

The Diseases of Coffee under the Changing Climate: The Established Situation in Kenya

Harrison M. Mugo¹, Lucy W. Irungu² and Paul N. Ndegwa²

1. Coffee Research Foundation, Ruiru, Kenya

2. University of Nairobi, School of Biological Sciences, Nairobi, Kenya

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Abstract: The distribution of key diseases of coffee particularly the Coffee berry disease (CBD) and Coffee leaf rust (CLR) in Kenya depended on coffee growing agro-ecological zones, which have varied climatic conditions. Under the changing climate, there has been an observed shift in their altitudinal distribution. To ascertain whether these diseases have shifted in their distribution, an extensive field survey covering 120 coffee farmers/households in all the coffee growing agro ecological zones was conducted. The survey established four coffee diseases; –viz. Coffee berry disease, Coffee leaf rust, Fusarium root disease (FRD) and Bacterial blight of coffee (BBC) as of economic importance to the farming community. The CBD, CLR and FRD were widely distributed in all coffee growing agro ecological zones. Of the four diseases, the CBD (65%) and CLR (63.3%) were most common as reported by the farmers, however these diseases dominated in their respective agro ecological zones; CBD (72.2%) in Upper Midland 1 (UM1) and CLR (75.0%) in Upper Midland 2 (UM2). Both diseases equally infected coffee farms (69.2%) in main coffee zone (UM2). According to the survey said diseases have increased their altitudinal range, a trend that will increase diseases pressure in coffee growing areas.

Key words: Coffee berry disease, coffee leaf rust, climate change, agro-ecological zones, altitudinal range.

1. Introduction

The distribution of plant diseases among other crop pests is governed primarily by the distribution of the host plant with climatic conditions also playing a major role. Globally, an estimated 350 different diseases infect coffee causing problems that decrease production [1]. In Kenya, infection of coffee trees by CBD and CLR constraints and limits its farming in various coffee growing agro-ecological zones. The distribution of these diseases in different coffee growing agro ecological zones in Kenya differs. For instance growing coffee at altitudes below 1,400 m a.m.s.l (above mean sea level) is limited by drought and severe attack by CLR caused by *Hemileia vastatrix* Berkeley and Broome. At altitudes 2,000 m

a.m.s.l., growing of coffee is limited by low temperatures and the destructive CBD caused by *Colletotrichum kahawae* Waller and Bridge [2]. With anticipated climate change, key coffee diseases in Kenya are expected to shift in their distribution across the coffee growing agro ecological zones.

Coffee in Kenya is mainly grown under shade or un-shaded systems in three agro-ecological zones (agroecozones); coffee-tea zone or Upper Midland 1 (UM1, 1,570-1,810 m a.m.s.l.), main coffee zone or Upper Midland 2 (UM₂, 1,395-1,675 m a.m.s.l.) and marginal coffee zone or Lower Midland 3 (UM3, 1,330-1,560 m a.m.s.l.). The climatic conditions of these zones also vary especially in annual mean temperature and rainfalls [3]. The effect of climatic changes are thus likely to be felt more on the UM1 and UM2 where key coffee diseases such as CBD, CLR and BBC caused by *Pseudomonas syringae* pv.

Corresponding author: Harrison M. Mugo, Ph.D., research fields: biological control, integrated pest management. E-mail: mugohmu@yahoo.com.

Garcae are likely to be favoured by the upward rise in temperatures' regimes.

The distribution of Coffee berry disease, Coffee Leaf Rust and Bacterial blight of coffee in Kenya coffee growing agro ecological zones varies. To mitigate the likely crop losses due to their infection, coffee varieties suitable for various agro-ecological zones have been developed by Coffee Research Foundation, Ruiru, Kenya. Such varieties includes; Ruiru 11 [4] and Batian that grows in all agro-ecological zones and are resistant to CBD and CLR, K7-normally grown in low to medium altitude with partial resistance to CLR and CBD, SL 28-grown in medium to high altitude but is susceptible to CBD and CLR, and SL 34-grown in high altitude but susceptible to CBD and CLR.

The study was carried out to determine the common diseases of coffee and the likely changes in their distribution from one agro-ecological zone to another due to climate change. This aimed to create the required awareness to the coffee growers on the anticipated changes in distribution of coffee diseases across the different coffee growing agro-ecological zones.

2. Materials and Methods

A countrywide survey that covered six coffee growing provinces and thirteen major coffee growing districts in Kenya was used to determine the common diseases of coffee, their distribution and management across coffee growing agro-ecological zones. The survey was conducted through coffee farm/household visits. Data from the farms/households were adduced by interviewing the farmers through use of structured questionnaire. The coffee farmers/respondents interviewed from the thirteen coffee growing districts were randomly selected from the three UM-subzones (UM1, UM2, and UM3). The surveyed coffee growing districts per province were selected based on mean national coffee production where 82% of the Kenyan coffee comes from the central and eastern provinces.

2.1 Sampling Design and Farms Distribution

A sample size of $N = 120$ (where N was the number of farms) was allocated to the six provinces namely; Coast ($n = 4$), Eastern ($n = 36$), Central ($n = 48$), Rift Valley ($n = 16$), Western ($n = 8$) and Nyanza ($n = 8$), in a proportionate stratified sampling design with $n = N \cdot p_i$, where p_i was the proportion of coffee produced in each province. The allocated sample sizes for each province were distributed randomly among the subzones present in the selected districts; Taita ($n = 4$), Machakos ($n = 8$), Makueni ($n = 4$), Embu ($n = 12$), Meru Central ($n = 12$), Kiambu ($n = 12$), Muranga ($n = 12$), Kirinyaga ($n = 12$), Nyeri ($n = 12$), Nakuru ($n = 8$), Bungoma ($n = 8$), Trans-Nzoia ($n = 8$) and Kisii ($n = 8$). A total of 36, 52 and 32 farms/farmers were sampled or interviewed in UM1, UM2 and UM3, respectively (Fig. 1). In each UM-subzone, four farms were selected for the survey of coffee diseases. Following the principle of disproportionate, most of the sampled farms (70%) were located in eastern and central provinces, which are the main coffee-growing regions in Kenya. The t -test graphs were used to compare the data collected.

2.2 Distribution of Coffee Diseases

The CBD and CLR are specifically known common coffee diseases of Arabica coffee in UM1 and UM3 coffee growing agro ecological zones in Kenya, respectively. A face to face home interview using a structured questionnaire was employed to determine common diseases of coffee, their distribution and management practices applied by the farmers. Farm owners (respondents) from the randomly selected farms in each agro ecological zone per district were interviewed. Details of coffee management practices and the common diseases known by the farmers were obtained from the respondents and their farm records. The coffee diseases mentioned by the farmers were confirmed by

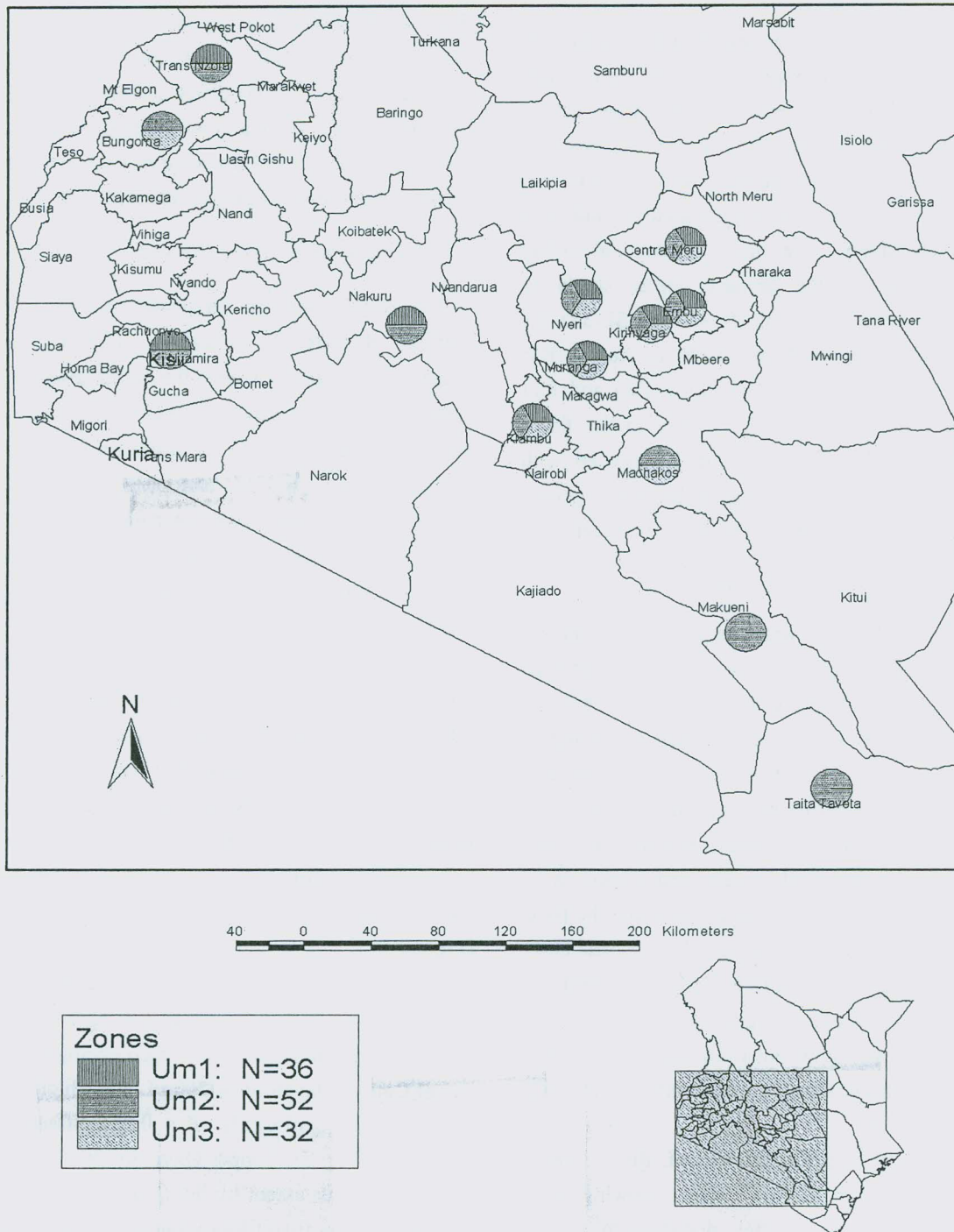


Fig. 1 Distribution of coffee growing agroecozones in Kenya. Source: Regional centre for mapping of resources for development.

randomly selecting ten coffee trees from each farm for visual examination where the presence or the absence of the disease(s) in each farm was recorded on site. The tree parts (leaves, young berries, branches and

roots) were visually examined for the infection and the actual presence of the coffee diseases. The coffee diseases stated and known by the respondent were confirmed to be present or absent.

3. Results

The coffee farmers interviewed were categorized into three groups according to their farm sizes; smallholders, medium estates and large estates (plantations). Out of the 120 farmers interviewed, 76.6% ($n = 92$) were smallholders, while 6.7% ($n = 8$) and 16.7% ($n = 20$) represented the medium and large estates, respectively. The main commercial coffee varieties grown by the farmers, either singly or combined were the Scots Lab (SL-28 and SL-34), the improved hybrid cultivar Ruiru-11(R11), Kent 7 (K7) and Blue Mountain (BM). The SLs (41%) and R11 (22%) were the main varieties grown in the farms sampled. A combination of SL/R11 followed with 18% of the farms whereas the rest either purely grown or combined only represented less than 10% each.

3.1 Distribution of Coffee Diseases

Four coffee diseases were realized and found to constrain coffee productivity in the farms surveyed (Table 1). Among these, CBD [65% ($n = 78$)] and CLR [63.3% ($n = 76$)] were common according to the survey (Table 1). Fusarium root disease and Bacterial blight of coffee occurred in < 10% of the farms surveyed hence were less common. The CBD, CLR and FRD were widely spread and present in all the three coffee agro-ecological zones while the BBC occurred only in two agro ecological zones; the UM1 and UM2 (Table 1). The coffee farms with CBD and CLR infection were not significantly ($P > 0.05$) different from each other but were significantly ($P < 0.05$) different from those that were infected by FRD and BBC (Fig. 2).

The presence and dominance of the common diseases; CBD and CLR in coffee growing agro ecological zones varied. They occurred in all the agro ecological zones (Fig. 3). In UM1, the coffee farms (72.2%) with Coffee berry disease infection were significantly ($P < 0.05$) higher than those infected by Coffee leaf rust (Fig. 3). The both diseases equally infected coffee farms (69.2%) in

UM2 and were not significantly ($P > 0.05$) different from each other (Fig. 3). In UM3, coffee farms (75.0%) had Coffee leaf rust infection that significantly ($P < 0.05$) differed from those infected by CBD (Fig. 3). The two diseases were widely spread in all the coffee growing districts except Taita Taveta where only CBD was reported (Fig. 4).

3.2 Management of Coffee Diseases

The farmers sprayed fungicides recommended by Coffee Research Foundation (CRF) as the management strategy against the coffee diseases. Four fungicides were mainly sprayed according to the survey (Table 2). Their use varied across the agro ecological zones. In UM1 and UM2, their application against coffee diseases was not statistically ($P > 0.05$) different from each other. But the use of fungicides in UM3 was statistically ($P < 0.05$) different from UM1 and UM2 (Fig. 5).

Copper Oxychloride 500 g/L and Chlorothalonil 750 g/L were common fungicides used, with over 10% of the farmers applying the products to manage the diseases (Fig. 6). The coffee farms (31.8%) used Copper Oxychloride 500 g/L as major fungicide to manage the diseases across all the agro ecological zones. This significantly ($P < 0.05$) differed from coffee farms (11.7%) that used Chlorothalonil 750 g/L (Fig. 6).

The use of both Copper Oxychloride 500 g/L and Chlorothalonil 750 g/L across the agro ecological zones varied widely. In all the agro ecological zones, use of Copper Oxychloride 500g/L and Chlorothalonil 750 g/L was significantly ($P < 0.05$) different from each other (Fig. 7). Copper Oxychloride 500 g/L was used in a greater extent by the farmers in all the agro ecological zones than Chlorothalonil 750 g/L. The use of either Copper Oxychloride 500 g/L or Chlorothalonil 750 g/L in UM3 was less significant ($P < 0.05$) as compared with UM1 or UM2 (Fig. 7). In UM1 and UM2 the level of either Copper Oxychloride 500 g/L or Chlorothalonil 750 g/L use was not significantly ($P >$

Table 1 Coffee diseases and their distribution.

Common name	Scientific name	% farms attacked	Agroecozone
Coffee berry disease (CBD)	<i>Colletotrichum kahawae</i> Waller and Bridge	65.0	UM1, UM2, UM3
Coffee leaf rust (CLR)	<i>Hemileia vastatrix</i> Berkeley and Broome	63.3	UM1, UM2, UM3
Fusarium root disease (FRD)	<i>Fusarium solani</i> (Martius)	6.7	UM1, UM2, UM3
Bacterial blight of coffee (BBC)	<i>Pseudomonas syringae</i> pv. <i>garcae</i>	5.8	UM1, UM2

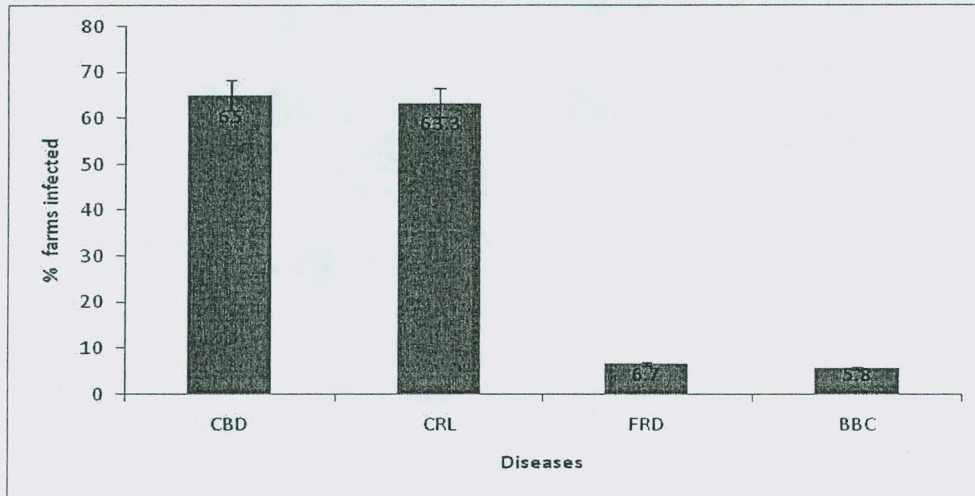


Fig. 2 Coffee farms (%) infected by coffee diseases.

CBD = Coffee berry disease, CLR = Coffee leaf rust, FRD = Fusarium root disease, BBC = Bacterial blight of coffee.

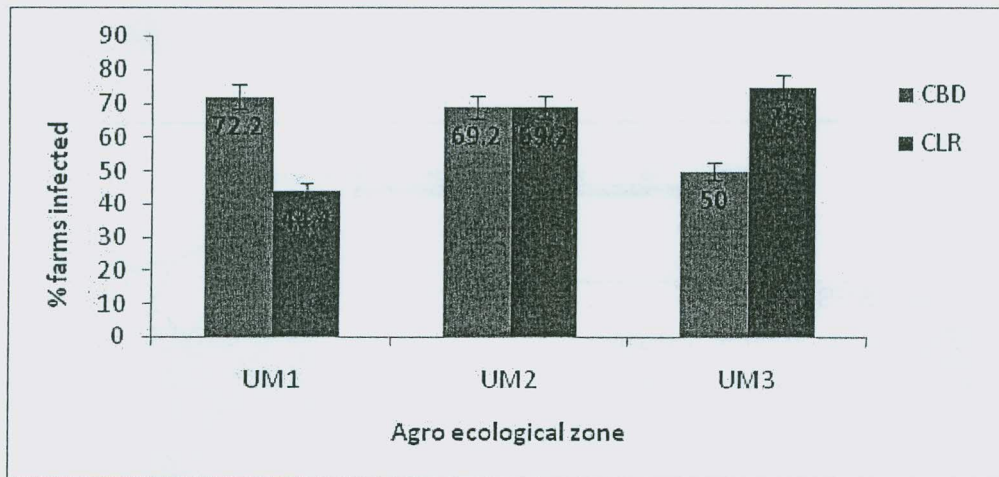


Fig. 3 Coffee farms (%) infected by common diseases of coffee and their distribution in agro ecological zones.

CBD = Coffee berry disease, CLR = Coffee leaf rust.

0.05) different from each other (Fig. 7).

4. Discussions and Conclusion

The field survey mainly covered small coffee growers (Smallholders 76.6%) who contribute an estimated 60% of the national coffee production. The

commercial coffee varieties grown by the farmers included the SLs, R11, K7 and BM. The SLs though susceptible to major coffee diseases; CBD and CLR compared to R11 remained the most commonly grown varieties by farmers (41%). No reasons were fully established as to why this was the situation but some

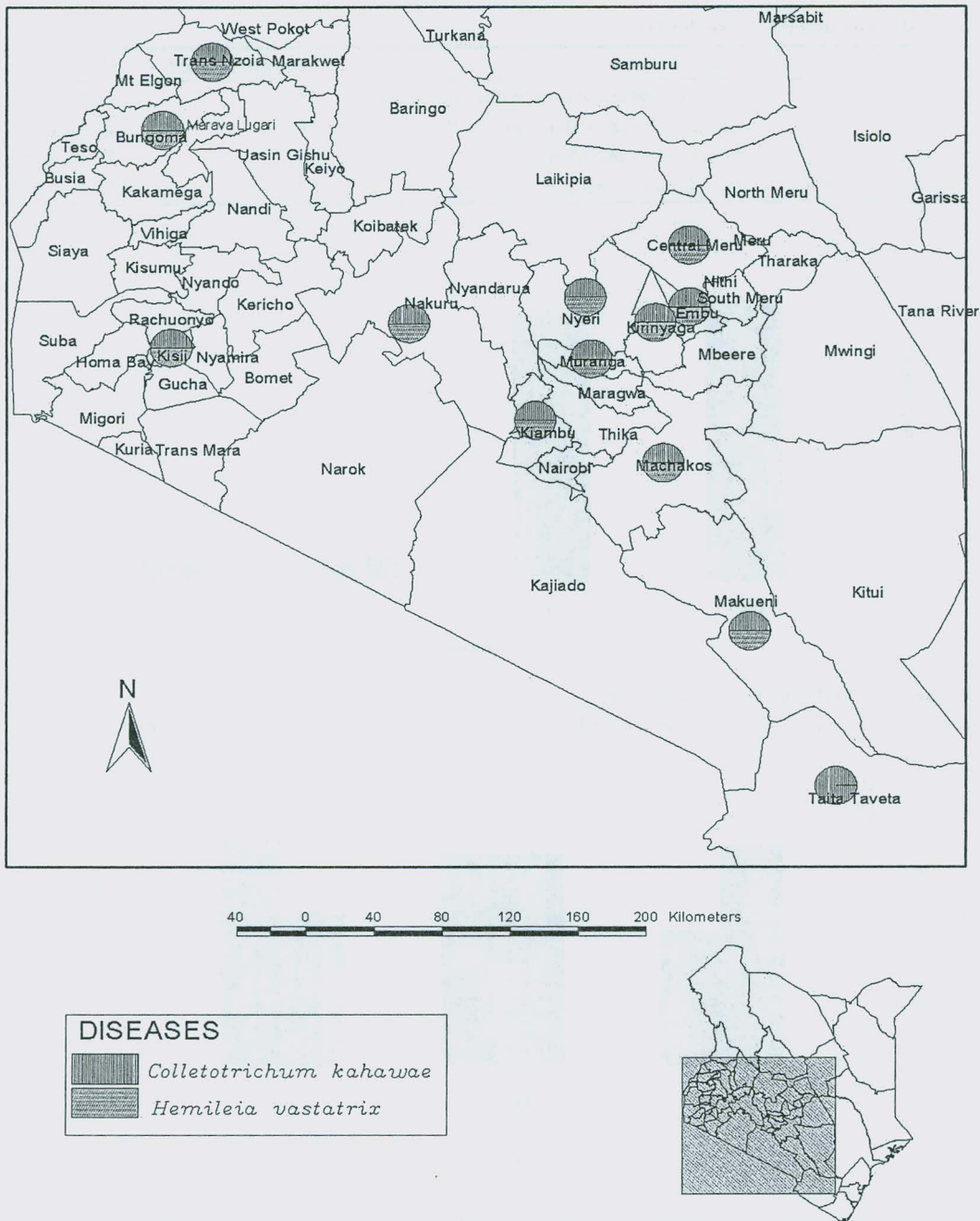


Fig. 4 Distribution of coffee berry disease and coffee leaf rust in coffee growing areas. Source: Regional centre for mapping of resources for development.

Table 2 Fungicides sprayed in coffee farms.

Fungicide/Active ingredient	Trade name(s)
Copper oxychloride 500 g/L	Cobox 500 Cu WP
Chlorothalonil 750 g/L	Daconil 750 WP
Cyproconazole 100 g/L	Alto 100 SL
Dithianon 500 g/L	Delan 500 SC

farmers indicated that R11 suffers from moisture stress during the dry spell. Despite this, SLs were the first varieties to be introduced in Kenya when coffee commercialization started. This may be the significant factor that contributes for their cropping dominance in all the coffee growing agroecozones in Kenya.

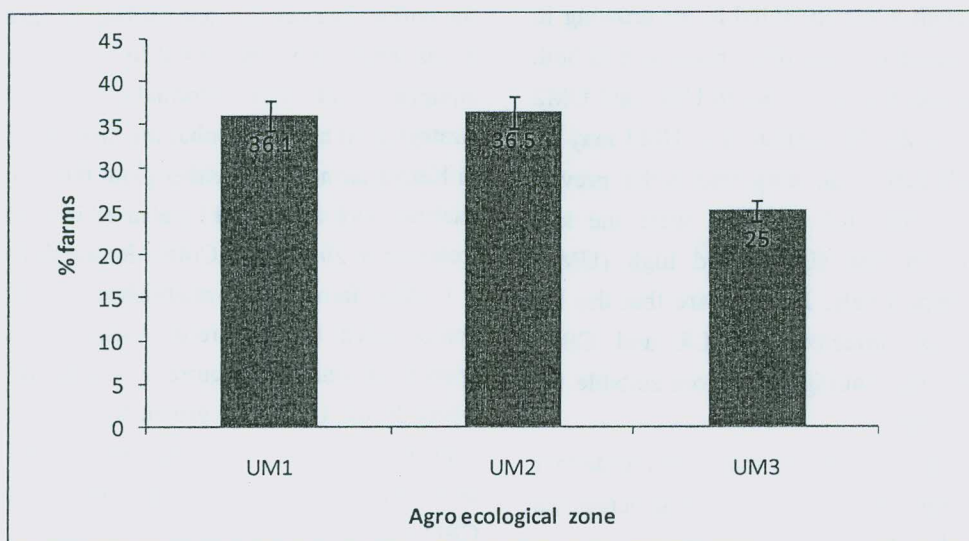


Fig. 5 Coffee farms (%) using fungicides in different agro-ecozones.

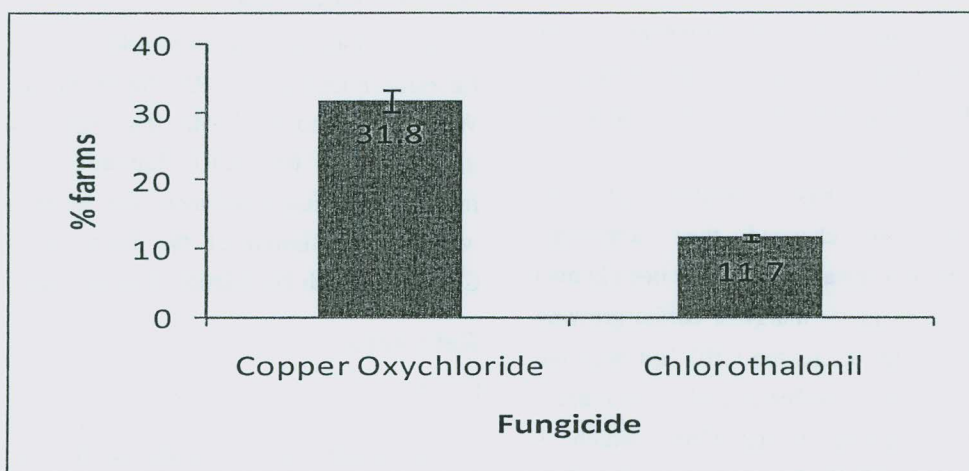


Fig. 6 Coffee farms (%) using common fungicides.

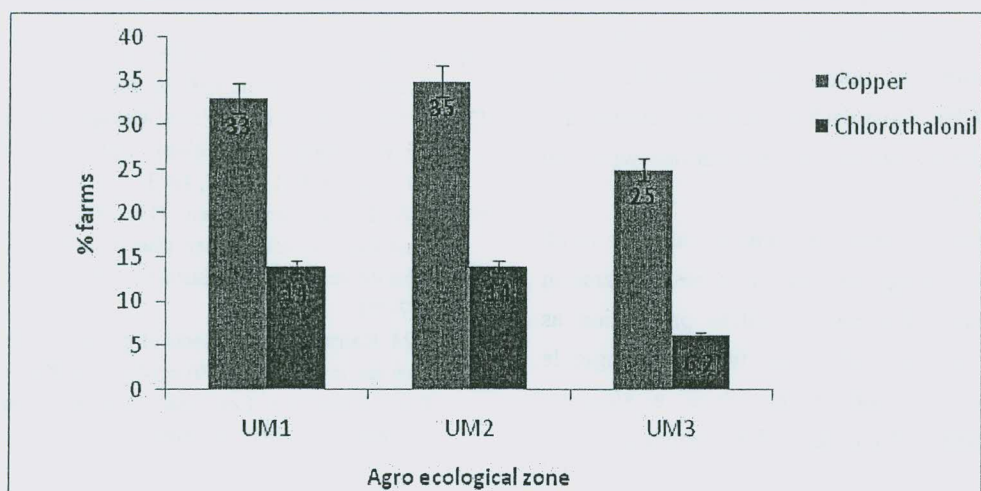


Fig. 7 Coffee farms (%) using copper oxychloride 500 g/L and chlorothalonil 750 g/L in different agro-ecozones.

The R11 though a variety suitable for growing in all the agroecozones because of its resistance to both CBD and CLR was mainly grown in UM1 and UM2 as compared to UM3. Its limitation in UM3 may be due to low rainfall and high temperatures that prevail in the zone [3]. The K7 and BM were the key varieties grown in low (UM3) and high (UM1) altitude areas respectively. Reasons are that the K7 and BM are less infected by CLR and CBD, respectively [2] thus making them more suitable for the two agroecozones.

It was evident from the survey that coffee hosts four key coffee diseases that were widely spread across the coffee growing districts and agro ecological zones. As reported by the farmers, the four diseases were common to their farms and affected coffee production. Among the four coffee diseases reported during the survey, CBD, CLR and FRD infected coffee in all the agro ecological zones.

During the survey it was established that some coffee diseases have changed their altitudinal distribution range. For instance, CLR has been known only as a problem in lower marginal coffee growing zone, UM3. Unlike the CLR, the CBD has been the limiting factor in growing coffee in UM1. The current findings evidently indicated that CBD, which is commonly found in UM1, has now spread and is becoming a problem in both UM2 and UM3. The CLR has also changed its spread from UM3 and has become common in both UM1 and UM2. The incidences of CBD have earlier been reported to have decreased in the higher altitude plantations with that of CLR increasing [5].

The two diseases were prevalent or rampant in all the coffee growing agro ecological zones, a situation that has increased the cost of coffee production as farmers have to control them through fungicide spraying to evade crop losses. Such a situation requires intervention by making the farmers aware of

the coffee diseases that are shifting to agro-ecological zones where they never used to occur. Farmers when equipped with this information will be able to strategize on how to combat the diseases. For instance, in Kenya farmers may either plant the resistant coffee varieties such as Ruiru 11 (released in 1985) or Batian (released in 2010) from Coffee Research Foundation.

Coffee farming as established in this study is compounded by numerous disease constraints and appropriate remedies require to be designed. The trend where Ruiru 11 is only grown by 22% of farmers as compared to 41% growing SLs if reversed will contribute significantly towards the management of CBD and CLR.

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