterial disease, Coffee berry disease (CBD) caused by Colletotrichum kahawae, coffee wilt disease (CWD) caused by Gibberella xylarioides and coffee leaf rust (CLR) caused by Hemileia vastatrix are the three major economically important biotic coffee production constraints in the country (Eshetu et al., 2000). Although the rest were found minor importance under current situation, a few diseases like coffee thread blight and bacterial blight of coffee have been identified potential threat for Arabica coffee (Belachew, 2015).

Coffee leaf rust (CLR), induced by Hemileiav astatrix Berkeley and Broome, is a major disease of Coffea Arabica, which constitutes about 75% of total coffee production in the world. It has been estimated that crop losses in Brazil would be about 30 - 50% if no control measures were taken (Cabral *et al.*, 2015). On this basis, world crop losses from the disease may be roughly calculated at $1-2 billion annually (Cabral *et al.*, 2015). Coffee leaf rust is therefore one of the seven most important diseases and pests of tropical crops (Kushalappa and Eske, 1989). It causing fungi belong to the family of pucciniaceae in the order of uredinales of the class Basidiomycetes. The genus has unknown pycnidial and aecidial stages and only the dikaryotic uredospores are responsible for the disease development (Maia et. al., 2013). The pathogen exists in different physiologic groups and over 50 different races have been identified all over the world (Cabrala et al., 2016). Among these, five physiologic races were reported to exist in Ethiopia (Meseret *et al.*, 1987). It was first reported in Ethiopia in 1934 (Sylvain, 1958) but the disease had existed for long time without cause excessive damage to C. Arabica plantations as in other countries. The long-term coexistence of coffee and rust (Eskes, 1989), high genetic diversity and high level of resistance (Van der Graaff, 1981), low average productivity associated with shade and existence of antagonistic biological agents might have maintained rust at low level.

The disease occurs in Ethiopia at tolerable level under a balanced path system and it inflicts minor attack to the crop except in certain areas and some pocket fields planted with homogeneously susceptible cultivars at lower elevations (Eshetu *et al.*, 1999; Meseret *et al.*, 1987). The effect of shade on the occurrence of CLR could be shown in nursery experiments at the Jimma Agricultural Research Centre (JARC) (Girma *et al.*, 2008). All young coffee trees grown under the shade were infected more seriously with rust than in the non-shaded sites. A large number of coffee accessions were evaluated by Meseret (1996) including (CBD) resistant selections and reported existence of partial resistance to CLR. Similarly, Adugna *et al.* (2009) tested large number of Arabica coffee collections for resistance to CLR and reported existence of significant differences among the collections.

The availability of resistant varieties and effective fungicides for the control CLR although it may still cause losses varying between 10 and 40% in different countries (Silva *et al.*, 2006). According to Wondimu (1991) the importance of CLR is increasing with an estimated national percent tree attack of 12.9 % which raised to 36 % after ten years. Therefore, these reviews paper give the crucial information about the current status of CLR occurrence and prevalence of diseases by concentrating on management practices at Sidama and

Gedeo zones of southern Ethiopia. Even though many research findings documented major coffee diseases and insect pest's situation in coffee productions there was little background information available on the CLR intensity in relation to management practices in the study areas. Thus, to obtain baseline information for the development of suitable interventions for the management of the disease, a survey was conducted in the coffee growing areas with the following objectives.

- To determine the intensity of CLR
- To determine how various crop management practices, contribute to the disease distribution.

## MATERIALS AND METHODS

### Description of study areas

The survey was conducted from September to December during 2016 and 2017 in major coffee growing areas of Sidama and Gedeo zones of South Nation Nationality and People Regional State (SNNPRS), Ethiopia. Sidama zone has-geographic coordinates of latitude/North: 5o 45″ and 6′ 45″ and longitude/East, 38o and 39′. It has a total area of 10,000 km2 in a variety of climatic conditions. Its altitude ranges from 1500 to 2500 meter above sea level. It has a mean annual rainfall of 400 to 799 mm and the mean annual temperature ranges from 20°C to 24.9°C (CSA, 2006). Gedeo zone is located at 369 km from Addis Ababa to Southern parts of the country and 90 km from Hawassa and Capital City of the Region, South Nation Nationality and People Regional State (SNNPRS), Ethiopia. Geographically, the zone is located North of Equator from 50 53'N to 60 27'N Latitude and from 380 8' to 380 30' East, Longitude. The altitude ranges from 1500 to 3000 meter above sea level. l. The zone has sub-humid tropical climate receives mean annual rainfall of 1500 mm with range of 1200 and 1800 mm. The mean monthly temperature is 21.5oC with mean monthly maximum and minimum temperature of 25oC and 18oC, respectively (CSA, 2006). The survey was conducted at six districts of the two zones namely Dalle, Shebedino, Aletawondo, Wonago, Yergachaffee and Dilla Zurai.

### Data collection procedures

Based on the secondary information from the office of agricultural district, the major coffee producing peasant associations were selected based on the coffee producing potential and from each peasant association four farms were surveyed at interval of about 3-5km along the roads. At each farm, 10 randomly selected trees on a diagonal transect across the farm were assessed for disease incidence and severity. Sampled trees were counted and tagged in order of 1-10 with the help of visible colored labels. On each sampled tree, three branches representing the top, middle and lower canopy layers were selected to assess CLR incidence and severity. Rust incidence expressed in percentage was determined as the number of diseased leaves per branch. Similarly, rust severity as proportion of leaf area rusted was estimated on all leaves of sampled branch using diagrammatic scale developed by Kushalappa and Chaves (1980). In the diagrammatic scale, 1, 3, 5, 7 and 10 indicates 1, 3, 5, 7 and 10% of leaf area rusted, respectively. Any rust severity on the leaves was estimated by making a cumulative count of each sporulating lesion area per leaf (Figure 1) following the scale of Kushalappa and Chaves (1980). In addition, the status of management practices (weeding, pruning, mulching, fertilizer applications, topography, shade type and level) on each farm was visual observed. Altitude in meters above sea level (m. a. s. l) was recorded, using extra Ground Positioning System (GPS) at a central point for each surveyed farm. The data were summarized on excel spreadsheet and the mean rust severity, incidence and altitudes were computed and illustrated by tables and figures. The Pearson correlation and linear regression analysis for mean of CLR severity and incidence with altitude were done by using Minitab 17.

## RESULTS AND DISCUSSION

The assessment of CLR was made in six districts of major coffee growing areas of Sidama and Gedeo zones of Southern Ethiopia; revealed its presence in all farms assessed varying in magnitude with season/year and location of coffee farms. A total of 99 and 90 coffee farms were observed during 2016 and 2017, respectively. We observed a total of 189 coffee farms during the surveyed periods of the years (Table 1). CLR was widely distributed in the surveyed districts. This indicates that only 34.5% of surveyed farms were disease free (Table 2). The remaining farms had varying levels of disease incidence and severity (Figure 2 and Figure 3).

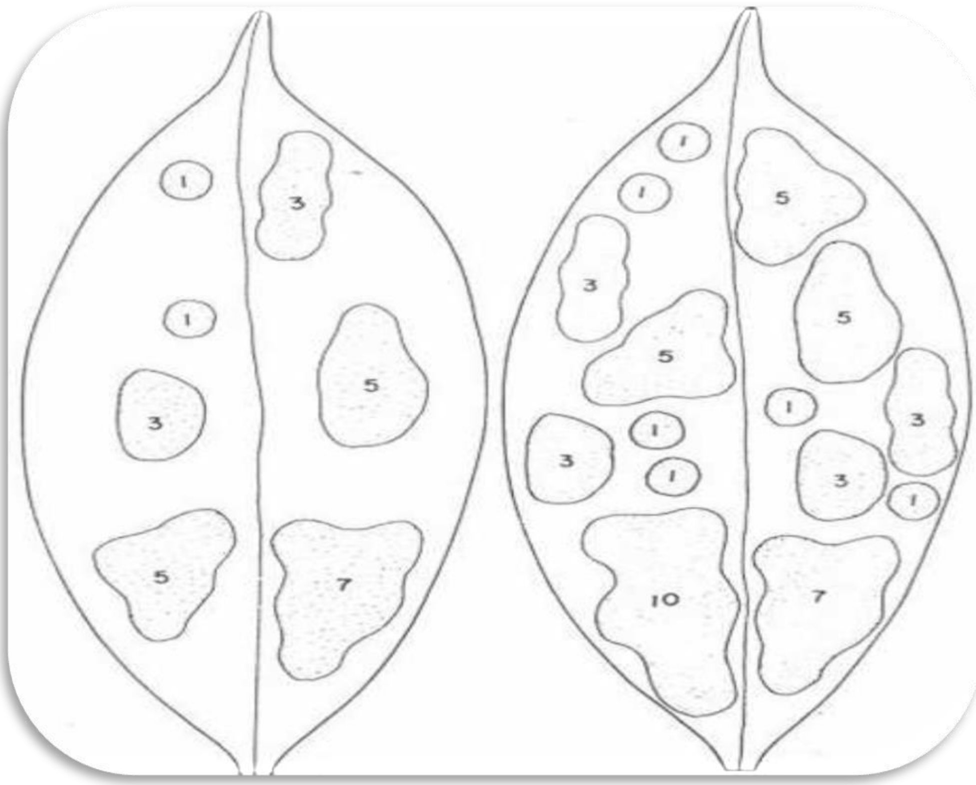


Figure 1. Assessment key for percent coffee leaf area rusted (Adopted from Kushalappa and Chaves, 1980).

Table 1. Distribution of surveyed farms per district during the survey years.

| District | Number of farms per year in each district | | |
|---|---|---|---|
| | 2016 | 2017 | Total |
| Dalle | 19 | 15 | 34 |
| Shebedino | 16 | 15 | 31 |
| Aletawondo | 16 | 15 | 31 |
| Dillazuria | 16 | 15 | 31 |
| Wonago | 16 | 15 | 31 |
| Yergachaffee | 16 | 15 | 31 |
| Total | 99 | 90 | 189 |

Table 2. Distribution of CLR in surveyed district.

| District | % of farms with CLR per year in each district | | |
|---|---|---|---|
| | 2016 | 2017 | Total |
| Dalle | 100 | 100 | 100 |
| Shebedino | 100 | 100 | 100 |
| Aletawondo | 94 | 100 | 97 |
| Dillazuria | 100 | 100 | 100 |
| Wonago | 75 | 100 | 87.5 |
| Yergachaffee | 69 | 93 | 81 |

In all assessed coffee farms, the rust incidence and severity in relation to management practices were visually observed. The survey data showed that the highest mean of rust incidence and severity was recorded at Shebedino (41.54%) and (16.04%) followed by Dalle (36.67%) and (15.36%) district whereas the lowest was at Yerega Chaffee (16.34%) and (2.44%) during the year 2016(Figure 2). In 2017, the highest value was recorded at Dilla zuria (44.67%) and (21.77%) whereas the lowest was at Yerga chaffee (4.69%) and (0.31%), respectively (Figure 3). The overall mean percentage of incidence and severity results showed that the highest rust incidence and severity was recorded at Dilla Zuria (38.62%) and (13.80%) while the lowest was at Yerga chaffee (10.52%)and (1.38%) district, respectively (Figure 4).This might be due to variation of variety compositions, production systems, management practices (weeding, pruning, mulching, shade level, ages of coffee trees),environmental condition(rainfall, temperature, relative humidity, altitudes, soil fertility). Similar work by other authors reported in plantation and garden higher rust incidence than in forest coffee (Eshetu *et al.*, 1999). According to Avelino (2006) the intensive production systems make variation in rust intensity with coffee management practices.

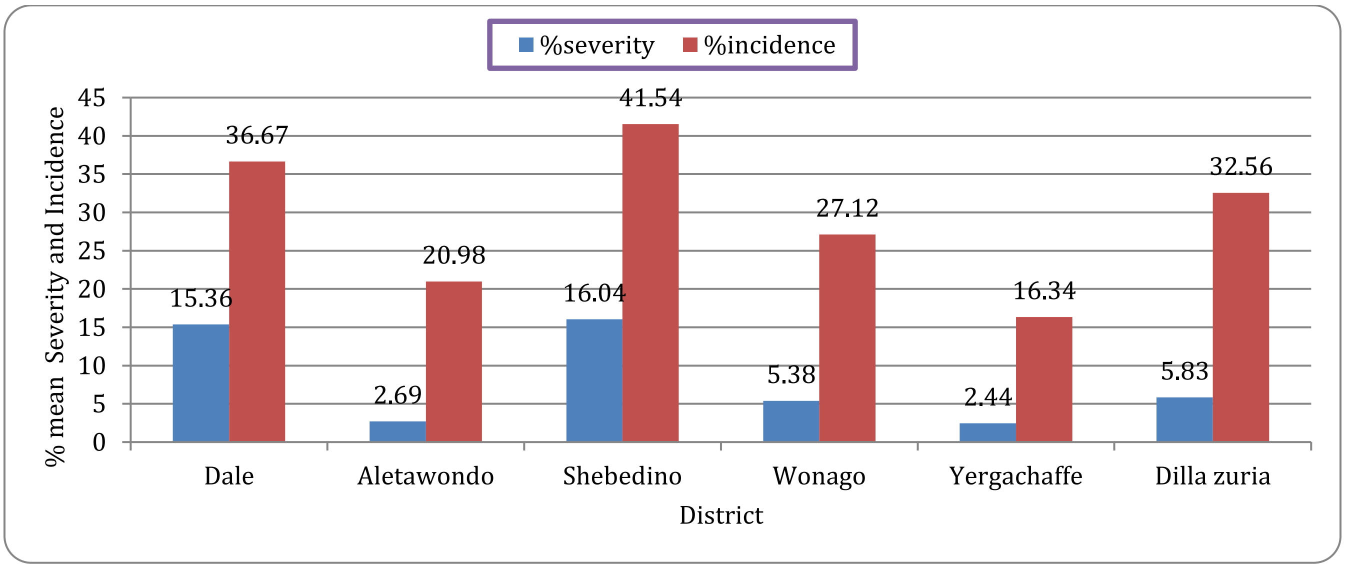


Figure 2. The mean % of CLR Severity and Incidence in 2016 among districts.

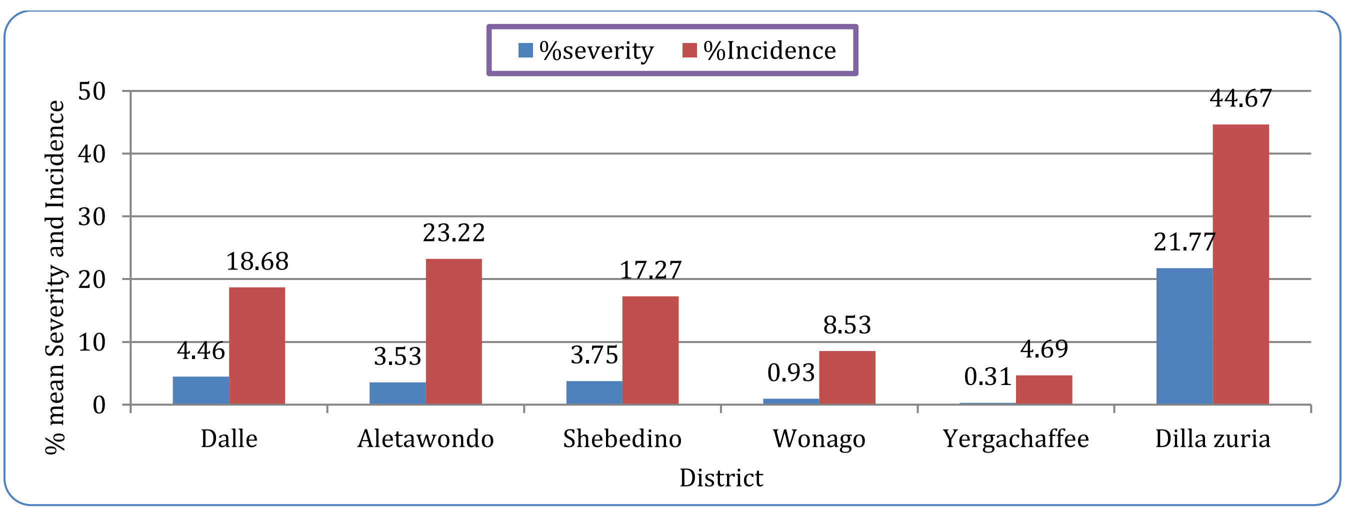


Figure 3. The mean % of CLR Severity and Incidence in 2017 among districts.

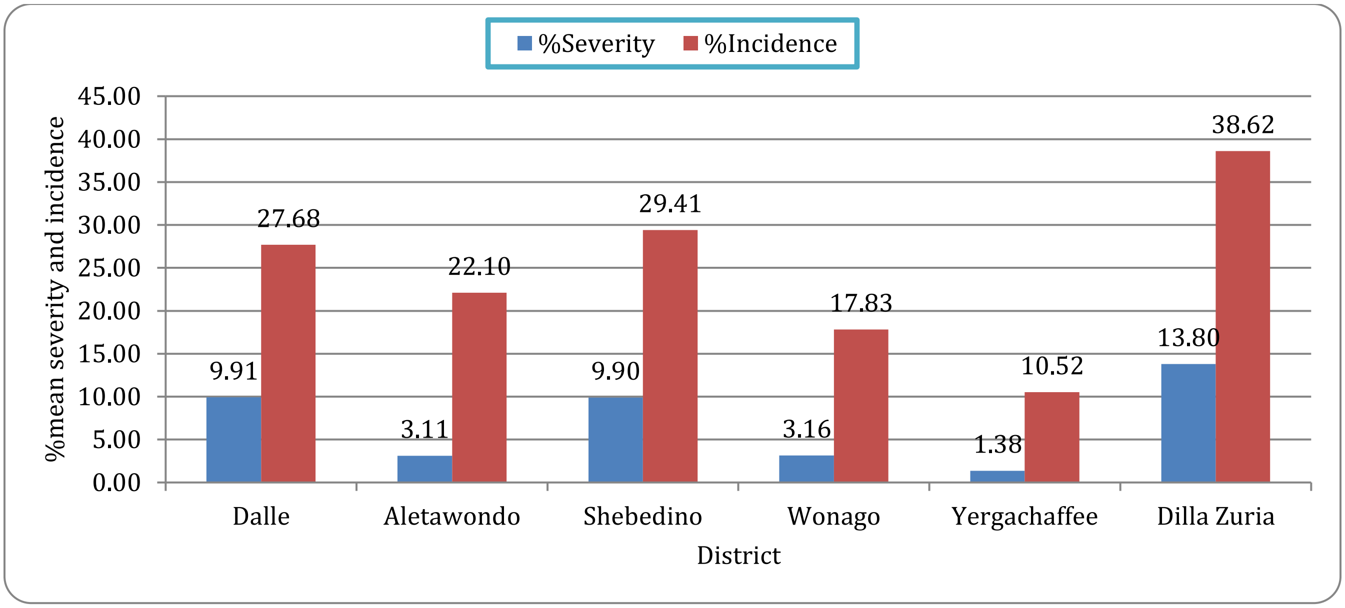


Figure 4. The overall mean % Severity and Incidence of CLR among districts.

Table 3. Pearson coefficient of correlation between altitudes and severity and incidence of CLR.

| Variable | **Al** | **S** | **I** |
|---|---|---|---|
| Al | 1 | | |
| S | -0.8 | 1 | |
| I | -0.62 | 0.95 | 1 |
| P-value | | 0.058 | 0.044 |

Al = Altitude, S = Severity, I = Incidence

Table 4. Analysis of linear regression for mean altitudes versus CLR severity and incidence.

| SN | District | Altitude | Severity | Incidence |
|---|---|---|---|---|
| 1 | Dale | 1799 | 9.91 | 27.68 |
| 2 | Shebedino | 1890 | 3.11 | 22.10 |
| 3 | Aletawondo | 1870 | 9.90 | 29.41 |
| 4 | Dillazuria | 1630 | 13.80 | 38.62 |
| 5 | Wonago | 1816 | 3.16 | 17.83 |
| 6 | Yirgacheffe | 1947 | 1.38 | 10.52 |
| 7 | mean | 1825 | 6.87 | 24.35 |
| 8 | SE± | 0.0138, 0.0253 | 25.2 | 46.3 |
| 9 | P-value | 0.058, 0.044 | 0.044 | 0.026 |

SE = Standard of Error for each variable

The results indicate that there is statistical (p = 0.058 for severity, p = 0.044 for incidence) an inverse relationship between CLR intensity (severity, r= -0.80 and incidence, r= -0.82) and altitude (Table 3). In addition, there is statistical (p = 0.003) a positive relationship between CLR mean severity and incidence (r=0.95) (Table 4). This implies that CLR incidence and severity increases with each unit decrease in farm altitude. This association is more elaborated in the following resultant linear regression equation:

Y= -0.036X+73.16 and Y = -0.074X +158.9

Where;

Y= percentage means of CLR severity and incidence, respectively and X= altitude in m.a.s.l) (Figure 6 and 7).

The highest altitude range (1838-2056) was found at Yerga chaffee while the lowest was found at Dilla Zuria (1434-1825) district, respectively (Figure 5). This might be at higher elevations low night temperatures followed with low day temperatures was found which make the pathogen in passive for a longer period and slower epidemic while in lower elevation it hastens rust development since high temperature make suitable condition for pathogen. At lower altitudes, CLR may benefit from higher temperatures (Lamouroux *et al.*, 1995).

The influence of altitude on the occurrence and distribution of CLR was reported by many researchers (Kushalappa and Eske, 1989; King'ori and Masaba, 1994; Brown *et al.*, 1995). The negative correlation was also reported by Kushalappa and Eske (1989) who found that higher altitudes were associated with lower disease severity. This finding prioritizes higher lying areas as more disserving of efforts to develop CLR resistant varieties with adaptability to such conditions.

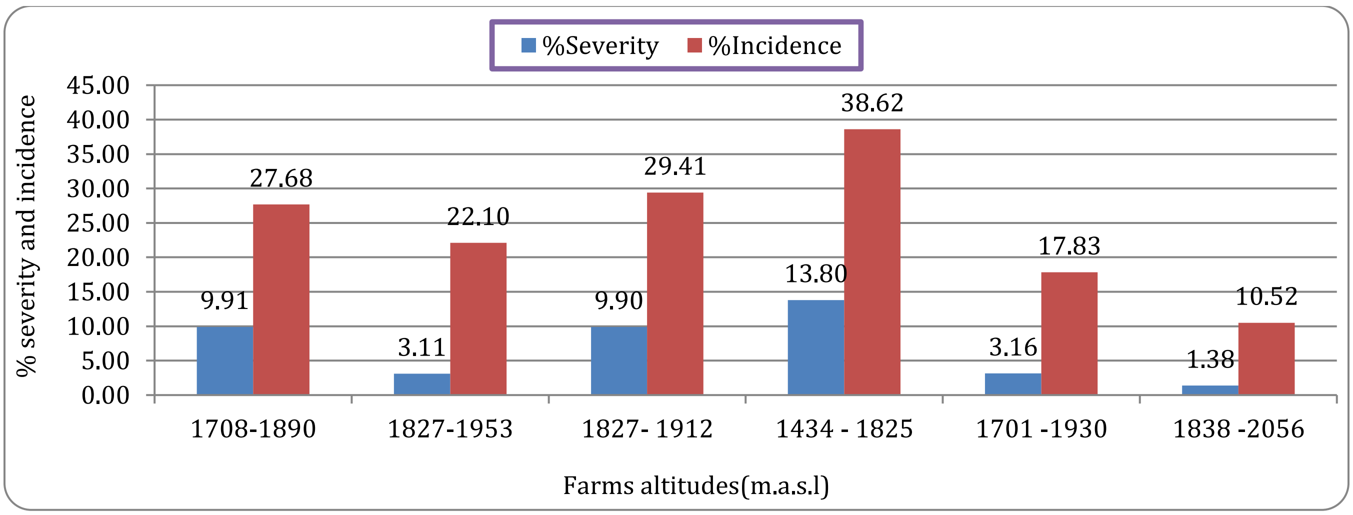


Figure 5. Relationship between altitude and rust intensity.

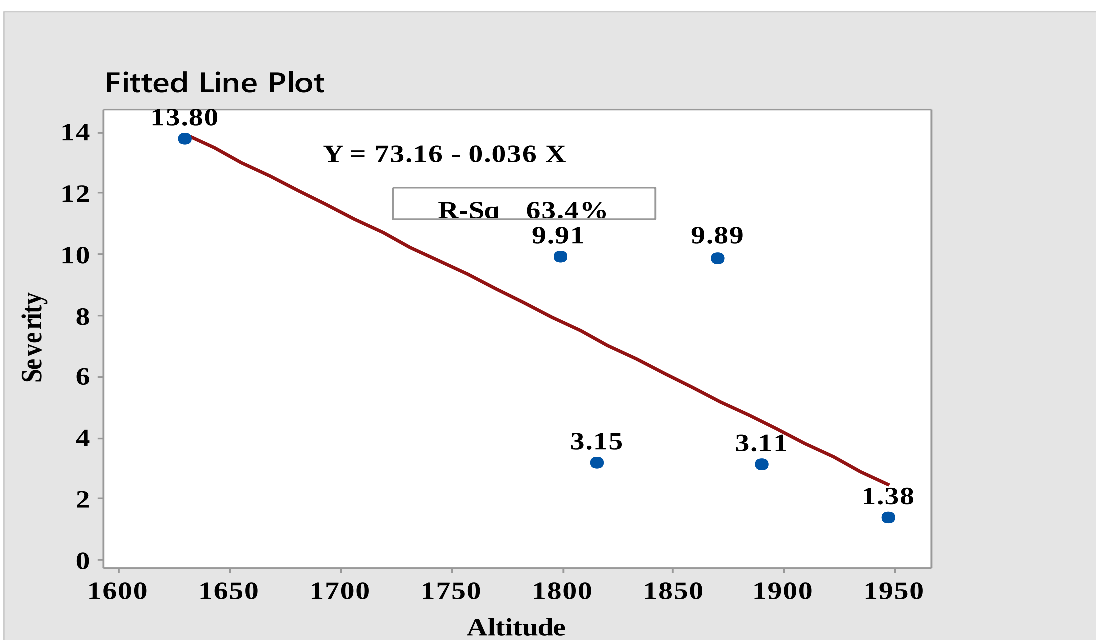


Figure 6. The mean average severity of CLR versus altitudes of the districts.

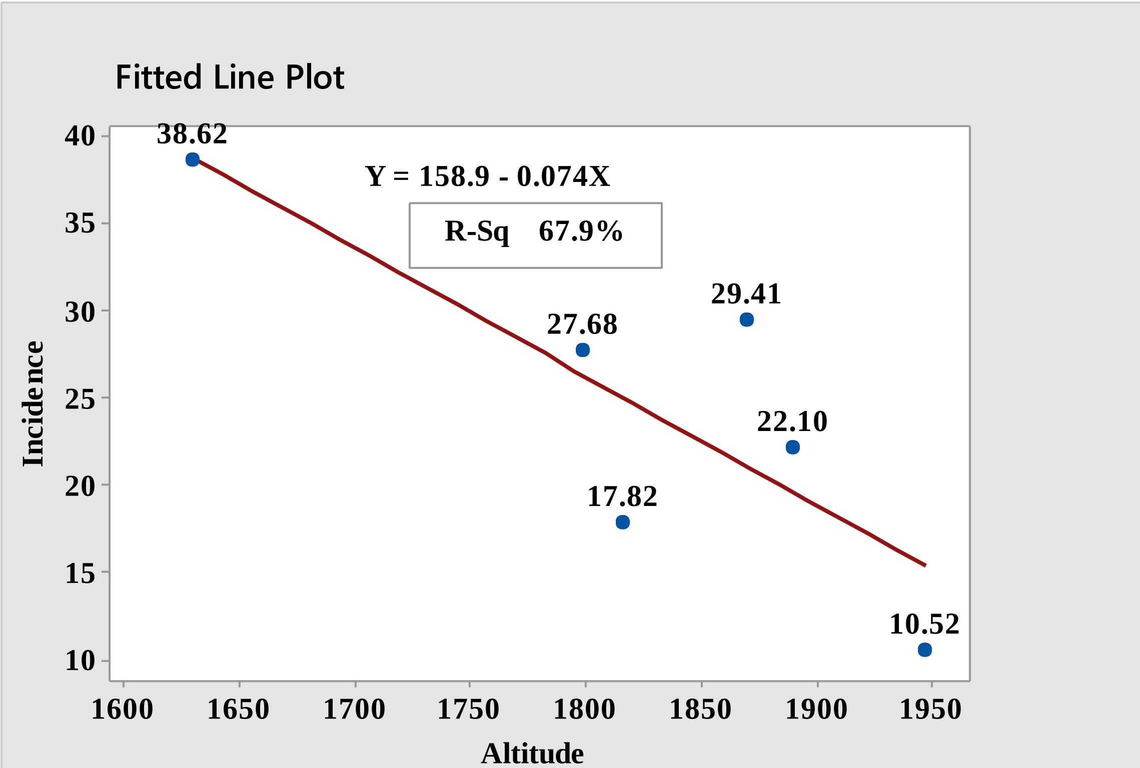


Figure 7. the mean average incidence of CLR versus altitudes of the districts.

**Management practices and CLR Incidence and Severity**

The present study showed that there was a relationship between CLR incidence and severity with ages of coffee trees, shade intensity and cultivars. The results showed that a largest number of coffee farms (94, 103 and 123) were found in ages of (11-20), low shade level and mixed (local and improved) cultivars, respectively (Figure 8). The highest incidence (25.08%) and severity (8.60%) was recorded in ages of (>20) coffee trees. This might be due to the poor management practices such as, weeding, mulching, pruning, and application of manure; overbearing, cropping systems have been done. No due attention was given by farmers on aged coffee trees on their farms because they thought as unproductive and they have been stayed for a long period of time without stumping. As a consequence, poor management coupled with prevailing environmental factors could have enhanced susceptibility of coffee to leaf rust and coffee berry disease. Bock (1962) stresses the influence of some management practices such as pruning, weed management and use of soil amendments on CLR development. Hakiza (1997), Mouen Bedimo *et al.* (2007) and Joseph (2012) observed that high level management including: - pruning, mulching, appropriate fertilizer application and good weed control contribute to masking the adverse effect of CLR and CBD epidemic on Arabica and Robusta coffee. These good management practices increase plant vigor, making them more tolerant to disease attack (Joseph, 2012). This indicates that in areas of good management practices the intensity of rust was low as compare to poor management practices.

The shade level results indicate that the highest number of CLR incidence (20.57%) and severity (7.35%) was obtained from low shade level, respectively (Figure 8). Because in low shade level efficient light penetration under such conditions make high temperature which in turn increases disease intensity. Additionally, there might be the presence of optimum microclimate conducive for pathogen occurrence and distribution. Shade systems in coffee mainly act on environmental parameters in limiting disease incidence (Mouen Bedimo *et al.*, 2007). Temperature is one of the most important environmental factors that determine spore germination and penetration of Hemileia vastatrix (Beer *et al.*, 1998).

High incidence and severity within thin and medium shade intensities can be explained by presence of optimum microclimate conditions that favor CLR pathogen infection and colonization of coffee leaves (Beer et al., 1998).

In addition, efficient light penetration under such conditions keeps temperatures well regulated. The result also showed that in very low shade level the incidence (16.49%) and severity (2.71%) was low (Figure 8). This partly due to less competition occurs among coffee trees planted with shade trees in farms. Nutrient stress predisposes coffee to disease infection especially during heavy bearing stages of growth (Agrios, 2005; McMahon, 2012). The low CLR incidence and severity in very low shade level of coffee farms can be attributed to less competition for resources such as soil nutrients, moisture and light which occurs among coffee inter-planted with shade trees. Additionally, in very low shade level of coffee farms lower humidity levels than shaded farms an environmental factor required during successful penetration of host tissue by coffee rust. The types of cultivars they were used categorized as collections (variety trials, variety verification trails), released variety and local/mixed/ cultivars. In this condition, the highest rust incidence (19.47%) and severity (6.10%) was recorded on mixed cultivars than released and collections of several genotypes (Figure 8). Because mixed cultivars are more susceptible and less management practices than improved varieties. According to Wolfe (1985), the susceptible local cultivars may increase the disease pressure on improved varieties in the mixed landrace-variety growing conditions. Similar work was reported by (Eskes, 1983) indicated that many coffee plants in Ethiopia do not have any recognizable major resistance gene and the resistance of C. arabica to rust may be due to minor genes. These minor genes are sensitive to environmental factors, such as light intensity and temperature. In general, in most coffee farms the statuses of management practices were very poor which makes favorable conditions for pathogen development. These practices are poor weeding, low pruning and mulching, poor application of manure, susceptible cultivars, poor cropping systems, low shade level, aged and complex stand of coffee trees without any management practices.

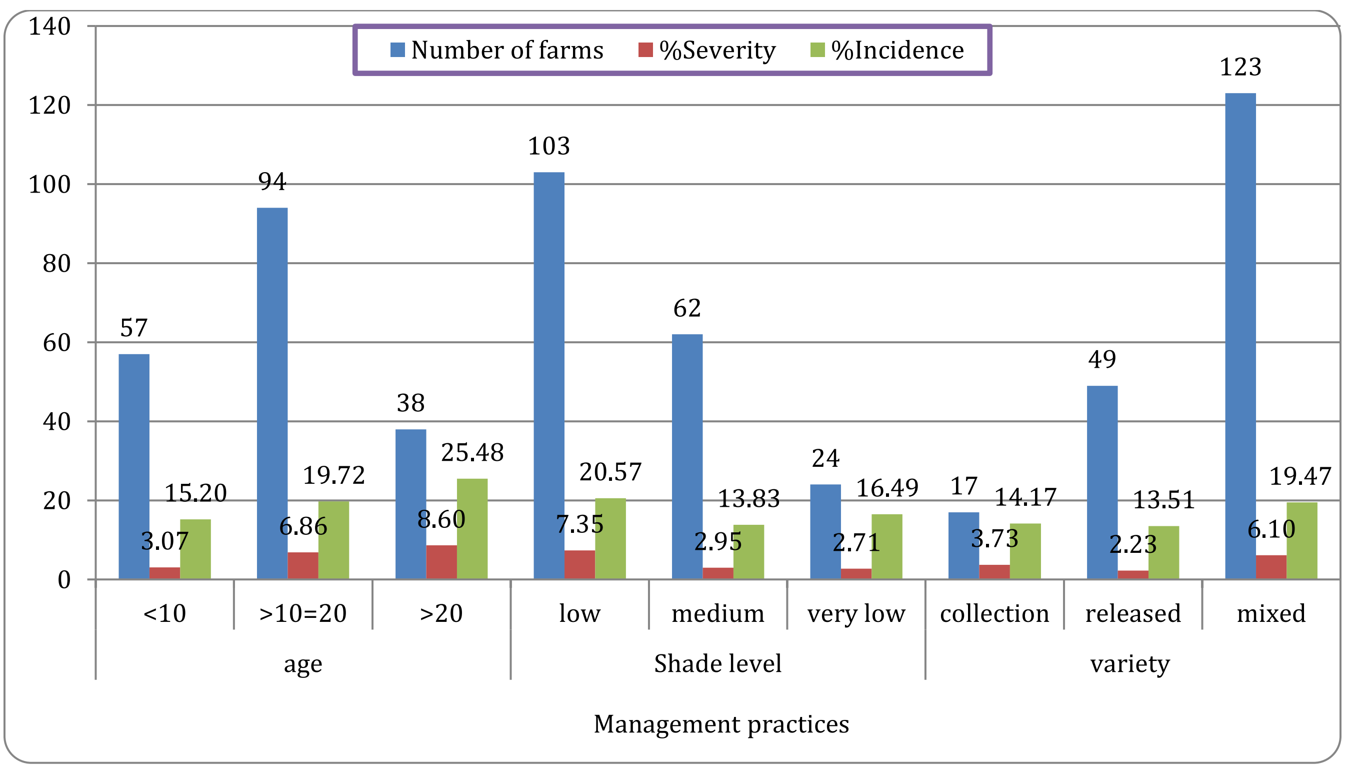


Figure 8. The overall mean of CLR severity and incidence regarding to ages of coffee trees, shade level and cultivars in assessed farms.

## CONCLUSION AND RECOMMENDATIONS

CLR was widely distributed in most assessed districts of Sidama and Gedeo zones of Southern Ethiopia revealed its presence in all assessed farms varying in magnitude with season/year and location. The disease intensity was remarkably increasing from time to time in all assessed coffee farms implied conduciveness of environmental conditions for rust development over time. In most observed coffee farms, unproductive and aged coffee trees, mixed cultivars that more susceptible, low shade level, poor (weeding, pruning, mulching and composting), complex stand of coffee trees, were observed as a critical problem. Hence the disease was remarkably increasing from time to time in all assessed coffee farms, appropriate measurement like farmers' awareness creation and training on how to control disease as well as appropriate agronomic managements likes weeding, mulching, composting, pruning, stumping, low shade level, and local landraces (mixed) with aged trees has to be seriously undertaken. In addition, development of CLR resistant varieties to southern Ethiopia through resistant breeding has to be set high priority.

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