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**Discovery Agriculture**

# Assessment of current phytosanitary status and farmer practices on the control of insect pests and diseases of Robusta coffee (*Coffea canephora* Pierre) in Tanganyika sector, Eastern Democratic Republic of Congo (DRC)

**Shomari Kiete[1,2]*, Adrien Byamungu Ndeko[3], Espoir Bisimwa Basengere[3,4], Obedi Nyamangyoku Ishibwela[1,4]**

**To Cite:**
Kiete S, Ndeko AB, Basengere EB, Ishibwela ON. Assessment of current phytosanitary status and farmer practices on the control of insect pests and diseases of Robusta coffee (*Coffea canephora* Pierre) in Tanganyika sector, Eastern Democratic Republic of Congo (DRC). *Discovery Agriculture* 2026; 12: e4da3181
doi:

**Author Affiliation:**
[1]Faculty of Agriculture and Environmental Sciences, Université Espoir du Congo, Baraka, Sud-Kivu, Democratic Republic of Congo (DRC)
[2]Department of Environment and Natural Resource Management, Institut Supérieur de Développement Rural de Fizi, Baraka, Democratic Republic of Congo (DRC)
[3]Faculty of Agriculture and Environmental Sciences, Université Evangélique en Afrique, Bukavu, Sud-Kivu, Democratic Republic of Congo (DRC)
[4]Faculty of Agriculture and Environmental Sciences, Université Catholique de Bukavu, Bukavu, Sud-Kivu, Democratic Republic of Congo (DRC)

***Corresponding author:**
Shomari Kiete,
Faculty of Agriculture and Environmental Sciences, Université Espoir du Congo, Baraka, Sud-Kivu, Democratic Republic of Congo (DRC)
Email: shomari.xavier@uec.ac.cd, https://orcid.org/0000-0002-5244-2295

**Peer-Review History**
Received: 25 May 2025
Reviewed & Revised: 18/June2025 to 12/January/2026
Accepted: 27 January 2026
Published: 16 February 2026

**Peer-Review Model**
External peer-review was done through double-blind method.

Discovery Agriculture
pISSN 2347-3819; eISSN 2347-386X



DISCOVERY SCIENTIFIC SOCIETY

## ABSTRACT

After oil, Coffee is the most important agricultural commodity upon which more than 125 million people in 70 countries, including DRC, are dependent for their economy, especially foreign exchange earnings. Coffee crop is facing numerous constraints, including pests and diseases, price volatility, plantation ageing, etc. The study assessed current coffee field health status and farmers' knowledge of pest and disease management in the Tanganyika sector. A survey was conducted using a mixed questionnaire and field observations to collect data on coffee pests and diseases from 12 randomly selected plants along two intersectional diagonals in each inspected field. Results revealed the following disease incidence levels: coffee leaf rust (30.7%), anthracnose (25.6%), die-back (11.5%), Fusariosis (7.1%), leaf blight (6.3%), and Cercosporiosis (1.7%) as the most frequent diseases. Disease severity, considering moderate, intense and severe attacks, respectively, was as follows: rust (32.1%, 39.1% and 9.2%), anthracnose (32.9%, 25.7% and 12.3%), die-back (10.2%, 7.1% and 1.0%), and Fusariosis (16.4% and 5.1% for moderate and intense attacks). Cropping systems had a highly significant effect on disease incidence and severity ($P < 0.0005$), with older plantations (45–60 years) and the Babungwe Nord group being the most heavily infested and damaged. Coffee grown as a pure stand was more severely affected than coffee under intercropping systems. Regarding insect pests, the coffee berry borer (21.3%), ants (19.9%), fruit flies (18.1%), and thrips (16.4%) were the most prevalent, followed by defoliating and mining caterpillars, A. orbitaliss, stem borers, and the coffee berry moth. In terms of severity, the most damaging pests were the coffee berry borer (21.5%, 29.6% and 6.2%), fruit flies (11.2%, 29.8% and 5.1%), thrips (31.2% and 6.2%), and stem borers (9.2%, 9.2% and 1.0%), followed by defoliating and mining caterpillars, A. orbitaliss, the coffee berry moth and stink bugs. Marked variations were observed amongst groupings and plantation age, whereas cropping systems had no significant effect on pest severity in most cases ($P > 0.05$). Farmers demonstrate limited knowledge of coffee pests and diseases and rely on inadequate practices for their control. Such a gap leads to lower productivity and poverty exacerbation amongst coffee farmers from Fizi in the Eastern DRC.

**Keywords:** Pest Status, Farmer skills, Pest and Diseases, Pest management, Robusta coffee, Tanganyika, Fizi, Democratic Republic of Congo

# 1. INTRODUCTION

Coffee production represents a major economic stake for more than 25 million farms in approximately 70 producing countries across humid tropical and intertropical ecosystems. For many decades, Coffee stands as the world's second-largest commodity in terms of trade after oil, sustaining the livelihoods of around 125 million people active in its value chain worldwide (ICO, 2015; 2024). Coffee farming is mainly traditional and highly labour-intensive, particularly during harvesting, which accounts for the largest share of production costs (CIRAD, 2003b). In the small-scale farms, the work is executed by family manpower, whereas larger holdings rely on hired workers who may be recruited from distant areas. Entire populations therefore depend on coffee in producing regions (CIRAD, 2007; Hindorf and Omondi, 2011; Kalonji-Mbuyi et al., 2009). Approximately, 25 million smallholders in developing countries account for more than 70% of global coffee production and bear the heaviest burden of these constraints (Rutherford and Phiri, 2006).

From Kenya to Côte d'Ivoire, via the DRC, coffee production is a cash crop for more than 80% of smallholders contributing to the household subsistence, income generation, and poverty alleviation. In the DRC, average yields remain low compared with the African mean: approximately 485 kg $ha^{-1}$ for Robusta and 600 kg $ha^{-1}$ for Arabica, whereas the production potential of available plant material is estimated at 1,000–1,200 kg $ha^{-1}$ (Downie et al., 2018; Bamenga-Bopoko et al., 2025). The trend reflects a critical low level of agricultural intensification. Improving average yields, therefore, constitutes one of the key avenues for increasing production and improve coffee-dependent households' livelihoods (CIRAD, 2003a; Kucel et al., 2010).

In the DRC, agro-industrial plantations and fields (coffee, cocoa, oil palm, etc.) are installed in zones with favourable edaphic and climatic conditions (Bwiza et al. 2024). Coffee (both arabica and robusta) cover a cumulated acreage of 157,950 hectares informally employing more than 15,000 small-scale farmers and dependents. In 2023, DRC's exportation volume decreased from 10,424 tons in 2022 to 7,380 tons due to war in the most producing areas of Ituri, South and North Kivu. Shockingly, Congolese coffee farm workers perceive nearly 2$ (lower than the poverty threshold), a poor pay according to the standard measure of poverty and lower than the DRC's standard minimum wage as per law (Downie et al., 2018; Binwa et al., 2023). By way of illustration, average production in 2001 was estimated at 39,000 tonnes of coffee (80% Robusta) (Bedimo et al., 2008). Coffee and oil palm currently represent the principal agricultural export commodities (over 50% of local agricultural export value) of the Tanganyika sector, with a smuggling market oriented towards Burundi and Rwanda (Asa, 2010; Binwa et al., 2023).

The primary characteristic of village-level coffee farming is the small size of planted areas, almost always below 5 ha and, in East Africa, rarely exceeding 0.5 hectares. Coffee complements subsistence crops and enables farmers to meet other household needs (Pinard, 2007). Du Thai (2002) states that in Viet Nam, monoculture also known as **sun coffee** can exceed 5 t/ha of yields, in stark contrast to the majority of African smallholder coffee systems, where weakened coffee trees on small plots compete with food crops. These systems are typically extensive, with yields at or below 500 kg/ha of green coffee, whether under monocropping or intercropping (Rubabura et al., 2015).

Under monocropping, coffee trees are more susceptible to severe pest and disease attacks since coffee is a preferred host species, compared to intercropping systems in which coffee benefits ecologically from associated species that provide passive protection (Rutherford and Phiri, 2006). In Uganda, Kenya and northern Tanzania, sun coffee is particularly affected by berry anthracnose, die-back and the coffee berry borer, whereas the presence of agroforestry species providing shade in Brazil reduces borer incidence by nearly half (Bieysse et al., 1999; Kucel et al., 2010; Adong et al., 2024, Sunguti et al., 2024). Excess soil moisture associated with excessive shade from banana intercropped with coffee promotes the spread of defoliating caterpillars, rust, root rots, and anthracnose in southern Cameroon and Central African Republic (Bieysse et al., 2002). Inversely, the beneficial coffee–cocoa association in Côte d'Ivoire, where inter-rows are occupied by seasonal grain grasses at lower altitude, constitutes a barrier to invasion by numerous leaf mining and defoliating caterpillars (DaMatta, 2004; ICO, 2015).

Most previous research has focused on production and marketing aspects, with a few anglings on the element of coffee pathologies in Fizi Territory. Thus, to improve coffee farming along the Tanganyika lakeshore, and to promote diversified food production through intercropping food crops with coffee, it is essential to understand the prevailing cropping systems and/or coffee diseases, their incidence and severity, to identify solutions and assess current farmers' knowledge of pest management, thereby initiating the revitalisation of the coffee local industry in Fizi.

Currently, coffee growers in Tanganyika face numerous challenges. Some are intrinsic constraints including limited knowledge of coffee pests and diseases, reliance on inappropriate control practices, resistance to innovation and new technologies, and poverty. Extrinsic constraints include low levels of sectoral mechanisation, climate change threats, high production costs, and volatile coffee prices, and access to innovation, difficulties in accessing credit and certification schemes (organic, eco-friendly coffee, etc.), limited dissemination of improved and productive varieties, declining soil fertility under continuous cultivation, price volatility, increasingly irregular rainfall due to climate change, and, above all, pests and diseases.

Basing on the above backdrop, we therefore conducted a study along a lowland in Tanganyika sector in the Eastern DRC from June to August 2024 to determine (i) the most occurrent and damaging insect pests and diseases influencing the production of *C. robusta*, (ii) the control measures employed by small-scale farmers to address these biotic challenges that are likely to become a threat to Robusta coffee production under the future climate change scenarios. The study provides an information and a prerequisite for developing sustainable pest and disease control strategies as well as making decisions for the rational and evidenced management practices.

## 2. MATERIALS AND METHODS

### 2.1. *Study Area*

The study area comprised three groupings (Babungwe Nord, Balala Nord, and Basimukuma Nord) within the Tanganyika sector (4°05′38″ S and 29°04′58″ E, 1,200 m a.s.l.) (Msambya, 2011). Fizi Territory encompasses a wide diversity of eco-climatic zones highly favourable to agriculture and livestock production, particularly with the rainy season extends over more than nine months. Fizi Territory possesses the largest wetland potential in South Kivu Province, with wetlands covering 48% of the province. These humid lands benefit from sedimentary deposits from a dense hydrographic network, resulting in alluvial soils rich in organic matter, suitable for sustainable agriculture. Soils in the Tanganyika sector are diverse, comprising clay-loam soils in the highlands and fine sandy alluvium in the lowland coastal areas along Lake Tanganyika. Humus-rich alluvial soils are found in the valleys of Kenya Bay, Kabondozi and Nundu. The climate is highly variable, with a mean annual temperature of 20–25°C and annual thermal amplitudes of approximately 2–6°C. Annual rainfall ranges from 1,000 to 1,800 mm depending on altitude and climate with eight humid months, one semi-humid month and three dry months (June, July and August) (Mishima, 2009; Asa, 2010; Kwetu et al., 2016).

### 2.2. *Sampling and Data Collection*

Phytosanitary survey was conducted in the three groupings of the Tanganyika sector. The identification of coffee plantations was performed thank to the key baseline set by Asa (2010), indicating that the sector comprises approximately a hundred of unorganised coffee growers, complemented by direct field observations. Insect pest and disease symptoms were assessed through visual diagnosis. Photography facilitated image storage and the analysis of visible signs and symptoms correlated with potential causal agents through a meticulous comparison. These observations were combined with an exploratory survey to identify the most occurring and damaging insect pest and diseases within the circumscribed survey sites. Identification was carried out using the diagnostic key of Autrique and Perreaux (1989), followed by careful examination to match images and symptoms with their respective causal agents.

Farm sampling was elaborated using a proportion-based sampling technique to determine sample size and ensure valid analyses. Sample size was calculated using the following parameters:

$$n_o = \frac{Z_{\propto}^2 \, Pq}{e^2}$$

- **Z:** standard value associated with the required confidence level (95% → 1.96);
- **n:** sample size;
- **P:** proportion of individuals exhibiting the studied characteristic, here the proportion of coffee farmers (0.8 or 80%);
- **q:** proportion of individuals not exhibiting the characteristic (1 − P = 0.2);
- **$e^2$:** desired margin of error (5%; e = 0.05; $e^2$ = 0.0025)
- $e$ = 0,05 → $e^2$ = 0025 P = 0,8 ~ 80% $q$ = (1-p) = (1-0,8) = 0,2

- $n_0 = \frac{(1{,}96)^2 \times 0{,}8\ (1-0{,}8)}{0{,}00625} = \frac{0{,}614656}{0{,}00625} = 98{,}34\ \approx 98\ individus.$

### 2.3. *Determination of Disease and Pest Incidence and Severity*

Incidence and severity of diseases and insect pests were assessed on 12 randomly selected plants along two intersectional diagonals in each inspected field, allowing extrapolation to the entire field and estimation of the number of affected coffee plants.

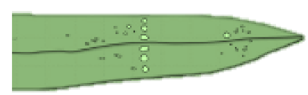
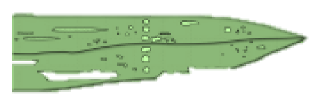
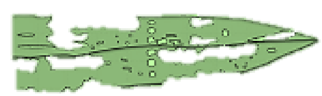
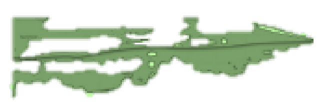
Insect pest incidence (I) was calculated as the number of infested plants divided by the total number of plants assessed (1,176 plants in this study), multiplied by 100, using the formula:

$$I = \frac{\sum_{t-1}^{n} Pt}{N} \times 100$$

where $Pt$ stands for the number of infested plants during the study period and $N$ the total number of plants assessed along the diagonals (Bigirimana et al., 2012, Nsambu et al., 2014).

Mean severity was calculated as the sum of the products of observed frequencies at each rating level divided by the total number of symptomatic plants. Disease and pest severity scales, developed by Davis et al., (1992) then by IITA and standardised by CIAT in 2005 for cassava, were adapted to coffee and ranged from 1 to 5 (Table 1):

**Table 1**. Scale of damage severity of coffee insect pests and diseases

| Scale | Description of the simplified model | Visual aspects | Response |
|---|---|---|---|
| 1 | no visible symptom or damage (no damage) |  | Highly Resistant |
| 2 | *light damage*: symptoms present on less than 25% of leaves and/or stems |  | Moderately Resistant |
| 3 | *moderate damage*: symptoms present on 25% to 50% of leaves and/or stems |  | Sensitive |
| 4 | *intense damage*: symptoms present on 50 to 80% of leaves and/or stems |  | Moderately Sensitive |
| 5 | *severe damage*: symptoms present on more than 80% of leaves and/or stems |  | Highly Sensitive |

Adapted from Davies's scale: (Bigirimana et al., 2012; Toepfer et al., 2021; Ojuumola et al., 2022).

### 2.4. *Data Analysis*

Disease and pest incidence and severity data were analysed and mean values compared using analysis of variance (ANOVA) at the 0.05 significance level using XLSTAT version 2024.04 on data entered in Microsoft Excel 2010. Means were separated using Fisher's Least Significant Difference (LSD) test and the Chi-square ($\chi^2$) test to assess relationships between severity levels and cropping systems.

## 3. RESULTS

### 3.1. Characterisation of the surveyed farms and coffee growers

The table 2 shows that coffee farming in the Tanganyika sector is predominantly managed by older farmers (55.2 ± 10.2). The household size average is six members (6.6 ± 1.9), only about two to three individuals per household are engaged in coffee-related activities (2.8 ± 1.3). Smallholder coffee production is practiced on tiny plots, averaging barely one hectare, with a mean area under coffee of 1.03 ± 0.4 ha. Most smallholder coffee farms in Tanganyika were planted more than 45 years ago, with a mean plantation age of 46.3 ± 7.2 years, and regeneration pruning is realised at an interval of nearly five years (5.8 ± 1.6).

**Table 2**: Characterisation of coffee farming in Tanganyika

| Variables | Grouping | | | Total Mean |
|---|---|---|---|---|
| | Babungwe Nord | Balala Nord | Basimikuma Nord | |
| Age | 56,2 ± 8,8 | 54,1 ± 10,5 | 55,4 ± 11,2 | 55,2 ± 10,2 |
| Household size | 6,6 ± 2,1 | 6,8 ± 1,7 | 6,5 ± 2,1 | 6,6 ± 1,9 |
| Family man-power | 2,9 ± 1,4 | 2,8 ± 1,3 | 2,6 ± 1,1 | 2,8 ± 1,3 |
| Field surface (ha) | 1,3 ± 0,5 | 0,9 ± 0,3 | 0,9 ± 0,5 | 1,03 ± 0,4 |
| Age of plantation | 47,4 ± 6,9 | 45,7 ± 6,4 | 45,7 ± 8,1 | 46,3 ± 7,2 |
| Regenerative Interval | 5,4 ± 1,3 | 5,6 ± 1,3 | 6,3 ± 2,0 | 5,8 ± 1,6 |

**A. Characterisation of Coffee Plantations**

The current ownership status of coffee fields is largely the result of inheritance (48.9%), which substantially reduces the level of interest and investment in coffee cultivation among current occupants (Table 3). Only a limited proportion of fields remain in the hands of those who initially established them (27.5%). Coffee plantations are predominantly managed under monocropping systems (53.06%), which prevail over intercropping systems (46.94%). In intercropped coffee systems, coffee is mainly associated with oil palm (18.4%) or with wild species (14.3%) that grow spontaneously within coffee fields and provide shade. Most existing plantations were established using seedlings obtained from neighbouring fields (91.8%). Upkeeping operations are primarily limited to land clearing, weeding, field sanitation and pruning. The most frequently practised pruning regimes include upkeeping and regeneration pruning (67.4%), as well as maintenance pruning combined with formative and regeneration pruning (16.3%).

**Table 3**: Characterisation of coffee plantations in Tanganyika

| Variables | Groupings | | | | | | Total Means | |
|---|---|---|---|---|---|---|---|---|
| | Babungwe Nord | | Balala Nord | | Basimikuma Nord | | | |
| | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| **Plot acquisition mode** | | | | | | | | |
| Purchase | 9 | 28,1 | 3 | 9,09 | 4,00 | 12,12 | 16 | 16,3 |
| Donation | 0 | 0,00 | 1 | 3,03 | 1,00 | 3,03 | 2 | 2,04 |
| Inheritance | 16 | 50,0 | 14 | 42,42 | 18,00 | 54,55 | 48 | 48,9 |
| Lease | 0 | 0,00 | 3 | 9,09 | 2,00 | 6,06 | 5 | 5,10 |
| Plantation | 7 | 21,9 | 12 | 36,36 | 8,00 | 24,24 | 27 | 27,5 |
| **Cropping Systems** | | | | | | | | |
| Intercropping | 21 | 65,6 | 14 | 42,42 | 11 | 33,33 | 46 | 46,9 |
| Monoculture | 11 | 34,4 | 19 | 57,58 | 22 | 66,67 | 52 | 53,1 |
| **Type of association** | | | | | | | | |
| Coffee-Palm | 9 | 28,3 | 5 | 15,15 | 4 | 12,12 | 18 | 18,4 |
| Coffee-Palm-Pineapple | 6 | 18,8 | 0 | 0,00 | 0 | 0,00 | 6 | 6,12 |
| Coffee-Palm-Banana | 2 | 6,25 | 1 | 3,03 | 4 | 12,12 | 7 | 7,14 |
| Coffee-Palm-Wild tree | 3 | 9,38 | 8 | 24,24 | 3 | 9,09 | 14 | 14,3 |
| Coffee-Palm-orchard | 1 | 3,13 | 0 | 0,00 | 0 | 0,00 | 1 | 1,02 |
| **Origin of the seedlings** | | | | | | | | |
| Settler fields | 8 | 25,0 | 0 | 0,00 | 0 | 0,00 | 8 | 8,16 |
| Neighbour fields | 24 | 75,0 | 33 | 100 | 33 | 100 | 90 | 91,8 |
| **Type of pruning** | | | | | | | | |
| Maintenance-Regener | 19 | 59,4 | 22 | 66,67 | 25 | 75,76 | 66 | 67,4 |
| Maint-Fruit-Regener | r3 | 9,38 | 5 | 15,15 | 3 | 9,09 | 11 | 11,2 |
| Maint-Form-Regener | 5 | 15,6 | 6 | 18,18 | 5 | 15,15 | 16 | 16,3 |
| Null | 5 | 15,6 | 0 | 0,00 | 0 | 0,00 | 5 | 5,10 |

**B. Productivity of coffee plantations in Tanganyika**

The table 4 depicts that the highest planting densities were recorded in the Balala Nord grouping (2,330 ± 401.2 plants ha$^{-1}$), with each plant producing on an average less than 1 kg (0.58 ± 0.33 kg). Mean yields per hectare remain low overall (489.6 ± 47.6 kg ha$^{-1}$). Nevertheless, Balala Nord exhibited stronger performance, both in terms of gross production (402.2 ± 44.2 kg ha$^{-1}$) and the quantity of coffee obtained after de-parchment (327.6 ± 9.8 kg), followed by Basimukuma Nord, with respective values of 323.2 ± 51.2 and 244.9 ± 10.6 kg.

**Table 4**: Productivity of coffee plantations in Tanganyika

| Yield variables | Groupings | | | Total Mean |
|---|---|---|---|---|
| | Babungwe Nord | Balala Nord | Basimukuma Nord | |
| Planting density (plant/ha) | 2 235 ± 453,4 | 2330 ± 401,7 | 2 194 ± 507,9 | 2 253 ± 454 |
| Yield per plant (kg) | 0,53 ± 0,37 | 0,60 ± 0,33 | 0,61 ± 0,28 | 0,58 ± 0,33 |
| Yield per hectare (kg/ha) | 138,8 ± 47,4 | 402 ± 44,2 | 323,2 ± 51,2 | 489,6 ± 47,6 |
| Processed yield | 95,9 ± 7,8 | 327,6 ± 9,8 | 244,9 ± 10,6 | 286,8 ± 9,4 |
| Quantity sold (kg) | 102,3 ± 5,5 | 310,6 ± 4,2 | 236,1 ± 7,3 | 252,9 ± 5,6 |
| Sale Price (USD) | 0,71 ± 0,09 | 0,77 ± 0,06 | 0,65 ± 0,06 | 0,71 ± 0,07 |

**C. Productivity as per pruning type**

A careful examination of the table 5 reveals a marked variation in yield per plant and per hectare according to pruning type. The combined application of maintenance, formative and regeneration pruning resulted in the highest yields, with mean values of 0.763 ± 0.31 kg per plant and 470.2 ± 39.7 kg ha$^{-1}$, respectively. In the second position comes the combination of maintenance and regeneration pruning (0.603 ± 0.322 kg per plant and 443.2 ± 40.7 kg ha$^{-1}$). In contrast, fields that did not undergo any pruning exhibited the lowest yields, averaging 0.230 ± 0.09 kg per plant and 291.5 ± 41.6 kg ha$^{-1}$.

**Table 5**. Productivity according to pruning type

| Variables | Types of pruning | | | |
|---|---|---|---|---|
| | Maint-Regener | Maint-Fruit-Regener | Maint-Form-Regen | Null |
| Yield per plant | 0,603 ± 0,322 | 0,484 ± 0,34 | 0,763 ± 0,31 | 0,230 ± 0,09 |
| Yield per ha (Kg) | 443,2 ± 40,7 | 310,1 ± 44,38 | 470,2 ± 39,7 | 291,5 ± 41,6 |

**D. Productivity of coffee as per intercropping components**

The table 6 indicates that planting densities are highest in fields where coffee plants are associated exclusively with oil palm, as well as in systems where wild species grow spontaneously within the coffee plantations. Excluding monocropping systems, which recorded the highest production levels (342 ± 19.1 kg ha$^{-1}$), coffee–oil palm associations achieved higher yields (334.3 ± 8.0 kg ha$^{-1}$) than other intercropping configurations, followed closely by the coffee–oil palm–banana association (302.9 ± 61.0 kg ha$^{-1}$).

**Table 6**. Productivity according to cropping association type

| Variables | Type of intercropping | | | | | |
|---|---|---|---|---|---|---|
| | Caf-Pal | Caf-Pa-An | Caf-Pal-Ba | Caf-Pa-Svg | Caf-Pa-Vr | Monoc |
| Yield per plant | 0,3 ± 0,1 | 0,22 ± 0,3 | 0,37 ± 0,2 | 0,32 ± 0,1 | 0,25 ± 0,0 | 0,81 ± 0,3 |
| Yield/ha (Kg) | 334,3 ± 43 | 116,1 ± 27,6 | 301,9 ± 41,0 | 221,7 ± 50,7 | 162,8 ± 39,2 | 342 ± 29,1 |
| Plant density | 1,804 ± 62 | 1,680 ± 81,3 | 1,720 ± 89,4 | 2,009 ± 42,4 | 1,519 ± 88,7 | 2,443 ± 56,1 |
| Product/SC | 358,6 ± 58 | 171,8 ± 35,2 | 320,9 ± 69,4 | 205,7 ± 33,3 | 625,0 ± 0,00 | 351,9 ± 12,9 |

### 3.2. Incidence and severity of diseases and pests in coffee plantations of Tanganyika

**A. Incidence of pests and diseases in coffee plantations as per groupings**

The results in table 7 highlight the most prevalent diseases, coffee leaf rust (29.9 ± 11.7) and anthracnose (25.8 ± 13.7), Fusariosis (7.1 ± 2.8), with Cercosporiosis showing the lowest incidence (1.7 ± 0.13). In terms of spatial distribution within the study area, the Babungwe Nord grouping exhibited the highest incidence for all recorded diseases: anthracnose (28.1 ± 15.9), rust (32.3 ± 8.7), Fusariosis (15.4 ± 6.1), and Cercosporiosis (3.1 ± 1.5). Regarding the insect pests, the coffee berry borer showed the highest incidence, with a mean value (21.5 ± 6.5), Babungwe Nord being the most affected grouping (22.6 ± 8.8), followed by Basimukuma Nord (21.3 ± 3.4) and Balala Nord (20.7 ± 7.3). Red ants (*Azteca instabilis*), thrips (*Hoplandothrips marshalli*) and fruit flies (*Ceratitis coffeae*) also exhibited high incidence levels.

**Table 7**. Incidence of pests and diseases in the three groupings of the Tanganyika sector

| Variables | Groupings | | | Total Mean |
|---|---|---|---|---|
| | Babungwe Nord | Balala Nord | Basimikuma Nord | |
| **Insect pests** | | | | |
| Coffee Berry Moth | 4,4 ± 0,78 | 0,0 ± 0,0 | 6,5 ± 2,02 | 4,6 ± 0,9 |
| *Ceratitis coffeae* | 20,1 ± 14,9 | 20,7 ± 15,5 | 13,4 ± 15,3 | 18,1 ± 15,4 |
| *Epicampoptera* | 14,8 ± 10,1 | 11,8 ± 11,4 | 13,8 ± 11,2 | 13,2 ± 10,9 |
| *Antestiopsis orbitalis* | 4,4 ± 0,78 | 7,5 ± 3,3 | 0,00 ± 0,00 | 4,1 ± 1,3 |
| *Azteca instabilis* | 20,5 ± 5,01 | 19,5 ± 7,61 | 19,9 ± 5,8 | 19,9 ± 6,5 |
| *Diarthrothrips coffeae* | 20,1 ± 5,21 | 13,9 ± 5,21 | 15,4 ± 6,6 | 16,4 ± 4,5 |
| *Habrochila* | 11,8 ± 7,51 | 11,8 ± 7,82 | 8,9 ± 4,04 | 10,9 ± 6,5 |
| Coffee Berry Borer | 22,6 ± 8,80 | 20,7 ± 7,31 | 21,3 ± 3,4 | 21,5 ± 6,5 |
| Coffee Stem Borer | 9,2 ± 4,7 | 6,3 ± 2,3 | 9,3 ± 5,1 | 8,3 ± 3,9 |
| *Leucoptera sp.* | 12,2 ± 2,31 | 12,8 ± 1,66 | 13,8 ± 1,7 | 13,0 ± 1,8 |
| **Diseases** | | | | |
| Coffee Berry Disease | 28,1 ± 15,9 | 25,5 ± 13,3 | 23,9 ± 11,9 | 25,8 ± 13,7 |
| Coffee Leaf Rust | 32,3 ± 8,72 | 29,0 ± 13,5 | 28,5 ± 12,3 | 29,9 ± 11,7 |
| Coffee Wilt Disease | 15,4 ± 6,13 | 1,5 ± 1,1 | 4,8 ± 0,4 | 7,1 ± 2,8 |
| Cercosporiosis | 3,1 ± 1,5 | 0,0 ± 0,0 | 2,3 ± 0,2 | 1,7 ± 0,13 |
| **Non-parasitic diseases** | | | | |
| Coffee Leaf Blight | 9,8 ± 6,5 | 0,00 ± 0,00 | 9,3 ± 1,4 | 6,3 ± 2,3 |
| Die-back | 16,6 ± 9,9 | 0,00 ± 0,00 | 11,4 ± 9,3 | 9,3 ± 6,4 |

**B. Severity of diseases and pests in the Tanganyika groupings**

Fungal diseases, namely Coffee Leaf Rust and Anthracnose, constitute two main constraints affecting coffee plants to varying degrees (Table 8). Coffee leaf rust was the most recurrent disease 4 (38.7%) inflicting intense attacks. In terms of spatial distribution, Coffee Leaf Rust caused intense damage in the Babungwe Nord grouping, where severity class 4 reached 46.8%. Anthracnose ranked at the second position, with attack levels ranging from severe, class 4 (26.5%) to moderate class 3 (32.6%). Amongst insect pests, the coffee berry borer inflicted the most damaging attacks on coffee plants, with severity ranging from intense (29.6%) to moderate (21.5%). Basimukuma Nord was the most affected grouping (36.4%), followed by Balala Nord (33.3%) and Babungwe Nord (18.7%). In addition, the fruit fly (*Ceratitis coffeae*) caused intense attacks (30.6%). Marked spatial variation in fruit fly incidence and severity were observed, with Balala Nord (39.4%), Basimukuma Nord (27.3%) and Babungwe Nord (25.0%).

C. **Insect Pest and Disease Incidence as per Cropping Systems**

The coffee leaf rust occurred in poorly upkept coffee plantations associated with orchards (41.7 ± 0.0), pineapple (37.5 ± 4.2) and banana (26.2 ± 5.3); (Table 9). Anthracnose also occurred with high incidence (25.8 ± 13.7), with coffee–pineapple associations being the most affected (41.7 ± 4.8), followed by coffee–orchard (25.0 ± 0.0). Cercosporiosis (13.9 ± 10.0) and Fusariosis (26.4 ± 5.7) were more pronounced in coffee plantations hosting pineapple. Concerning non-parasitic diseases, findings show that leaf blight showed high incidence intercropping coffee-orchards (41.7 ± 0.0) and pineapple (26.4 ± 5.7), while die-back was particularly severe in coffee plantations where the understorey was occupied by pineapple (36.1 ± 15.0). The coffee berry borer was the most damaging pest, exhibiting by far the highest incidence compared with other pests, except ants. Coffee-palm-pineapple associations were the most favourable to the coffee berry borer (43.1 ± 8.9), followed by coffee-palm-orchard systems (25.0 ± 0.0) and coffee-palm-wild vegetation associations (23.8 ± 13.0).

**Table 8**. Severity of diseases and pests as per groupings

| Variables | Severity Scale | Groupings | | | | | | Total Mean | |
|---|---|---|---|---|---|---|---|---|---|
| | | Babungwe Nord | | Balala Nord | | Basimikuma Nord | | | |
| | | Frequency | % | Frequency | % | Frequency | % | Frequency | % |
| Leaf rust | 1 | 0 | 0,00 | 3 | 9,1 | 2 | 6,1 | 5 | 5,1 |
| | 2 | 2 | 6,2 | 5 | 15,2 | 7 | 21,2 | 14 | 14,3 |
| | 3 | 11 | 34,4 | 9 | 27,3 | 11 | 33,3 | 31 | 31,6 |
| | 4 | 15 | 46,8 | 12 | 36,4 | 11 | 33,3 | 38 | 38,7 |
| | 5 | 4 | 12,5 | 4 | 12,1 | 2 | 6,1 | 10 | 10,2 |
| Fusariosis | 1 | 15 | 46,8 | 31 | 93,9 | 27 | 81,8 | 73 | 74,5 |
| | 2 | 2 | 6,2 | 1 | 3,0 | 0 | 0,0 | 3 | 3,1 |
| | 3 | 11 | 34,3 | 1 | 3,0 | 4 | 12,1 | 16 | 16,3 |
| | 4 | 4 | 12,5 | 0 | 0,0 | 2 | 6,1 | 6 | 6,1 |
| Anthracnosis | 1 | 6 | 18,7 | 6 | 18,2 | 5 | 15,2 | 17 | 17,3 |
| | 2 | 7 | 21,8 | 1 | 3,0 | 3 | 9,1 | 11 | 11,2 |
| | 3 | 6 | 18,7 | 13 | 39,4 | 13 | 39,4 | 32 | 32,6 |
| | 4 | 8 | 25,0 | 8 | 24,2 | 10 | 30,3 | 26 | 26,5 |
| | 5 | 5 | 15,6 | 5 | 15,2 | 2 | 6,1 | 12 | 12,2 |
| Die-back | 1 | 22 | 68,7 | 33 | 100 | 19 | 57,5 | 74 | 75,5 |
| | 2 | 2 | 6,3 | 0 | 0,0 | 4 | 12,1 | 6 | 6,1 |
| | 3 | 4 | 12,5 | 0 | 0,0 | 6 | 18,2 | 10 | 10,2 |
| | 4 | 3 | 9,4 | 0 | 0,0 | 4 | 12,1 | 7 | 7,1 |
| | 5 | 1 | 3,1 | 0 | 0,0 | 0 | 0,0 | 1 | 1,0 |
| Cercosporiosis | 1 | 27 | 84,3 | 33 | 100 | 30 | 90,9 | 90 | 91,8 |
| | 2 | 2 | 6,3 | 0 | 0,0 | 1 | 3,0 | 3 | 3,1 |
| | 3 | 3 | 9,4 | 0 | 0,0 | 2 | 6,1 | 5 | 5,1 |
| Blight | 1 | 18 | 56,3 | 28 | 84,8 | 29 | 87,8 | 75 | 76,5 |
| | 2 | 6 | 18,7 | 2 | 6,1 | 1 | 3,0 | 9 | 9,2 |
| | 3 | 4 | 12,5 | 2 | 6,1 | 3 | 9,1 | 9 | 9,2 |
| | 4 | 4 | 12,5 | 1 | 3,0 | 0 | 0,0 | 5 | 5,1 |
| Bark beetles | 1 | 14 | 43,8 | 11 | 33,3 | 8 | 24,2 | 33 | 33,6 |
| | 2 | 2 | 6,3 | 2 | 6,1 | 6 | 18,2 | 10 | 10,2 |
| | 3 | 7 | 21,8 | 7 | 21,2 | 7 | 21,2 | 21 | 21,5 |
| | 4 | 6 | 18,7 | 11 | 33,3 | 12 | 36,4 | 29 | 29,6 |
| | 5 | 3 | 9,4 | 2 | 6,1 | 0 | 0,0 | 5 | 5,1 |
| Thrips | 1 | 9 | 28,1 | 17 | 51,5 | 11 | 34,4 | 37 | 38,1 |
| | 2 | 11 | 34,4 | 3 | 9,1 | 9 | 28,1 | 23 | 23,7 |
| | 3 | 12 | 37,5 | 10 | 30,3 | 9 | 28,1 | 31 | 31,9 |
| | 4 | 0 | 0,0 | 3 | 9,1 | 3 | 9,4 | 6 | 6,2 |
| Habrochila | 1 | 27 | 81,8 | 22 | 66,7 | 22 | 68,7 | 71 | 72,4 |
| | 2 | 3 | 9,1 | 7 | 21,2 | 6 | 18,7 | 16 | 16,3 |
| | 3 | 3 | 9,1 | 4 | 12,1 | 4 | 12,5 | 11 | 11,2 |
| Fruit flies | 1 | 12 | 37,5 | 12 | 36,4 | 19 | 57,6 | 43 | 43,8 |
| | 2 | 3 | 9,4 | 4 | 12,1 | 3 | 9,1 | 10 | 10,2 |
| | 3 | 7 | 21,8 | 2 | 6,1 | 2 | 6,1 | 11 | 11,2 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 4 | 8 | 25,0 | 13 | 39,4 | 9 | 27,3 | 30 | 30,6 |
| | 5 | 2 | 6,1 | 2 | 6,1 | 0 | 0,0 | 4 | 4,1 |
| Epicampoptera | 1 | 9 | 28,1 | 15 | 45,5 | 13 | 39,4 | 37 | 37,7 |
| | 2 | 11 | 34,4 | 11 | 33,3 | 6 | 18,2 | 28 | 28,6 |
| | 3 | 11 | 34,4 | 6 | 18,2 | 10 | 30,3 | 27 | 27,5 |
| | 4 | 1 | 3,1 | 1 | 3,0 | 4 | 12,1 | 6 | 6,1 |
| Coffee Leaf Miner Worm | 1 | 15 | 46,8 | 14 | 42,4 | 13 | 39,4 | 42 | 42,9 |
| | 2 | 3 | 9,4 | 7 | 21,2 | 11 | 33,3 | 21 | 21,4 |
| | 3 | 11 | 34,4 | 10 | 30,3 | 7 | 21,2 | 28 | 28,5 |
| | 4 | 3 | 9,4 | 2 | 6,1 | 2 | 6,1 | 7 | 7,1 |
| Coffee Berry moths | 1 | 31 | 96,8 | 33 | 100 | 30 | 90,9 | 94 | 95,9 |
| | 2 | 0 | 0,0 | 0 | 0,0 | 2 | 6,1 | 2 | 2,0 |
| | 3 | 1 | 3,1 | 0 | 0,0 | 1 | 3,0 | 2 | 2,0 |
| *Antestiopsis orbitalis* | 1 | 31 | 96,8 | 28 | 84,8 | 33 | 100 | 92 | 93,8 |
| | 2 | 0 | 0,0 | 3 | 9,1 | 0 | 0,0 | 3 | 3,1 |
| | 3 | 1 | 3,1 | 2 | 6,1 | 0 | 0,0 | 3 | 3,1 |
| Red Ants (*Azteca instabilis*) | 1 | 25 | 78,1 | 29 | 87,8 | 25 | 75,7 | 79 | 80,6 |
| | 2 | 5 | 15,6 | 3 | 9,1 | 1 | 3,0 | 9 | 9,2 |
| | 3 | 2 | 6,3 | 1 | 3,0 | 6 | 18,2 | 9 | 9,2 |
| | 4 | 0 | 0,0 | 0 | 0,0 | 1 | 3,0 | 1 | 1,0 |

**Table 9**. Incidence of insect pest and diseases as per cropping systems and responses to crop associations

| Variables | Applied Cropping Systems | | | | | | ANOVA | | |
|---|---|---|---|---|---|---|---|---|---|
| | Coffee-Palm | Coff-Pal-Pin | Coff-Pal-Ban | Coff-Pal-Wild | Coff-Pal-Orch | Monocult | **F** | **P-Value** | **Sign** |
| **Diseases** | | | | | | | | | |
| Anthracnose | 14,8 ± 9,8a | 41,7 ± 4,8c | 19,0 ± 3,1ab | 23,8 ± 9,4ab | 25,0 ± 0,0abc | 29,3 ± 8,4bc | 6,3199 | 0,0001 | HS |
| Leaf rust | 23,1 ± 4,4a | 37,5 ± 4,2 b | 26,2 ± 5,3ab | 22,0 ± 10,7a | 41,7 ± 0,0b | 33,8 ± 9,0b | 5,5089 | 0,0002 | HS |
| Cercosporiosis | 0,0 ± 0,0a | 13,9 ± 10b | 0,0 ± 0,0a | 0,0 ± 0,0a | 0,0 ± 0,0a | 6,2 ± 1,8a | 7,0168 | 0,0001 | HS |
| Fusariosis | 12,0 ± 4,5a | 29 ± 14,2b | 10,7 ± 3,1a | 3,0 ± 0,7a | 0,0 ± 0,0a | 8,7 ± 3,7a | 6,7974 | 0,0001 | HS |
| Die-back | 7,9 ± 2,8a | 36,1 ± 15b | 9,5 ± 1,3a | 5,8 ± 2,4a | 0,0 ± 0,0a | 9,7 ± 5,0a | 12,607 | 0,0001 | HS |
| Leaf Blight | 11,6 ± 4,7b | 26,4 ± 5,7c | 2,4 ± 5,8a | 0,0 ± 0,0a | 41,7 ± 0,0c | 7,8 ± 3,0a | 13,115 | 0,0001 | HS |
| **Insect pests** | | | | | | | | | |
| Coffee Berry Borer | 13,0 ± 6,0a | 43,1 ± 8,9b | 17,9 ± 9,3a | 23,8 ± 13ab | 25,0 ± 0,0ab | 20,8 ± 6,1a | 3,5778 | 0,0053 | S |
| Habrochila | 7,9 ± 2,8a | 22,2 ± 5,5b | 11,9 ± 4,0ab | 8,7 ± 3,6a | 0,0 ± 0,0a | 10,0 ± 6,1a | 4,0855 | 0,0021 | S |
| Fruit Flies | 13,4 ± 4,7a | 31,9 ± 3,1a | 13,1 ± 5,3a | 22,6 ± 4,5a | 0,0 ± 0,0a | 17,7 ± 5,3a | 2,0655 | 0,0768 | NS |
| Thrips | 19,9 ± 9.1 ab | 30,6 ± 9,0b | 26,2 ± 12b | 11,9 ± 9,2a | 33,3 ± 0,0 b | 13,1 ± 8,6 a | 3,4284 | 0,0069 | S |
| Coffee Berry Moth | 0,0 ± 0,0a | 0,0 ± 0,0a | 3,6 ± 1,7a | 0,0 ± 0,0a | 0,0 ± 0,0a | 1,3 ± 0,3a | 0,8280 | 0,5330 | NS |
| Red Ants | 21,8 ± 4,9a | 16,7 ± 0,0a | 20,2 ± 4,1a | 22,0 ± 8,1a | 25,0 ± 0,0a | 21,0 ± 6,8a | 0,7440 | 0,5925 | NS |
| Epicampoptera | 14,4 ± 9,5a | 18,1 ± 8,9a | 10,7 ± 9,7a | 13,1 ± 10a | 16,7 ± 0,0a | 12,5 ± 8,6a | 0,4019 | 0,8463 | NS |
| *A. orbitalis* | 3,8 ± 0,9a | 0,0 ± 0,0a | 0,0 ± 0,0a | 0,0 ± 0,0a | 0,0 ± 0,0a | 6,5 ± 2,1 a | 0,6092 | 0,6930 | NS |
| Coffee Leafminer | 8,8 ± 5,2a | 23,6 ± 6,2c | 9,5 ± 5,3a | 16,1 ± 5,7b | 0,0 ± 0,0a | 13,1 ± 6,6b | 2,0988 | 0,0725 | NS |
| Coffee Stem Borer | 8,8 ± 1,2 b | 0,0 ± 0,0 a | 3,6 ± 1,7 ab | 6,4 ± 1,8b | 25 ± 4,6c | 7,3 ± 3,4b | 3,4078 | 0,0072 | S |

*Values followed by same letters within same column do not differ significantly at P ≤ 0.05; mean values were separated using Fisher's Least Significant Difference (LSD) test.*

Attacks attributable to leaf-rolling thrips were recorded with high incidence in systems where coffee was associated with the oil palm and orchard species (33.3 ± 0.0%), followed by coffee–oil palm–pineapple intercrops (30.6 ± 9.0%), and coffee grown under banana plantations (26.2 ± 12.0%). Fruit flies were most prevalent in coffee farms associated with pineapple (31.9 ± 3.1%) and in coffee–oil palm–wild vegetation systems (22.6 ± 4.5%). Ants showed a marked preference for orchard-based systems, with higher incidences observed in coffee–orchard associations (25.0 ± 0.0%), compared with other systems, although these differences were not statistically pronounced. Comparative analysis of all cropping associations indicates that monoculture systems are generally more vulnerable to pest and disease pressure than mixed cropping systems. For coffee leaf rust, mean incidence values were higher in monoculture than intercropping system (33.8 ± 9.0% vs 28.5 ± 4.9%). A similar pattern was observed for anthracnose (29.3 ± 8.4% vs 25.8 ± 13.7%).

Conversely, higher incidences of leaf blight (16.4 ± 3.2% vs 7.8 ± 3.8%), thrips (24.3 ± 7.8% vs 13.1 ± 6.6%), and coffee berry borer (24.5 ± 7.4% vs 20.0 ± 6.1%) were recorded in intercropping systems.

### D. Severity of Coffee Diseases and Pests as per Cropping Association Type

The table 10 highlights the prevalence of various coffee diseases and pests in Tanganyika, indicating that coffee leaf rust is by far the most severe disease, causing increasingly intense (39.2%) and moderate (31.9%) attacks on coffee plants. Differences were remarked across cropping systems: monoculture plantations were the most exposed to severe attacks (26.8%), meanwhile coffee–oil palm associations experienced severe (5.2%) and intense (7.2%) attacks.

Coffee berry anthracnose was the second most devastating disease, responsible for severe (25.7%) and intense (32.9%) attacks. Sun coffee (monoculture systems) was subjected to intense (16.4%), moderate (13.4%), and severe (10.3%) attacks. Coffee–palm–wild associations suffered from moderate attacks (9.2%), followed by coffee-palm associations, which were susceptible to moderate (7.2%) and light (6.2%) attacks.

**Table 10**: Damage score for insect pests and diseases as per cropping system

| Variables | Severity Score | Type of cropping systems | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Cof-Pal | C-P-A | C-P-B | C-P-S | C-P-V | Monoc | % | P-value | Sign |
| Coffee Leaf Rust | 1 | 0,0000 | 0,0000 | 0,0000 | 2,0619 | 0,0000 | 3,0928 | 5,1546 | 0,0082 | Yes |
| | 2 | 6,1856 | 0,0000 | 2,0619 | 3,0928 | 0,0000 | 3,0928 | 14,4330 | | |
| | 3 | 7,2165 | 0,0000 | 2,0619 | 7,2165 | 1,0309 | 14,4330 | 31,9588 | | |
| | 4 | 5,1546 | 3,0928 | 2,0619 | 2,0619 | 0,0000 | 26,8041 | 39,1753 | | |
| | 5 | 0,0000 | 3,0928 | 1,0309 | 0,0000 | 0,0000 | 5,1546 | 9,2784 | | |
| Anthracnose | 1 | 5,1546 | 0,0000 | 2,0619 | 1,0309 | 0,0000 | 9,2784 | 17,5258 | 0,0051 | Yes |
| | 2 | 6,1856 | 0,0000 | 0,0000 | 2,0619 | 0,0000 | 3,0928 | 11,3402 | | |
| | 3 | 7,2165 | 1,0309 | 2,0619 | 9,2784 | 0,0000 | 13,4021 | 32,9897 | | |
| | 4 | 0,0000 | 3,0928 | 3,0928 | 2,0619 | 1,0309 | 16,4948 | 25,7732 | | |
| | 5 | 0,0000 | 2,0619 | 0,0000 | 0,0000 | 0,0000 | 10,3093 | 12,3711 | | |
| Fusariosis | 1 | 10,309 | 1,0309 | 4,1237 | 13,402 | 1,0309 | 45,3608 | 75,2577 | < 0,001 | Yes |
| | 2 | 2,0619 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 1,0309 | 3,0928 | | |
| | 3 | 6,1856 | 1,0309 | 3,0928 | 1,0309 | 0,0000 | 5,1546 | 16,4948 | | |
| | 4 | 0,0000 | 4,1237 | 0,0000 | 0,0000 | 0,0000 | 1,0309 | 5,1546 | | |
| Cercosporiosis | 1 | 18,3673 | 2,0408 | 7,1429 | 14,2857 | 1,0204 | 48,9796 | 91,8367 | 0,0002 | Yes |
| | 2 | 0,0000 | 2,0408 | 0,0000 | 0,0000 | 0,0000 | 1,0204 | 3,0612 | | |
| | 3 | 0,0000 | 2,0408 | 0,0000 | 0,0000 | 0,0000 | 3,0612 | 5,1020 | | |
| Fruit Flies | 1 | 10,3 | 1,03 | 4,12 | 5,15 | 1,03 | 22,6 | 44,32 | 0,5571 | No |
| | 2 | 0,00 | 1,03 | 0,00 | 1,03 | 0,00 | 8,24 | 10,30 | | |
| | 3 | 3,09 | 2,06 | 1,03 | 0,00 | 0,00 | 5,15 | 11,34 | | |
| | 4 | 5,15 | 1,03 | 2,06 | 7,21 | 0,00 | 14,4 | 29,89 | | |
| | 5 | 0,00 | 1,03 | 0,00 | 1,03 | 0,00 | 2,06 | 4,12 | | |
| Coffee Berry Moth | 1 | 10,3 | 6,18 | 6,1856 | 13,4021 | 0,0000 | 44,329 | 80,41 | 0,0020 | Yes |
| | 2 | 4,12 | 0,00 | 0,0000 | 1,0309 | 1,0309 | 3,0928 | 9,27 | | |
| | 3 | 4,12 | 0,00 | 0,0000 | 0,0000 | 0,0000 | 5,1546 | 9,27 | | |
| | 4 | 0,00 | 0,00 | 1,0309 | 0,0000 | 0,0000 | 0,0000 | 1,03 | | |
| Coffee Berry Borer | 1 | 10,3093 | 1,0309 | 2,0619 | 3,0928 | 0,0000 | 16,4948 | 32,9897 | 0,0210 | Yes |
| | 2 | 2,0619 | 0,0000 | 1,0309 | 1,0309 | 1,0309 | 5,1546 | 10,3093 | | |
| | 3 | 2,0619 | 3,0928 | 0,0000 | 5,1546 | 0,0000 | 11,3402 | 21,6495 | | |
| | 4 | 4,1237 | 0,0000 | 4,1237 | 5,1546 | 0,0000 | 16,4948 | 29,8969 | | |
| | 5 | 0,0000 | 2,0619 | 0,0000 | 0,0000 | 0,0000 | 3,0928 | 5,1546 | | |
| Die-back | 1 | 16,326 | 0,0000 | 4,0816 | 12,244 | 1,0204 | 41,836 | 75,510 | < 0,001 | Yes |
| | 2 | 1,0204 | 0,0000 | 3,0612 | 1,0204 | 0,0000 | 1,0204 | 6,1224 | | |
| | 3 | 1,0204 | 2,0408 | 0,0000 | 1,0204 | 0,0000 | 6,1224 | 10,204 | | |
| | 4 | 0,0000 | 3,0612 | 0,0000 | 0,0000 | 0,0000 | 4,0816 | 7,1429 | | |
| Leaf Blight | 1 | 10,3093 | 0,0000 | 6,1856 | 14,433 | 0,0000 | 45,360 | 76,288 | < 0,001 | Yes |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 1,0309 | 2,0619 | 1,0309 | 0,0000 | 0,0000 | 5,1546 | 9,2784 | | |
| | 3 | 6,1856 | 0,0000 | 0,0000 | 0,0000 | 1,0309 | 2,0619 | 9,2784 | | |
| | 4 | 1,0309 | 4,1237 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 5,1546 | | |
| Epicampoptera | 1 | 5,1020 | 1,0204 | 3,0612 | 5,1020 | 0,0000 | 23,4694 | 37,7551 | 0,4125 | No |
| | 2 | 3,0612 | 3,0612 | 1,0204 | 7,1429 | 1,0204 | 13,2653 | 28,5714 | | |
| | 3 | 8,1633 | 2,0408 | 2,0408 | 1,0204 | 0,0000 | 14,2857 | 27,5510 | | |
| | 4 | 2,0408 | 0,0000 | 1,0204 | 1,0204 | 0,0000 | 2,0408 | 6,1224 | | |
| Coffee Leafminer | 1 | 10,2041 | 1,0204 | 4,0816 | 4,0816 | 1,0204 | 22,4490 | 42,8571 | 0,1000 | No |
| | 2 | 1,0204 | 0,0000 | 1,0204 | 6,1224 | 0,0000 | 13,2653 | 21,4286 | | |
| | 3 | 4,0816 | 5,1020 | 1,0204 | 4,0816 | 0,0000 | 14,2857 | 28,5714 | | |
| | 4 | 3,0612 | 0,0000 | 1,0204 | 0,0000 | 0,0000 | 3,0612 | 7,1429 | | |
| Thrips | 1 | 4,1237 | 1,0309 | 1,0309 | 6,1856 | 0,0000 | 25,7732 | 38,1443 | 0,0081 | Yes |
| | 2 | 7,2165 | 3,0928 | 2,0619 | 1,0309 | 0,0000 | 10,3093 | 23,7113 | | |
| | 3 | 7,2165 | 2,0619 | 1,0309 | 6,1856 | 1,0309 | 14,4330 | 31,9588 | | |
| | 4 | 0,0000 | 0,0000 | 3,0928 | 1,0309 | 0,0000 | 2,0619 | 6,1856 | | |
| Antestiopsis | 1 | 17,5258 | 6,1856 | 7,2165 | 14,4330 | 1,0309 | 47,4227 | 93,8144 | 0,0053 | Yes |
| | 2 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 3,0928 | 3,0928 | | |
| | 3 | 1,0309 | 0,0000 | 0,0000 | 0,0000 | 0,0000 | 2,0619 | 3,0928 | | |

**E. Incidence of Diseases and Pests by Plantation Age**

The results presented in the table 11 indicate that plantation age had a little influence on the incidence and severity of the diseases and pests at P = 0.05, except in isolated cases such as A. orbitalis (P = 0.0007), stem borers (P = 0.0007), and ants (P = 0.0285). Based on the mean incidence values for each disease and pest, it is noteworthy that leaf rust and anthracnose are the most frequent diseases: leaf rust (29.9 ± 13.5) and anthracnose (25.9 ± 10.8), with varying degrees of occurrence depending on whether the plantation is young or old. Older plantations (45–60 years) were the most susceptible.

Regarding insect pests, the most frequent are coffee berry borers (21.3 ± 6.4), ants (19.9 ± 5.8), fruit flies (18.1 ± 5.4), and thrips (16.4 ± 4.5). These are key phytosanitary threats requiring particular attention due to their high incidence and the extent of damage they cause. Their prevalence is facilitated by the weakened aerial organs of older coffee plants (45–60 years), which develop fewer defence mechanisms. Therefore, disease and pest incidence increase as well as the age of plantation increases, the older the coffee, the most susceptible it becomes.

**Table 11**. Incidence of Diseases and Pests as per plantation age

| Variables | Age range (years) | | | ANOVA | |
|---|---|---|---|---|---|
| | 10 - 30 | 30 – 45 | 45 - 60 | F | P-value |
| **Diseases** | | | | | |
| Coffee Leaf Rust | 27,1 ± 12,6 a | 31,3 ± 18,5 a | 31,5 ± 9,4 a | 0,5 | 0,5241 |
| Anthracnosis | 26,7 ± 14,8 a | 24,1 ± 12,7 b | 29,2 ± 4,8 a | 0,5 | 0,5723 |
| Die-back | 5,2 ± 1,3 d | 5,2 ± 2,6 de | 8,3 ± 4,4 e | 0,9 | 0,4113 |
| Fusariosis | 9,4 ± 2,8 cd | 5,8 ± 1,3 de | 6,2 ± 3,9 e | 0,3 | 0,6762 |
| Leaf Blight | 12,7 ± 4,2 c | 7,8 ± 3,0 d | 14,6 ± 3,2 c | 2,7 | 0,0501 |
| Cercosporiosis | 0,0 ± 0,0 e | 0,0 ± 0,0 e | 5,1 ± 0,3 e | 2,9 | 0,0502 |
| **Insect pests** | | | | | |
| Coffee Berry Borer | 20,8 ± 7,3 ab | 19,3 ± 7,6bc | 23,8 ± 4,4 b | 0,8 | 0,4321 |
| Red Ants | 19,1 ± 6,3 ab | 18,4 ± 6,4bc | 22,2 ± 4,8 b | 3,7 | 0,0202 |
| Fruit Flies | 14,6 ± 7,2 c | 17,6 ± 6,5bc | 18,5 ± 4,9 bc | 0,1 | 0,8192 |
| Thrips | 12,5 ± 6,0 c | 18,2 ± 3,0 bc | 25,0 ± 6,7 ab | 2,5 | 0,0876 |
| *E. marantica* | 13,2 ± 4,7 c | 13,2 ± 5,0 c | 13,5 ± 4,1 a | 0,4 | 0,6903 |
| Coffee Leafminer | 12,4 ± 1,8 c | 13,7 ± 2,0 c | 16,7 ± 1,8 c | 0,3 | 0,7723 |
| *Habrochila* | 11,7 ± 2,8 c | 9,2 ± 3,9 d | 10,4 ± 2,5cd | 1,6 | 0,1124 |

| | | | | | |
|---|---|---|---|---|---|
| Coffee Stem Borer | 4,1 ± 1,2 d | 9,0 ± 4,9 d | 12,3 ± 5,8cd | 7,9 | 0,0007 |
| Coffee Berry Moth | 0,0 ± 0,0 e | 2,8 ± 0,5 e | 5,6 ± 1,3 e | 0,4 | 0,6906 |
| *A. orbitalis* | 5,0 ± 1,1 d | 2,8 ± 0,5 e | 8,4 ± 2,5 e | 0,7 | 0,0007 |

*Values followed by the same letters within a column are not significantly different at P ≤ 0.05; means were separated using Fisher's Least Significant Difference (LSD) test.*

F. **Severity of diseases and pests as per coffee plantation age**

The susceptibility of coffee plantations to pests and diseases varies considerably with age. All plantations surveyed in this study were over 25 years old, as previously noted, which predisposes them to a wide range of pests and diseases (Table 12).

When classified per age, medium-aged plantations (30–45 years) experienced: (i) **Severe attacks**: leaf rust (20.6%) and coffee berry borer (15.5%); (ii) **Intense attacks**: anthracnose (10.3%), fruit fly (29.3%), coffee berry borer (13.4%), rust (20.6%) and anthracnose (10.3%), and (iii) **Moderate attacks**: anthracnose (10.3%), ants (15.5%), *Epicampoptera* (10.2%), thrips (10.3%), leaf-mining caterpillars (9.18%), fruit flies, coffee berry borers and rust (9.27% each). Older plantations (45–60 years) were more severely affected, with anthracnose (7.21%), rust (5.2%), and fruit flies (4.1%) causing the most severe damage. Moderate attacks in these older plantations were caused by ants (32.9%), rust (21.6%), thrips (20.6%), leaf-mining caterpillars (18.4%), *Epicampoptera* (17.3%), anthracnose (14.4%), coffee berry borer (10.3%), Fusariosis (8.24%), fruit flies (8.24%), borers (8.2%), leaf scorch (7.2%) and die-back (6.1%).

**Table 12**. Severity of Diseases according to Coffee Plantation Age in Tanganyika

| Variables | Severity Score | Age range | | | P-value |
|---|---|---|---|---|---|
| | | 10 - 30 years | 30 to 45 years | 45 - 60 years | |
| Anthracnose | 1 | 0,0000 | 6,1856 | 11,3402 | **0,9435** |
| | 2 | 1,0309 | 4,1237 | 6,1856 | |
| | 3 | 2,0619 | 10,3093 | 20,6186 | |
| | 4 | 1,0309 | 10,3093 | 14,4330 | |
| | 5 | 0,0000 | 5,1546 | 7,2165 | |
| Coffee Leaf Rust | 1 | 0,0000 | 1,0309 | 4,1237 | **0,9034** |
| | 2 | 1,0309 | 5,1546 | 8,2474 | |
| | 3 | 1,0309 | 9,2784 | 21,6495 | |
| | 4 | 2,0619 | 16,4948 | 4,1237 | |
| | 5 | 0,0000 | 20,6186 | 5,1546 | |
| Cercosporiosis | 1 | 4,0816 | 36,7347 | 51,0204 | **0,1986** |
| | 2 | 0,0000 | 0,0000 | 3,0612 | |
| | 3 | 0,0000 | 0,0000 | 5,1020 | |
| Fusariosis | 1 | 3,0928 | 27,8351 | 44,3299 | **0,6449** |
| | 2 | 0,0000 | 1,0309 | 2,0619 | |
| | 3 | 1,0309 | 7,2165 | 8,2474 | |
| | 4 | 0,0000 | 0,0000 | 5,1546 | |
| Coffee Berry Borer | 1 | 1,0309 | 8,2474 | 23,7113 | **0,6361** |
| | 2 | 0,0000 | 3,0928 | 7,2165 | |
| | 3 | 2,0619 | 9,2784 | 10,3093 | |
| | 4 | 1,0309 | 13,4021 | 2,0619 | |
| | 5 | 0,0000 | 15,4639 | 3,0928 | |
| Flies | 1 | 2,0619 | 17,5258 | 24,7423 | **0,4946** |
| | 2 | 0,0000 | 6,1856 | 4,1237 | |
| | 3 | 0,0000 | 3,0928 | 8,2474 | |
| | 4 | 2,0619 | 9,2784 | 18,5567 | |
| | 5 | 0,0000 | 0,0000 | 4,1237 | |

| | | | | | |
|---|---|---|---|---|---|
| Coffee Berry Moth | 1 | 4,0816 | 35,7143 | 56,1224 | **0,8078** |
| | 2 | 0,0000 | 1,0204 | 1,0204 | |
| | 3 | 0,0000 | 0,0000 | 2,0408 | |
| Antestiopsis | 1 | 2,0619 | 35,0515 | 56,7010 | **0,0053** |
| | 2 | 1,0309 | 1,0309 | 1,0309 | |
| | 3 | 1,0309 | 0,0000 | 2,0619 | |
| Leafminer worm | 1 | 1,0204 | 15,3061 | 26,5306 | **0,7786** |
| | 2 | 1,0204 | 9,1837 | 11,2245 | |
| | 3 | 1,0204 | 9,1837 | 18,3673 | |
| | 4 | 1,0204 | 3,0612 | 3,0612 | |
| Thrips | 1 | 1,0309 | 19,5876 | 17,5258 | **0,0079** |
| | 2 | 1,0309 | 2,0619 | 20,6186 | |
| | 3 | 1,0309 | 10,3093 | 20,6186 | |
| | 4 | 1,0309 | 4,1237 | 1,0309 | |
| Ants | 1 | 1,0309 | 19,5876 | 24,7423 | **0,1801** |
| | 2 | 2,0619 | 15,4639 | 32,9897 | |
| | 3 | 1,0309 | 1,0309 | 2,0619 | |
| Epicampoptera | 1 | 3,0612 | 12,2449 | 22,4490 | **0,4873** |
| | 2 | 1,0204 | 13,2653 | 14,2857 | |
| | 3 | 0,0000 | 10,2041 | 17,3469 | |
| | 4 | 0,0000 | 1,0204 | 5,1020 | |
| Leaf Blight | 1 | 2,0619 | 30,9278 | 43,2990 | **0,1349** |
| | 2 | 0,0000 | 4,1237 | 5,1546 | |
| | 3 | 1,0309 | 1,0309 | 7,2165 | |
| | 4 | 1,0309 | 0,0000 | 4,1237 | |
| Die-back | 1 | 3,0612 | 25,5102 | 46,9388 | **0,3717** |
| | 2 | 1,0204 | 4,0816 | 1,0204 | |
| | 3 | 0,0000 | 4,0816 | 6,1224 | |
| | 4 | 0,0000 | 2,0408 | 5,1020 | |
| | 5 | 0,0000 | 1,0204 | 0,0000 | |

### 3.3. Farmers' Perception of Coffee Diseases and Pests

In response to the escalating damage caused by pests, many farmers opt to abandon coffee cultivation in favour of food crops or oil palm, with pest management interventions often considered only as a secondary measure. Traditional control methods commonly involve preparations made from neem (*Azadirachta indica* A. Juss) leaves and bark powder, mixed with tobacco leaves and washing soap (Kifebe). This mixture is set to ferment for 24 hours before application, typically by spraying, at volumes of 100 L per acre. Farmers consider this treatment both effective and persistent, generally applying it twice annually. Smoke from dry and fresh leaves of *Cymbopogon citratus* and *Chrysanthemum cinerariefolium* burnt under the coffee shadow, and ash are additionally employed to repel ants, which hinder harvesting activities through their stings.

Where chemical control is ultimate solution and economically affordable, farmers recourse to synthetic phytosanitary products as an ultimate measure. Commonly used insecticides include Fenitrothion 1000, an organophosphate applied at 800 mL–1 L/ha, as well as Rocket 44 EC (Profenofos 40% + Cypermethrin 4% EC), and Calypso P 440 EC (100 mL/ha). These products have proven efficacy, and farmers who demonstrate proper application techniques typically acquired that skill through formal training, such as that provided by UGEAFI in 2010. Coffee farmers generally initiate control measures as soon as a few plants exhibit visible symptoms of disease, without distinguishing between insect pests and fungal pathogens. In practice, the insecticides previously cited are used indiscriminately as the primary control option, regardless of the causal agent. The decision to intervene is therefore not based on an established economic threshold or pest-specific diagnosis, but rather on the visual appearance of damage on individual coffee plants.

Data presented in the table 13 indicate that, in the face of increasing pest pressure, many coffee growers in the Tanganyika sector prioritise crop abandonment over active pest management. Coffee plantations are frequently replaced by food crops or oil palm, which are perceived as more profitable, resilient, and sustainable. Pest control thus becomes a secondary consideration, and farmers often adopt a passive attitude, observing the progressive decline of coffee plants before ultimately abandoning the crop.

**Table 13.** Farmers' Perception of Coffee Diseases and Pests in Tanganyika

| Variables | Groupings | | | | | | Total frequency | |
|---|---|---|---|---|---|---|---|---|
| | Babungwe Nord | | Balala Nord | | Basimukuma Nord | | | |
| | Frequency | (%) | Frequency | (%) | Frequency | (%) | Frequency | (%) |
| **Controlling measures** | | | | | | | | |
| *Abandon-observing* | 23 | 71,9 | 11 | 33,3 | 14 | 42,4 | 58 | 59,2 |
| *Control* | 8 | 25,0 | 20 | 60,6 | 18 | 54,5 | 46 | 46,9 |
| *Replant-Regenerate* | 1 | 3,1 | 2 | 6,1 | 1 | 3,0 | 4 | 4,1 |
| **Products** | | | | | | | | |
| Pesticides | 7 | 21,9 | 9 | 27,3 | 13 | 39,4 | 29 | 29,6 |
| Smoke-Ash-Sand | 25 | 78,1 | 24 | 72,7 | 20 | 60,6 | 69 | 70,4 |
| **Local availability of phytosanitary products** | | | | | | | | |
| Inexistence | 22 | 68,8 | 13 | 39,4 | 15 | 45,5 | 50 | 51,0 |
| Insufficiency | 0 | 0,0 | 2 | 6,1 | 0 | 0,0 | 2 | 2,0 |
| Sufficiency | 10 | 31,2 | 18 | 54,5 | 18 | 54,5 | 46 | 46,9 |
| **Farmers' Perception of the Cost of Phytosanitary Products** | | | | | | | | |
| Null (Inexistence) | 22 | 68,8 | 13 | 39,4 | 15 | 45,5 | 50 | 51,0 |
| Affordable | 5 | 15,6 | 7 | 21,2 | 14 | 42,4 | 26 | 26,5 |
| Expensive | 5 | 15,6 | 13 | 39,4 | 4 | 12,2 | 22 | 22,4 |
| **Effectiveness of Handling and Use of These Products** | | | | | | | | |
| Null (Inexistence) | 22 | 68,8 | 12 | 36,4 | 15 | 45,5 | 49 | 50,0 |
| No | 0 | 0,0 | 5 | 15,2 | 4 | 12,1 | 9 | 9,2 |
| Yes | 10 | 31,3 | 16 | 48,5 | 14 | 42,4 | 40 | 40,8 |
| **Efficacy of phytosanitary products** | | | | | | | | |
| Non-St | 0 | 0,0 | 1 | 3,0 | 1 | 3,0 | 2 | 2,04 |
| Satisfying | 10 | 31,3 | 19 | 57,6 | 17 | 51,5 | 46 | 46,9 |
| **Threshold** | | | | | | | | |
| Half-field attacked | 4 | 40,0 | 8 | 36,4 | 2 | 10,5 | 14 | 27,5 |
| Some plant damage | 6 | 60,0 | 12 | 54,5 | 16 | 84,2 | 34 | 66,7 |
| **Utilization of plant extracts** | | | | | | | | |
| No | 28 | 87,6 | 30 | 90,9 | 23 | 69,7 | 81 | 82,7 |
| Yes | 4 | 12,5 | 3 | 9,1 | 10 | 30,3 | 17 | 17,3 |
| **Interval between two interventions** | | | | | | | | |
| 6 months | 4 | 12,5 | 7 | 21,2 | 11 | 33,3 | 22 | 22,4 |
| 12 months | 0 | 0,0 | 11 | 33,3 | 1 | 3,0 | 12 | 12,2 |
| **Application status** | | | | | | | | |
| Liquid | 4 | 100 | 3 | 100 | 10 | 100 | 17 | 100 |
| Solid | 0 | 0,0 | 0 | 0,0 | 0 | 0,0 | 0 | 0,00 |
| **Doses** | | | | | | | | |
| A (1 - 10L) | 0 | 0,0 | 0 | 0,0 | 0 | 0,0 | 0 | 0,00 |
| B (10 - 100L) | 4 | 100 | 3 | 100 | 10 | 100 | 17 | 100 |
| C (>100L) | 0 | 0,0 | 0 | 0,0 | 0 | 0,0 | 0 | 0,00 |

# 4. DISCUSSION

The study findings indicate that all severity and incidence are highly correlated to the age, maintenance operations, and farmer awareness on pests and diseases. In Tanganyika, coffee plantations are over 25 years old, with an average age of 46 years. A similar result was found in Rwanda by Deraeck (2011) and in North Kabare, DRC by Nsambu et al. (2014), where the average age is 57 years. In the Tanganyika sector, coffee is cultivated in monoculture (53.06%), as it is in Vietnam (Du Thai, 2002) and in Brazil, the world's largest coffee producers, where coffee is grown in pure stand, with shade cultivation having been almost completely abandoned or intercropped (46.94%) with oil palm or banana (DaMatta, 2004; Volsi 2019). Similar association systems have been reported in Rwanda (Bigirimana et al., 2012); Mexico (Ubertino, 2015); Ethiopia (Hindorf and Omondi, 2011); Kenya, and Uganda (Matovu et al., 2013). According to Rubabura et al. (2015), the small size of plots dedicated to coffee remains the main characteristic of smallholder coffee farms (less than 5 hectares in all coffee-producing regions). For example, in Uganda, Robusta coffee is grown on small plots averaging 0.36 ha and Arabica on 0.23 ha (Matovu et al., 2013). In Tanganyika sector, the average plot size is (1.03 ± 0.4) ha, and the average production per tree is 0.58 ± 0.33 kg, whereas (Pinard, 2007, Rubabura et al., 2015) report that small-scale coffee producers in Kenya achieve an average production of 2.8 kg/tree/year.

Monoculture in Tanganyika exerted higher production performance (324 ± 29.1 kg/ha) as compared to intercrop. According to Bieysse et al. (1999); Durand (2014); Kimani et al. (2002), the yield reduction in intercropping is associated with: (i) low carbon assimilation under excessive shading, (ii) increased vegetative stimulus to the detriment of floral bud formation, and (iii) low formation of floral nodes per branch and floral buds at the node insertion. Recent studies conducted in Cameroon (Bieysse et al., 2002) and Côte d'Ivoire (CEDEAO-OCDE, 2007) showed that disease proliferation in mixed cultivation is slow. The reasons for this slower spread are the reduced air circulation due to the foliage of the shade tree canopy, the limited penetration of sunlight, which dries out the spores of rust-causing fungi, and the diminished splash effect of raindrops which facilitates disseminating the pests (DaMatta, 2004; Azeez, 2025).

The results of this study demonstrate that rust is indisputably the most prevalent disease (30.7%), followed by anthracnose (25.6%), leaf blight (14.9%), die-back (11.5%), Fusariosis (10.6%), and Cercosporiosis (3.4%). Such results are almost similar to those found by (Nsambu et al., 2015) in North Kabare, with minor difference being that anthracnose ranked first (33%), followed by rust (30%), then Cercosporiosis (22%), and finally die-back (15%).

Regarding coffee insect pests, the various devastating species are present at proportionally different incidence rates. The coffee berry borer is the most recurrent pest (23.9%), followed by the leaf-rolling thrips (22.5%), red ants (21.1%), fruit flies (16.5%), defoliating caterpillars (14.25%), leaf-mining caterpillars (11.9%), A. orbitaliss (10.1%), the stem borer (8.5%), the shield bug (1.7%), and finally the coffee husk borer (0.8%). These results are not contradictory to those of (Mugo et al., 2011; Nsambu et al., 2015). Comparing groupings, the Babungwe grouping is the most affected, which is due to the poor maintenance state of the fields, followed by the Balala North and Basimukuma North groupings; while in different cropping systems, for certain pests and diseases such as rust, the berry borer, thrips, die-back, and leaf blight, the Coffee-Palm-Pineapple and Coffee-Palm-Wild undergrowth associations are the most affected.

Following the 2012 rust epidemic which reached regional proportions in South America, Avelino et al. (2015) note that shading was proposed as a means to slow the dispersion of orange rust spores and thus the disease between plots, landscapes, and countries. Studies conducted in Kenya and Ethiopia by Hindorf and Omondi (2011) show that the berry borer and anthracnose are the two significant pests affecting coffee in Eastern Africa. This is consistent with the results found in this study, where berry borer and anthracnose cause significant damage in coffee plantations regardless of the cropping system in place.

In Africa, the coffee berry borer is perceived as the most dangerous pest and a serious handicap to the African coffee industry, with high prevalence. In Kenya, for example, infestations reaching 80% during the most unfavourable dry season, causing yield and quality losses, have been recorded. Severe attacks can affect over 80% of attacked depressed berries in Uganda (Matovu et al., 2013), Ghana (Wongnaa et al., 2021), and 96% in DRC (Kalonji-Mbuyi et al., 2009) and Tanzania (Otieno et al., 2019).

In 2006, Rutherford (2006), Mendesil et al. (2012) demonstrated that Fusariosis, coffee leaf rust and Anthracnose are the three major coffee pests in Africa, a hypothesis endorsed by Matovu et al. (2013), both accounting for over 80% losses in coffee yield and quality losses of marketable coffee in Ethiopia and Uganda, the top two African coffee producers, with acute damages in Tanzania (Otieno et al., 2021). Coffee monoculture is a victim of these two diseases, as are the intercropping considered in this study (Zeru et al., 2009). We emphasise that in certain circumstances, the cropping system had a very significant influence ($P=0.05$) on the incidence and severity of diseases, specifically in the cases of anthracnose ($P=0.0051$), Cercosporiosis ($P<0.0002$), Fusariosis ($P<0.0001$), and coffee leaf rust

(P=0.0082). However, for most insect pests, the effect of the cropping system was almost negligible: fruit flies (P=0.55) (Bote and Struik, 2011; Azeez, 2025).

Fusariosis or Coffee Wilt Disease (7.1%) and Cercosporiosis are the two other severe fungal diseases. The former, as shown by Rutherford (2006), has caused considerable production losses in Africa since 1927 but was quickly curbed by the use of resistant varieties and phytosanitary measures. Estimates from 1987 show that incidence was 19% in coffee-producing areas; only two years after, it reached 30%, mainly in the Haut-Uélé district (Kalonji-Mbuyi et al., 2009; Bamenga-Bopoko et al., 2025). The re-emergence of CWD in 1990 on Robusta in the DRC as reported by (Kalonji-Mbuyi et al., 2009) led to heavy losses, as the disease is reported with high incidence; for example, in Isiro, in the mid-1990s, 90% of plantations were affected, Mambasa (36%), Poko (34%), Bafwasende (28%), Opala (29%) and Banalia (27%), while in Yangambi the disease was not reported. Cercosporiosis is present in associated cultivation with low incidence and non-negligible severity in southern Cameroon and Central African Republic (Bieysse et al., 2002; Bamenga-Bopoko et al., 2025).

Coffee farmers in Fizi territory have limited knowledge of diseases and control methods. Faced with the unbearable damage inflicted by these pests on coffee, the idea of abandoning cultivation comes first. The use of phytosanitary products is a practice still seeking its right place in the stronghold of Tanganyika coffee growers, unlike the results found in Kabare by Rubabura et al. (2015) and Bamenga-Bopoko et al. (2025) which reveal that farmers resort to pesticides and plant products with phytopharmaceutical properties that they use effectively and lead to potential substantial growth (Downie, 2018). The few practices employed include ash and smoke from a fire lit at the foot of a tree hosting a large population of ants (*Azteca instabilis*) and plant extracts of Cymbopogon and chrysanthemum, such practices are widely populated in India (Samy, 2018), where neem and chinaberry-like species are used as a sustainable control measures. Only two insecticides are used in the fight against coffee pathogens, whereas in Kenya, Ethiopia, and Uganda, more than 13 pesticides are easily accessible to farmers (Azeez, 2025).

## 5. CONCLUSION

This study, which focused on assessing the phytosanitary status and farmer knowledge in the fight against coffee diseases and pests, found that epidemiological studies in cash crops are rare. It reveals that unstructured coffee growers bearing the burden of ungranted sector are permanently willing to leave the sector and convert their land into food crops and market gardening. The health constraints and unilateral price fixation lead to discouragement. The age, seedling origin, farmer awareness on pest and diseases, and type of cropping systems are the determinants of the phytosanitary status. The results of the current study play a key role in developing policies and strategies to revive the coffee industry in the Eastern DRC and Tanganyika particularly is therefore crucial.

Coffee growers face countless problems, the main one being the instability of prices on the world market. Other challenges of coffee cultivation include difficulties in certifying the finished product, unilateral price setting, limited access to credit, diseases and insect pests, specific sensitivity to diseases and extreme climatic conditions (frost, drought, high humidity, loss of fertility...), especially in Arabica, which can significantly affect the quality and volume of marketable coffee, as pests do.

Monoculture appears to be a sound production system for expecting better yields, still, it is not a practice to recommend for potential control of crop diseases and pests, as it exposes coffee trees to damage from diseases and pests. Coffee diseases and pests were more prevalent and severe in poorly maintained fields where coffee is associated with oil palm and the undergrowth occupied by invasive pineapples, rendering circulation and phytosanitary rounds impossible.

The ageing of coffee trees is an asset exploited by pests that attack older coffee trees which cannot develop defence mechanisms: rust, anthracnose, coffee berry borer, leaf-rolling thrips, die-back, fruit flies, and various caterpillars constitute the devastating arsenal against coffee trees in Tanganyika and plunge the coffee farmers of Fizi into poverty, at the same time and elsewhere, strict measures to combat these natural enemies of coffee involve good agricultural practices, notably pruning shade trees, regular maintenance work, and anticipatory control to curb the outbreak of any suspected case likely to jeopardise coffee production.

**Acknowledgments**

The authors express their profound gratitude to all women and men coffee growers of the Tanganyika sector for their availability, generosity, and valuable guidance in the accomplishment of this work.

**Author Contributions**

S.K: conception, manuscript, questionnaire, data collection and encoding. A.B.N: software, manuscript and survey questionnaire polishing. E.B.B: Supervision, pre-reading of the manuscript and questionnaire, manuscript proofreading, validation of results. O.I.N: reviewed the topic proposal, annotated and validated the results. All authors read and approved the final version of the manuscript and contributed critically to it by providing significant intellectual content.

**Funding**
This research did not receive any specific grant from funding agencies in the public, commercial, or nonprofit sectors.

**Conflict of interest**
The authors declare that they have no conflicts of interest, competing financial interests or personal relationships that could have influenced the work reported in this paper.

**Ethical approval**
The authors scrupulously respected ethical principles regarding research misconduct, data handling, and plagiarism. Prior to data collection, Free, Prior, and Informed Consent (FPIC) was obtained from all respondents, in accordance with the ethical guidelines for research involving local indigenous knowledge of the Institut Supérieur de Développement Rural de Fizi (ISDR Fizi). Verbal consent was obtained from all informants after explaining the purpose of the study and its potential benefits.

**Informed consent**
Oral informed consent was obtained from individual participants included in the study.

**Data availability**
All data supporting the findings of this study are embedded within the manuscript.

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