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Assessment of enset root mealybug (Cataenococcus ensete) Williams and Matile-Ferrero (Homoptera: Pseudococcidae) in enset-growing areas of Ari Zone, South Ethiopia

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ABSTRACT

This survey assessed the prevalence, incidence, distribution, and existing farmers' practices of root mealybug on enset (Ensete ventricosum), an important crop widely cultivated in Southern Ethiopia, such as the Ari zone. The study aimed to provide information to develop sustainable pest management. A survey was conducted in two woredas during the 2023/2024 cropping seasons. Fourteen (14) kebeles were purposively selected based on enset production potential. Data were collected through stratified random sampling across 95 farms, covering 485 enset plants complemented by farmer interviews. Findings of this study revealed a significant variation in prevalence and incidence; South Ari has a slightly lower mean prevalence and incidence than North Ari. Across both districts, the grand mean prevalence is 53.44%, and the grand mean incidence is 39.91%. Altitude influenced infestation levels, with higher rates observed at mid-altitudes (1681 and 2200 m.a.s.l.), with the corm being the most affected plant part. Farmer awareness was low, with 93.68% unaware of the pest, and most prioritized bacterial wilt. Pest management practices were limited, with 92.63% neglecting debris burning and only 36.84% applying cultural controls. The exchange of infested planting materials and poor field sanitation practices were identified as significant contributors to pest spread. The study recommends educating farmers on enset root mealybugs to increase awareness, promoting Integrated Pest Management (IPM), and enforcing stricter planting regulations to control pest spread and ensure sustainable enset production. These findings provide practical recommendations to local farmers for improving early detection, reducing pest damage, and enhancing yields by adopting sustainable practices.

Contribution/Originality: There is a scarcity of information on the pest status of root mealybugs in Enset-producing areas of the Ari zone. Therefore, this study aims to assess the prevalence, incidence, and distribution, along with farmers' practices, to develop sustainable solutions that mitigate the pest's impact and ensure the sustainable production of the crop.

1. INTRODUCTION

Enset (*Ensete ventricosum*) is a perennial herbaceous crop belonging to the Musaceae family, originating in Ethiopia and widely cultivated in the south and southwestern parts of the country and propagated in vegetative [1-

5] Enset is grown and distributed at altitudes between 1600 and 3000 m.a.s.l with an average annual rainfall of 1100-1500mm [6].

The crop plays a significance role in day-to-day life of our farmers and cultivating as a key staple food. The crop serves multiple purposes: as a staple and co-staple food source for over 20 million people, as well as providing fiber, animal forage, construction materials, and traditional medicines [7, 8]. Enset helps prevent soil erosion and maintain a positive nutrient balance, making it suitable for sustainable agriculture [9, 10].

Despite its immense importance for food security, income, and environmental sustainability, enset production in Ethiopia faces significant threats from pests and diseases [11]. Bacterial wilt was reported as the most important disease of enset by many scholars [12-17].

Most insects particularly the enset root mealybug (*Cataenococcus ensete*) was among the insect pests of enset plant [18]. The enset root mealybug (*Cataenococcus ensete*) is a major pest in southern Ethiopia, feeding on corms and roots. Infestations reduce yields, hinder growth, and threaten food security for smallholder farmers [19, 20]. This pest poses severe challenges to enset cultivation due to its cryptic habits, overlapping generations, and the lack of effective, widely adopted management practices [20]. Integrated pest management strategies include using clean planting materials, hot water treatments, and the application of natural products like wood ash and Militia ferruginea extracts were recommended in other locations [20-22].

In the Ari Zone, where enset is a cornerstone of livelihood and sustenance, limited awareness and traditional farming practices exacerbate these issues. Therefore, this study aims to assess the prevalence, incidence, and impact of enset root mealybug infestations and evaluate existing management practices among enset-growing communities in the Ari Zone to inform future strategies for sustainable enset production and pest management in the area.

2. MATERIAL AND METHODS

2.1. Description of the Survey Areas

The study was conducted in south and North districts of Ari Zone, South Ethiopia during 2023 and 2024 cropping seasons. The areas were selected purposefully based on enset production potentials and the distribution of pests. Initially kebele selection was done with collaboration with woreda agricultural office. About six kebeles, namely Zitna Dawa, Gasina Zama, Ayika Salmi, Shama Bulketi, Kellet and Ambi from North ari woreda and 8 kebeles namely, Wosat, Aynalalem, Mendir, Muti, Ayida, Gedir, Dordora and Del were selected from South Ari. These kebeles were the potential enset producing areas of Ari zone.

The zone is situated under major enset growing areas of Southern Region characterized by Dega and woyna dega agro ecologies. The annual rainfall of the area ranges from 950 to 1180mm. The mean annual minimum and maximum temperatures are 8.05°C and 18.9°C, respectively. The soil type is dominated by clay soil which is slightly acidic. North Ari is the other potential enset producing woreda in Ari zone. The agro ecology of the woreda is characterized by Dega and Woina Dega. The annual rainfall ranges from 620-1290 mm. The mean annual minimum and maximum temperatures are 7.6°C and 27.6°C, respectively. The soil type is dominated by clay soil. Both locations are characterized by bimodal rainfall, the main rainy season from March to May, and the short rainy season extending from September to October.

Figure 1 illustrates the map of sample woredas of Ari zone. Geographically, the Zone is located North of Equator from 5° 30‟N to 6° 20‟N latitude and from 36° 10‟ to 37° 20‟ East, longitude (Figure 1).

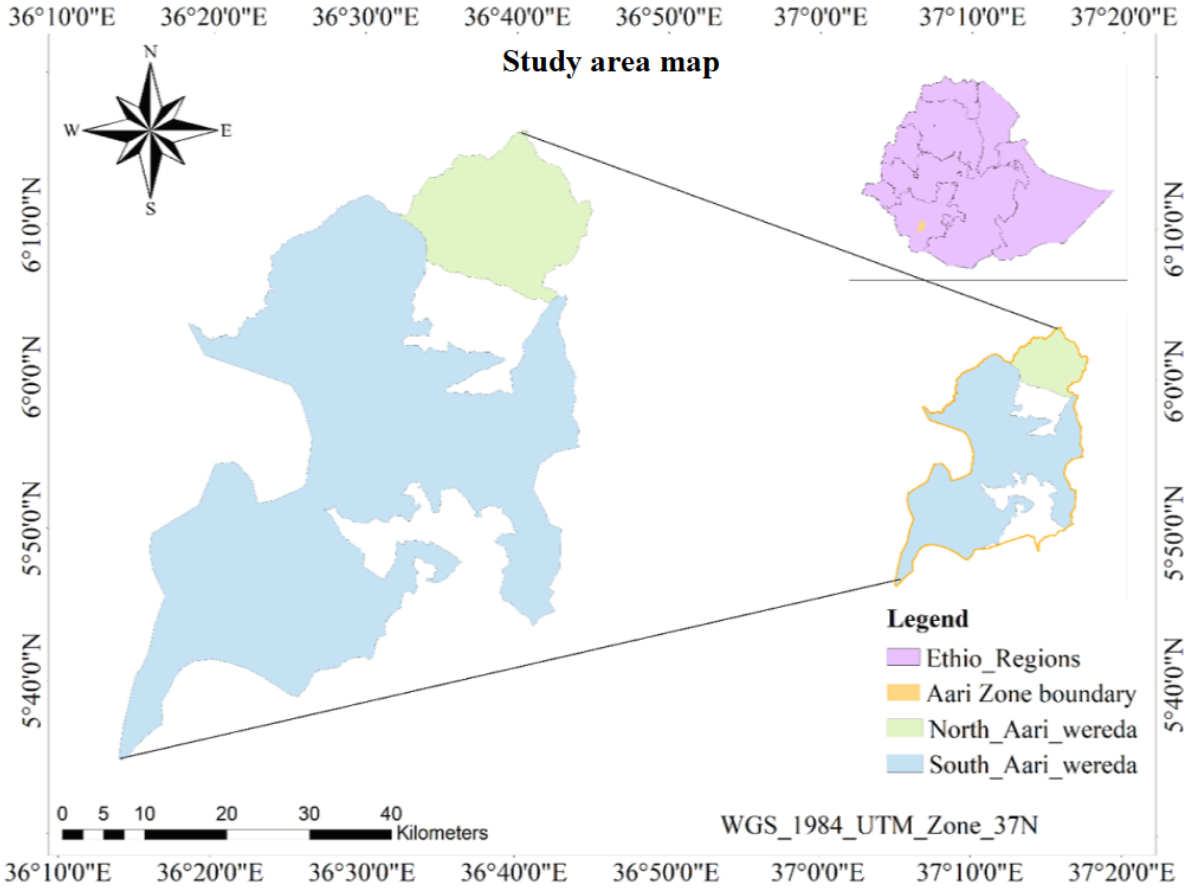

Figure 1. Location map of surveyed areas of Ari zone.

2.2. Survey Methods and Data Collection

Both Districts were selected purposively because they are potential in enset producing areas in the zone. Stratified random sampling methods used for collecting data from a total of fourteen (14) representative kebeles by consulting district experts on enset production status (only major enset growing kebeles was selected). Farms were surveyed from January to march, 2023/2024. Five to ten enset farms were randomly visited at a distance of 1-3km based on enset availability. From each selected field, five randomly selected enset plants were assessed. The population density of the enset root mealy bug on roots and corms were counted.

The data collection was conducted mainly through direct field observation and interview. From each farm 5 enset plants scouted for enset root mealybug population count. Totally Ninety-five (95) farms and 485 enset plants were visited and assessed. At each farm, a questionnaire was administered and the farm owner was asked about the age of the enset plant, about enset production status in comparison with crops commonly grown, landholdings, names of the clones and purpose each clone is grown, the reaction of each clone to the enset root mealybug, major challenges faced during enset production, awareness on enset root mealybug prevalence and its impact on enset production, complex pests occurred on enset crop production and existing management practices. if pesticides were applied and if so, which types were applied, if the farm was weeded. This information was collected from each farmer. In addition, it was confirmed by our own observation, particularly, in the case of weeding and whether the enset was intercropped. Altitude in meters above sea level (m.a.s.l) was taken, using a Garmin Ground Positioning System (GPS) at a central point for each farm surveyed. Data collected on infested plant (incidence), population count (severity) and infested farm (prevalence) were summarized as means for all farms surveyed and standard errors were calculated.

Mealy bug population was counted from corm and roots of infested enset plant.

Prevalence= (NIF/NTF) ×100, where,

NIF is the number of infested farms that represents the total number of farms that were found to have mealybug infestations during the survey or observation period; NTF is the number of total visited farm that refers to the overall number of farms that were surveyed or visited to assess the presence of mealy bug infestation.

Incidence = (NI/NT) ×100, where, NI is the number of infested plants that indicates the number of individual plants that were found to be infested by mealy bug pest; NT is the number of total observed plants that represents the total number of plants that were examined during the survey or study. Table 1 illustrates number of surveyed sample farms from each district. From South Ari sixty five (65) farms and from North Ari 30 farms were observed. Totally Ninety five (95) farms were visited. Figure 2 illustrates data collection procedure through field observation and interview in both districts that (A) represents North Ari and (B) represents South Ari woreda.

Table 1. Distribution of surveyed farms per districts.

Districts	Number of farms
South Ari	65
North Ari	30
Total	95

Figure 2. Field observation of Enset root mealybug (A) North Ari (B) South Ari.

3. RESULTS

3.1. Prevalence and Incidence of Enset Root Mealybug in North and South Ari Zone

Table 2 illustrates the prevalence and incidence of Enset Root Mealybug in sampled kebeles of North and South Ari woredas. The prevalence (percentage of farms affected) and incidence (percentage of infected enset plants) vary significantly among kebeles of North Ari. The highest prevalence (100%) was recorded in Zitna Dawa and Shama Bulketi, indicating that all farms in these kebeles are affected. Ayika Salmi showed no mealy bug infestation, with 0% prevalence and incidence. Ambi had a low prevalence (20%) but an extremely high incidence (88%), suggesting severe infestation on fewer farms. The overall mean prevalence for North Ari is 60%, and the mean incidence is 42%, showing that over half of the farms and a considerable portion of enset plants are affected.

In South Ari District: The prevalence ranged widely, with Ayida showing 100% prevalence and 88% incidence. Wosat and Mendir had the lowest prevalence (28.57% and 25%, respectively) and low incidence values (12.5%). The mean prevalence in South Ari is 46.88%, and the mean incidence is 37.81%. While South Ari has a slightly lower prevalence and incidence than North Ari, individual kebeles (e.g., Ayida) still show significant infestation. Across both districts, the grand mean prevalence is 53.44%, and the grand mean incidence is 39.91%, indicating that over half of the farms and a significant number of plants are affected across the region (Table 2).

Figure 3 illustrates the summary of prevalence and incidence of Enset Root Mealybug in North and South Ari woredas. In North Ari District, the average prevalence rate stands at 60%, with an incidence rate averaging 42%. Meanwhile, South Ari District reports a slightly lower mean prevalence of 46.88%, accompanied by an incidence rate of 37.81%. When considering the region as a whole, the combined average reveals a mean prevalence of 53.44% and an incidence rate of 39.91%, reflecting the overall health landscape across both districts.

Table 2. Distribution, prevalence and incidence of Enset root mealybug in selected enset producing kebeles of North and South Ari districts, Ari zone.

Districts	Kebele	% of farms with enset root mealybug (Prevalence) (%)	% of enset plant infected by Enset root mealybug (Incidence)
North Ari	Zitna dawa	100	68
	Gasina Zama	80	28
	Ayika Salmi	0	0
	Shama Bulketi	100	34
	Kellet	60	36
	Ambi	20	88
Mean		60	42
South Ari	Aynalalem	50	65
	Mendir	25	12.5
	Muti	30	14
	Ayida	100	88
	Gedir	37.5	52.5
	Dordora	44	40
	Del	60	18
	Wosat	28.57	12.5
Mean		46.88	37.81
Grand mean		53.44	39.91

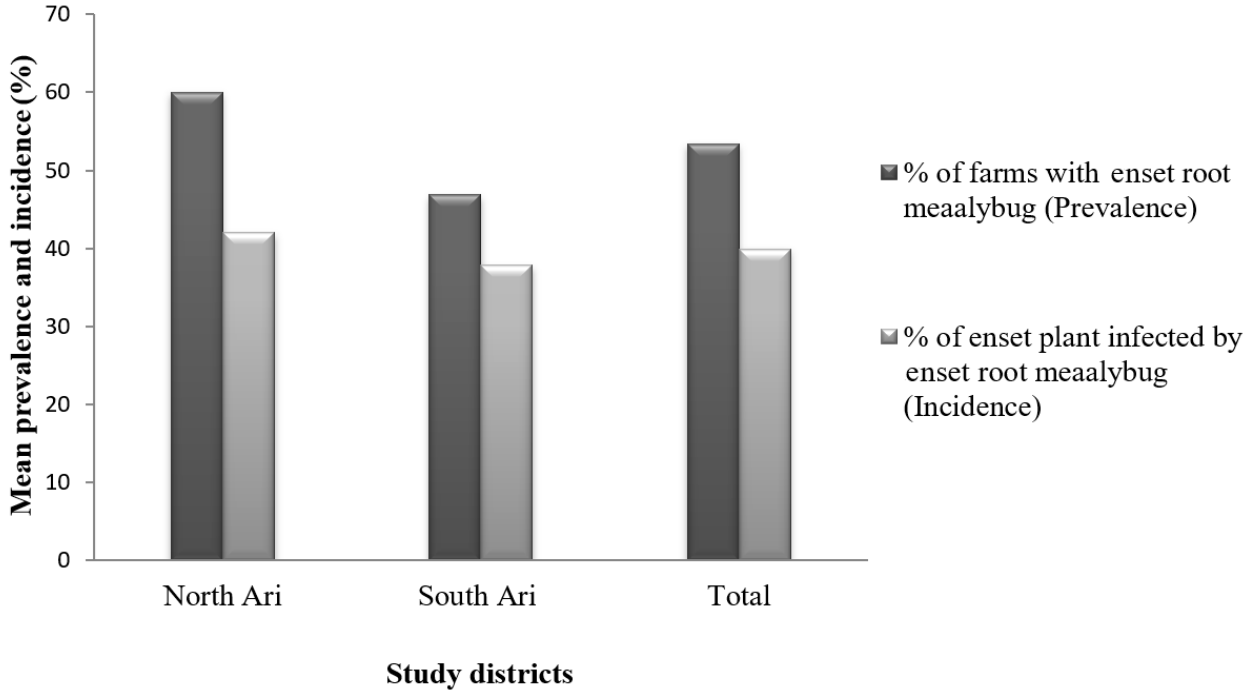

Figure 3. Prevalence and incidence of Enset root mealybug in selected study districts of Ari zone.

3.2. Effect of Altitude on Enset Mealy Bug Distribution and Incidence

Figure 4 illustrates the altitude of surveyed farms varied considerably between the districts. The highest-altitude farms were recorded in North Ari District, with an average of 2430 m.a.s.l., while farms in South Ari District had a mean altitude of 2067 m.a.s.l. The highest altitude point measured was 2860 m.a.s.l., and the lowest point was 1580 m.a.s.l. Altitude was found to influence the distribution and incidence of enset root mealy bug, as the relationship between the percentage of infested plants and altitude was quite apparent during the survey period. Across both districts, the highest percentage of infested farms (70%) was recorded in the altitude range from 1681 m.a.s.l. to 2200 m.a.s.l. Enset root mealy bug infestation decreased as altitudes increased. During the survey period, farms located at higher altitudes (typically above 2400 m.a.s.l.) had fewer mealy bugs, while those at lower altitudes (mainly from 1681 m.a.s.l. to 2200 m.a.s.l.) were more infested by the pest (Figure 4).

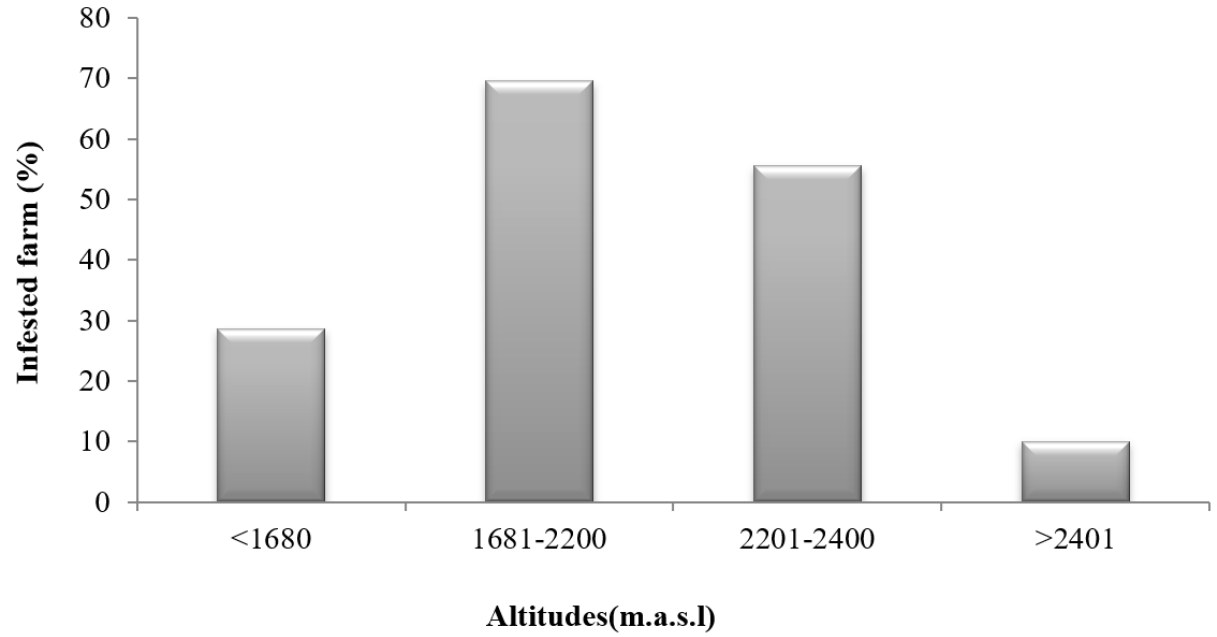

Figure 4. Effect of altitude on Enset mealybug infestation.

3.3. Distribution of Enset Root Mealy Bug Population on Enset Plant Parts

Figure 5 illustrates the number of mealy bugs found on different parts of enset plants sampled from 50 plants. Approximately 20 mealy bugs were observed on the corms, and fewer (about 10) were found on the roots. The total count of mealy bugs across both parts is about 30, reflecting the sum of the bugs found on the corm and roots. The pest distribution on different plant parts highlights its preference for specific areas like roots and corms, which might suggest targeted management practices. The infestation was more significant on the corm than on the roots (Figure 5). This suggests that control measures may need to focus on the corm, as it is the most infested part.

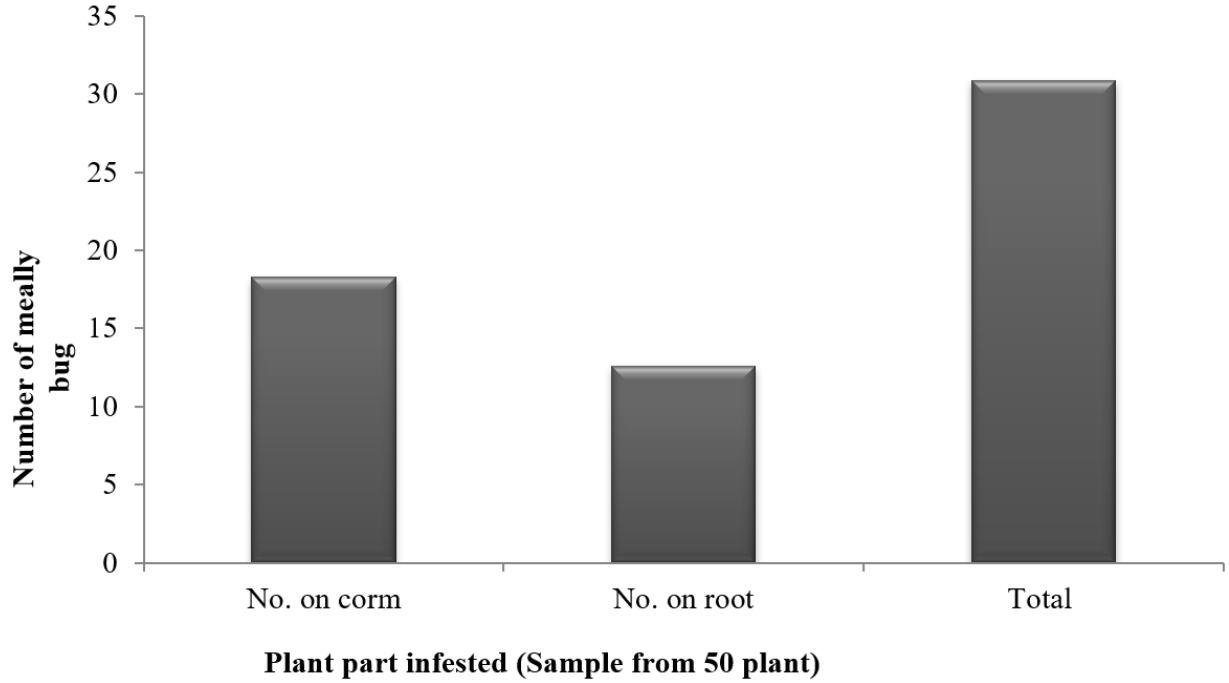

Figure 5. Distribution of enset root mealybug population on corm and roots of enset plants.

3.4. Farmers' Awareness and Practices

Table 3 illustrates farmers' awareness and practices toward enset root mealy bug. Farmers identified Enset bacterial wilt and rot (61%) as the most severe pest challenge, with mealy bugs (8.42%) being less prioritized, possibly due to a lack of awareness. Other challenges include mole rats (18.95%), termites (11.58%), and enset root mealybugs (8.42%), but they are less prominent compared to bacterial wilt and rot.

An overwhelming 93.68% of farmers do not know about the threat of enset mealybugs or their damage symptoms, suggesting a significant lack of awareness that could hinder timely intervention. Only 6.32% of respondents are aware of the mealy bug threat, highlighting a gap in education or extension services. Few farmers identified mealy bug-related damage symptoms: Retarded plant growth (50%) and dried outer leaves (33.33%) were the most recognized symptoms. Death of the whole plant was rarely noted (16.66%). No one mentioned "Reduced number of roots" as a symptom, possibly reflecting limited knowledge of root-level impacts. Pest infestations are perceived to be most severe during the dry season (93.68%), indicating that climatic conditions may exacerbate pest problems during this time. Only 6.32% associate pest severity with the wet season. Most farmers relied on themselves (75.79%) for enset farming, while some got help from model farmers (17.89%) and the Development Agent (DA) or research centers (6.32%). Pest infestations are perceived to be most severe on young crop growth stage (93.68%), indicating that stage of the crop may facilitate pest problems during this stage. Only 6.32% of respondent farmers associate pest severity with the old growth stage of enset crop (Table 3).

Despite this, 62.11% of farmers would exchange planting materials with other farmers or markets, indicating some level of engagement in the spread of pest populations, even though many may not be aware of the risks.

Interestingly, most farmers do not burn debris after cleaning the field (92.63%), a possible route for mealy bug spread. In terms of pest control, cultural practices (36.84%) are the most common management approach, while many farmers (63.15%) do nothing to manage pests. Chemical control and Integrated Pest Management (IPM) are not widely practiced (0%) (Table 3).

Table 3. Farmers perception on enset root mealybug in comparison with other challenging enset pests.

Asked questions	Variables	Frequency	Percentage
What are major pest challenges do you experience in enset farming?	Enset bacterial wilt and rot	58	61
	Enset root mealybug	8	8.42
	Mole rat	18	18.95
	Termite	11	11.58
Do you know threat of enset mealy bug and their damage symptom?	Yes	6	6.32
	No	89	93.68
How do you identify damage symptoms from healthy plant?	Death of the whole plant parts	1	16.66
	Dried outer leaves	2	33.33
	Reduced number of roots	0	0
	Retarded plant growth	3	50
In which season the pest infestation severe?	Dry season	89	93.68
	Wet season	6	6.32
On which crop growth stage of enset infestation severe?	Young stage	89	93.68
	Old age	6	6.32
From where did you get support on enset farming?	Developmental agents and research center	6	63.12
	Model farmers	17	17.89
	Myself	72	75.79
Would you exchange planting materials with another farmers and market?	Yes	59	62.11
	No	36	37.89
Would you do burning of debris after cleaning the field?	Yes	7	7.37
	No	88	92.63
What management option do you use?	Chemical	0	0
	Cultural practices	35	36.84
	Integrated pest management	0	0
	No intervention	60	63.15

4. DISCUSSION

4.1. Prevalence and Incidence of Enset Root Mealybug

Field survey was made in the current study areas to assess the prevalence, distribution, incidence and infestation of enset root mealybug as well as farmer's awareness on the prevalence and impacts of the pest.

In the present study, the prevalence of enset root mealybug in both North and South Ari Districts ranged from 0% (in Ayika Salmi) to 100% (in Zitna Dawa and Ayida), with an overall mean prevalence of 53.44% and incidence of 39.91%. Previous studies have reported varying levels of mealy bug infestation in other regions, with some studies in Ethiopia indicating similar or higher infestation rates. For example, a study by Teshome, et al. [23] in southern Ethiopia found a prevalence of 45–80% in enset-growing areas, which aligns closely with these findings. Similarly, Gebrehiwot, et al. [24] reported that the prevalence of mealy bug infestation varied significantly depending on local agricultural practices, climate, and altitude, reinforcing the relationship between pest distribution and environmental factors. A study conducted by Teshome, et al. [23] found that the enset root mealybug pest was present in various enset-growing areas.

A study by Getu and Abate [25] found that the prevalence of enset root mealybug could reach as high as 70-80% in some regions whereas; the incidence of the pest has been reported to be as high as 50-60% in some region.

4.2. Altitude and Mealybug Infestation

Altitude likely plays a role in the distribution and severity of mealybug infestation. Higher infestations may correlate with specific altitudinal ranges that favor the pest's survival and reproduction. The effect of altitude on mealy bug distribution in this study is consistent with findings from other studies. The study observed that the highest infestations occurred between 1681 m.a.s.l. and 2200 m.a.s.l., with a decline at higher altitudes. This supports previous research such as that by Mulugeta, et al. [26] who found that pests like mealybugs are more prevalent at lower altitudes, where warmer temperatures favor their survival and reproduction. Higher altitudes, where temperatures are cooler, were less conducive to pest outbreaks, confirming the findings in this study. This altitude-related pattern has been noted in several pest management studies in tropical and subtropical regions, which suggest that environmental conditions are crucial for pest dynamics.

4.3. Distribution of Enset Root Mealybug Population on Enset Plant Parts and its Impacts

Regarding, the density and distribution of enset root mealybug on enset plant, most of insect were recorded from the corms followed by roots. Addis [27] reported that most of the insect has found on the upper parts of the corm and the roots within a 20 cm radius of soil. The number of enset root mealy bug collected from the enset plant from study field were fewer in number when compared with study conducted in another location. However, the highest number of farm infested with enset root mealybug was observed in the study areas. For now, low population of enset root mealy bug recorded might not expect to cause threat to enset farming. Furthermore, Farmers' awareness on the presence of enset root mealybug on their field and its impact is very low. They consider as no substantial threat to enset farming from enset root mealybugs even when exist. Most farmers in the zone were exchange planting materials and allowing debris left on the field as source of fertilizer for live plant. These improper practices may cause the symptom complexity of enset root mealybug with major known pests such as Enset bacterial wilt, rot diseases, mole rat and termites as major challenges in enset production. The exchange of infested planting materials, less experience on burning of plant debris and lack of information on the pests among farmers do pose an additional risk for the spread/dispersal of the pest and occasional building up of the pest populations at the level of causing threat to enset farming. The pest distribution on different plant parts highlights its preference for specific areas like roots and corms, which might suggest monitoring and early detection of mealybug infestations and targeted management practices that could help to mitigate the spread of the pest and reduce crop losses.

According to Hailu, et al. [28] an infestation of mealybugs on enset can reduce yields by up to 40-50% in severely affected areas, leading to considerable economic losses for smallholder farmers who rely on the crop for subsistence and income. The enset root mealybug infests the roots and corm of enset plants, causing a reduced number of roots, reduced pseudo stem circumference, dried outer leaves, retarded plant growth and occasional death of the plant and reduced plant yields. Addis, et al. [29] reported that reduced plant yields critically affect the smallholders' food security and livelihood, and the overall farming sustainability in this region.

4.4. Farmer's Awareness, Perception and Practices on Enset Root Mealybug

While mealy bugs were not perceived as the most serious threat by most farmers in this study, with Enset bacterial wilt and rot (61%) being considered more damaging, this is consistent with findings from Tamrat, et al. [30]. In their study, farmers in southern Ethiopia also ranked bacterial wilt and other diseases as more critical than insect pests. This could be due to the widespread nature of bacterial diseases and their visible impact on enset plants, whereas mealy bugs, which often cause root damage and are less conspicuous, may be underreported or misidentified.

This study found a significant lack of awareness among farmers about the threat of enset root mealybugs, with 93.68% of farmers unaware of the pest's impact. This is consistent with other studies conducted in the Horn of Africa, where a gap in pest awareness and knowledge often leads to ineffective pest management practices. Hailu, et al. [31] observed similar results in their study in southern Ethiopia, where the majority of farmers did not recognize enset

root mealy bugs as a major pest, often attributing crop failure to other factors like disease or environmental stress. Furthermore, their research highlighted the importance of farmer education and extension services in pest management, an area where this study also points to the need for improvement.

The lack of knowledge observed here correlates with low intervention rates. Efforts should be made towards awareness creation to farmers and experts on the prevalence and importance of the major pests in general and enset root mealy bug specifically. Teach farmers on the specific characteristics of the pest including biology and ecology of enset root mealybug, symptom, spread route and its management practices is very important. Implementation of sustainable management such as proper seedling (suckers) preparation, development of resistance varieties, and implementation of improved agronomic practices such as field cleaning and burning of debris should be demonstrated. In general, we recommended that awareness creation with integrated approach is required in the areas which score highest prevalence and incidence to manage the enset root mealybug pest in the zone for sustainable production of the enset crop. In this study, cultural practices (36.84%) were the most common management method, while 63.15% of farmers did not implement any pest control measures. This finding is in line with Alemayehu, et al. [32] who noted that farmers often rely on traditional methods such as crop rotation or manual removal of pests, rather than chemical or integrated pest management (IPM) approaches. The low use of chemical control (0%) and IPM (0%) in this study mirrors the situation in other enset-growing regions, where there is limited access to pesticides or knowledge of IPM strategies. This suggests that while farmers may be aware of cultural practices, there is a lack of capacity and resources to implement more advanced or scientifically-backed pest management techniques.

5. CONCLUSION AND RECOMMENDATION

The enset root mealybug remains a significant threat to enset cultivation in Ethiopia, affecting both smallholder farmers' food security and their income. This study aimed to assess the prevalence, incidence, and impact of enset root mealybug along with current management practices, to develop sustainable solutions for enset farming in the study area and similar agro ecologies. This study results aligns with previous research in terms of the distribution and severity of enset root mealybug infestations, the role of environmental factors like altitude, and the limited awareness and management practices among farmers.

The findings underscore the importance of improving pest awareness, enhancing extension services, and adopting more sustainable pest management strategies, such as IPM, to mitigate the impact of pests on enset production. This reinforces the conclusions of earlier studies, highlighting a need for greater farmer education and practical pest management interventions. Many farmers lack sufficient knowledge about the pest's biology and effective control measures.

Integrated and sustainable approaches are needed to combat this pest effectively. High Infestation Levels observed during this study shows Mealy bug prevalence and incidences are widespread in both districts, with some kebeles experiencing severe impacts. Farmers show limited knowledge of mealy bug damage and minimal adoption of effective management practices. Expanding training and extension services on pest management, particularly focusing on integrated pest management (IPM) techniques and strictly controls on planting material exchange are crucial and can help farmer's better control the mealy bug.

Monitoring and early detection of mealy bug infestations could help mitigate the spread of the pest and reduce crop losses. Collaboration between government agencies, research institutions, and farmers is crucial for improving pest management practices and promoting sustainable agricultural practices.

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Competing Interests: The authors declare that they have no competing interests.
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