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Research Article

Prevalence and Management Practices of Faba Bean Gall (*Physoderma viciae*) in the Ethiopian Highlands

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Abstract

Faba bean (*Vicia faba* L.) is an important legume crop and is grown extensively in the Ethiopian highlands, 1,800 to 3,000 m.a.s.l. While this crop provides agronomic and effects and nutrition, production of faba beans is especially under threat from biotic stresses such as faba bean gall disease caused by *Physoderma viciae*. The present study investigated the distribution and traditional management of faba bean gall in the main production areas of the Ethiopian highlands. Researchers conducted field surveys in the sampled districts during the 2023/2024 major cropping season to assess disease severity and incidence as well as semi-structured interviews with farmers to obtain information on the traditional and modern management practices. Overall, faba bean gall disease, prevalence varied by altitude, host variety, and cropping management systems. Prevalence of disease was especially high in fields where faba beans were produced continuously and where there was no proper crop residue management. Farmers indicated that they attempted to combine traditional practices like crop rotation and fire clearing residues with very little use of resistant varieties. However most farmers did not integrate IDM in their management due to a lack of awareness and also low level of availability of resistant or tolerant cultivars. The research highlights the importance of extension services in promoting the IDM practices, such as use of certified seeds, crop rotation, and creating awareness, to lessen the incidence and impact of faba bean gall in the highland agro-ecosystem of Ethiopia.

Keywords

Faba Bean Gall, *Physoderma viciae*, Prevalence, Management Practices, Ethiopian Highlands

1. Introduction

Faba bean (*Vicia faba* L.) is the leading pulse crop of the Ethiopian highlands. It is the source of food and income for the households, as well as being a great help to the soil because it fixes nitrogen biologically. Besides, it is the main source of pulse production in the highland areas of the country, where the greatest contribution has been made by the regions of North and South Gondar, East and West Gojam, and Oromia and Tigray [1]. Nevertheless, just over the last few years, new emerging diseases have affected faba bean productivity, the most important of which to date has been faba bean gall (FBG), caused by the obligate parasitic fungus *Physoderma viciae*. The disease was first documented in Ethiopia about 2010 and has since spread to many highland areas, impacting thousands of hectares on faba bean, and has led to significant yield loss [2, 3]. FBG is characterized by tumor-like galls or swellings on pods, stems, and leaves that considerably reduce plant growth and the process of photosynthesis. The increasing incidence of FBG can be attributed

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to several factors including favorable environmental conditions (moderate temperatures and high humidity), local cultivars that are very susceptible to the disease, and little to no knowledge about managing the disease by smallholder farmers. Because of the serious threat that FBG disease poses to faba bean production and national food security, this review provided an overview of the prevalence and management of the disease and included the outline of recent research and challenges related to FBG in Ethiopia.

2. Literature Review

2.1. Overview of Faba Bean Production in Ethiopia

Faba bean (*Vicia faba* L.) is among the most grown pulse crops in Ethiopia and has an essential value for the country's economy. The major part of faba bean is the highland areas, where the altitude goes between 1800 and 3000 m a.s.l., and the climate is cool and moist [1]. The main centers of production of faba bean are the regions of Amhara, Oromia, Tigray, and Southern Nations, Nationalities, and Peoples' Region (SNNPR). As per the data published by the CSA, the area covered with faba bean comes to nearly 440,000 hectares annually, making the total area of pulses in the country from which faba bean contributes about 30% of the total cultivated area [1, 3]. Faba beans are also multifunctional crops in the Ethiopian farming system. In rural areas, they are a significant source of dietary protein where animal protein is either scarce or expensive. Faba beans also provide significant income support for smallholder farmers because there is a high local and export demand [2]. In addition, faba beans are critical to sustainable agriculture because they are a legume that can fix atmospheric nitrogen, generate soil fertility, and reduce synthetic fertilizer inputs. As a component in a crop rotation system, especially when grown with cereals such as wheat and barley, faba bean is a valuable crop [4]. Despite the value of faba bean, the productivity of faba bean in Ethiopia remains lower than is possible. Based on estimates, faba bean yields ranges from 1.6 to 2.1 tons per hectare, significantly below the average 3–4 tons per hectare achieved in countries with better management practices [5]. The differences in yield can be explained by a wide range of abiotic and biotic stresses including drought, poor soil fertility and, the most important diseases including faba bean gall (FBG), chocolate spot, and rust disease. Among these diseases, faba bean gall caused by the fungus *Physoderma viciae* is now one of the major production constraints for faba bean production in the highland areas of Ethiopia that threatens the viability of faba bean in enhancing food security and rural livelihoods [6, 3].

The attempts to address these issues have included the introduction of better varieties, improved extension services, and disease surveillance. Despite attempts to improve yields through these initiatives, challenges, including limited access to improved seed, poor disease management structures, and climate variability, have affected faba bean performance. Thus, a comprehensive approach will be required to ensure faba bean cultivation adapts to sustainably increase its productivity and maintain its role within the Ethiopian agriculture economy.

2.2. Prevalence and Distribution

Physoderma viciae was first formally reported in Ethiopia in the early 2010s, and since then it has quickly engulfed all key faba bean-producing highland areas in the country. Recurrent field surveys and disease mapping exercises have demonstrated that FBG is now endemic in parts of the Amhara, Tigray and Oromia regions. For example, FBG prevalence was reported at 85-90% in selected fields in North Gondar, West Gojjam and East Gojjam Zones [7]. FBG disease is highly prevalent in high altitude areas, usually at 2200 masl or above, where the ecological conditions of frequent cloud cover, continuous rain, and poorly drained soils create microclimates that favor the fungal pathogen's growth [3], and these areas often have high population density in cropped areas, contributing to the persistence of the disease.

Surveys from multiple cropping seasons indicated a disease incidence of 40–90% in fields, with disease severity often in the range of 30 to 70%, especially in fields with continuous faba bean production [7]. The disease distribution of faba bean gall (*Physoderma viciae*) was greatly influenced by a combination of agroecological and agronomic factors. In general, topography is influential, with valley bottoms and lowland areas providing poor drainage and excess moisture which can create a humid microclimate that allows for the release and movement of the pathogen's zoospores [3]. Late planting dates expose developing faba bean plants to extended rainfall during their young crop development stages, and these conditions increase the chances of infection and disease severity [7]. Field management practices such as close plant spacing promoted dense canopies, limited airflow, and extended leaf wetness duration, all of which exacerbate disease spread and severity [6]. Long term continued crop development without crop rotation and planting species from alternative plant families (e.g., cereals) allows for build-up of *P. viciae* resting spores in field soils during successive seasons, leaving the communities with high inoculum potential and outbreaks of disease [2]. The three factors, singly and in combination, have been important determinants of the spatial and temporal processes of faba bean gall occurring in communities in the Elders of Ethiopia Highlands.

Moreover, FBG frequently appears very early in low-lying wet fields and during extended periods of rain, FBG quickly progresses from initial infections into more severe stages. These epidemiological observations imply that agroecological elements, cultural practices, and cropping systems can greatly determine the presence and severity of FBG throughout the Ethiopian highlands.

2.3. Economic Importance

Faba bean gall (FBG), caused by *Physoderma viciae*, is an increasingly damaging disease in the Ethiopian highlands where faba bean is a major pulse for food security, cash income, and soil fertility [8, 9]. Yield losses can be substantial in conducive years due to: (1) direct reduction in photosynthetic area from galling and chlorosis; (2) lodging and stunting that depress stand vigor; (3) flower/pod infection leading to poor pod set and shriveled seed; and (4) quality downgrades that depress market price and seed value [10, 11]. Indirect costs include higher seed rates to compensate for stand loss, extra fungicide or sanitation costs, and constraints on rotations if residues carry inoculum [12]. At the community scale, severe FBG outbreaks reduce household protein supply, elevate grain prices, and diminish the nitrogen contribution of faba bean to cereal-based systems—raising fertilizer needs in subsequent crops [13, 14]. For seed systems, infected seed lots risk area-wide dissemination, undermining varietal gains and increasing certification costs [15].

2.4. Epidemiology and Symptoms of Faba Bean Gall (*Physoderma viciae*)

FBG epidemics are driven by the interaction of inoculum, young succulent host tissues, and extended free water [16, 17]. Primary inoculum originates from infected residues persisting in soil and from contaminated seed/seed coats [18]. Initial infections often occur at emergence on hypocotyls, stems, and petioles under cool-to-warm temperatures with prolonged leaf wetness or standing water [19]. Galls develop, within which sporangia form and release zoospores in water films; these motile propagates enable rapid, short-distance spread via rain splash and irrigation, producing multiple secondary cycles within wet spells [20, 21]. Dense canopies, high seeding rates, poorly drained fields, and continuous faba bean or closely related hosts intensify epidemics [13]. As crops senesce, infected tissues return to soil and resting structures persist to the next season, closing the cycle [9]. Effective management therefore hinges on clean seed, residue and water management, tolerant varieties, and well-timed protectant sprays during forecasted wet periods [14].

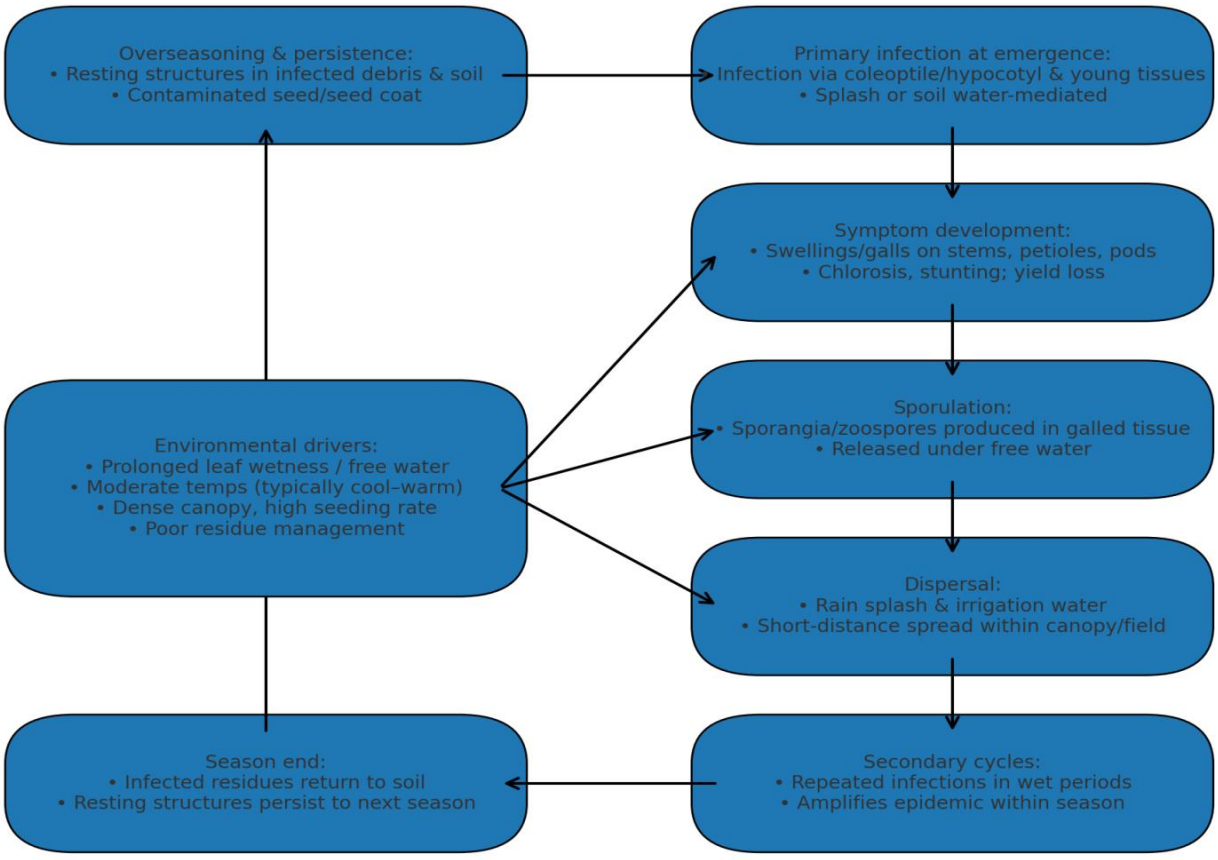

Figure 1. *Life cycle of faba bean gall [22, 2].*

Faba bean gall (FBG) is one of the most destructive emerging diseases of faba bean in Ethiopia, initially observed in 2010 but now well established across the highlands. The causal agent, *Physoderma viciae*, infects leaves, stems, and pods, producing characteristic gall-like swellings that distinguish it from other foliar diseases. Early infection usually

starts on the lower leaves, with the pathogen forming small, greenish to brown raised blisters, which later expand and develop into circular or irregular galls. These galls restrict photosynthetic capacity by damaging the leaf lamina, thereby reducing plant vigor and predisposing the crop to additional stress factors [2, 3]. The disease has been reported at high prevalence in major faba bean-growing regions such as Amhara, Tigray, and Oromia, with disease symptoms consistently linked to significant yield loss [22].

Typical field symptoms of FBG include lesion development and gall proliferation. Infected tissues often show blister-like swellings surrounded by chlorotic halos, which may coalesce and cover large leaf areas. On stems, elongated lesions cause mechanical weakness, and in pods, infections result in sunken dark patches that often shrink seed size or cause shriveling. Severe galling leads to premature defoliation and stunting of plants, which directly reduces the number of pods per plant and seeds per pod [11, 23]. Field assessments during 2020–2023 epidemics revealed that the severity of gall symptoms was strongly correlated with reductions in hundred-seed weight and grain yield, confirming the destructive potential of the disease when left unmanaged [2, 22].

The progression of FBG symptoms is closely associated with environmental conditions. The disease thrives in cool and humid weather, particularly under prolonged wet seasons, which are common in highland districts such as North Shoa, South Wollo, and parts of Amhara. In these environments, symptoms often progress from lower to upper leaves as the epidemic develops, leading to severe crop damage if conditions remain favorable [23, 21]. High disease pressure has been recorded in localized hotspots, with prevalence reaching over 95% in some districts, accompanied by incidence levels above 70% and severity exceeding 30% [2]. This symptom expression, coupled with the widespread distribution of the pathogen, explains the growing recognition of faba bean gall as a major production constraint in Ethiopia's highland farming systems [22].

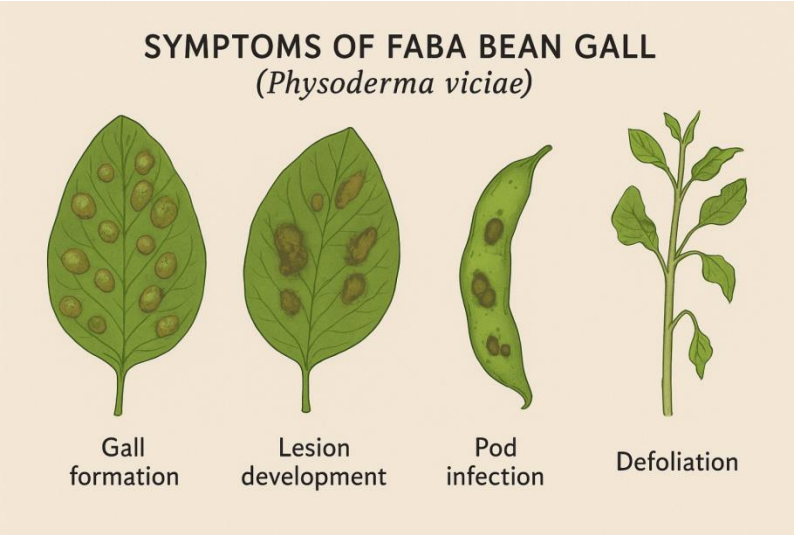

Figure 2. *Symptoms of faba bean gall [23, 21].*

2.5. Yield Impact

The yield impact of faba bean gall is devastating both quantitatively and qualitatively. Yield losses due to FBG infection, under native field conditions, can drastically vary due to site-specific factors such as the timing of infection, the level of infection, host variety, and management factors [2]. Controlled studies and in-field evaluations have shown that moderate infections reduced yield by 20–40%. However, severe infections particularly early in the vegetative or during flowering period can produce yield losses of 50–70% [6]. Farmers have also reported complete crop failure, in extreme cases where environmental conditions were favorable for infections spur, and were sold susceptible landraces without controls. Even moderately infected plants by *Physoderma viciae* are debilitating to the reproductive capacity and seed quality of faba bean plants. Infected plants will generally have fewer pods per plant, because the pathogen inhibits the normal flowering and pod-setting process, potentially by disrupting nutrient transport or hormonal balance [6]. In most instances when hooks were form, they are generally deformed and have a potential incomplete seed fill, meaning faba beans with very poor grain development and lower market value [2].

The seeds taken from diseased plants are often shriveled, small, and discolored. When seeds are affected by FBG, it is not only a concern for consumption but also for seed use [7]. This means that these seeds are often sold with lower 100-seed weights along with limited chances to germinate. This can lead to difficulties in seed multiplication and con-

sequently affect productivity in the next season [3]. All of this not only means less quantity yield, but it contributed to reduced seed quality, which contributes to small-holder farmers' economic loss from the disease. The disease also affects marketability, as the infected seeds are typically light, discolored, or small, and consequently are not as highly regarded and often fetch lower prices. In addition, as infected plants tend to senesce early, less biomass and its accompanying residues would be left behind for soil fertility management by mixed crop-livestock systems. Thus, these collectively are impacts of FBG typically being felt by households and the nation, which threaten food security, incomes, and export tensions for pulses. Without apparent and rapid intervention the disease is expected to invade newer highland territory through enhanced climate variability [3].

2.6. Management Strategies

Managing faba bean gall (*Physoderma viciae*) successfully is a holistic approach because it is soil-borne, has a long persistent life, and thrives under specific environmental conditions. There is no single strategy that will provide complete management, but using one or more of the cultural, genetic, chemical, and biological measures have some potential in decreasing the incidence and severity of faba bean gall disease. Below is a summary of current management strategies used in the highlands of Ethiopia.

2.6.1. Cultural Control

Cultural management strategies are the most affordable and server-building methods for smallholder farmers to reduce the burden and spread of FBG. Crop rotation is also a very important consideration; faba beans can be grown with non-host cereals such as wheat, barley or teff, which will gradually reduce the accumulation of resting spores of P. viciae in the soil [24]. In regions where there has been substantial disease pressure, planting faba bean very early has been recommended to allow the crop enough time to develop before peak rainfall, which is more conducive to zoospore release and infection [25]. In addition, deep ploughings to bury infected crop residue after harvest will reduce overwintering spores and ensuing the primary source of inoculum for the following season [26]. The way the surface of a crop is spaced can change the aeration of the canopy; this can reduce the leaf wetness period which interrupts the moisture-dependent infection cycle of the pathogen [27]. Although these practices do not eradicate disease, they can cumulatively suppress disease pressure substantially if used consistently with other management practices.

2.6.2. Host Resistance

Building delay and dissemination of resistant or tolerant faba bean varieties, is still a key component in the management of FBG. The breeding programs conducted in Ethiopia, report that moderate tolerance, highly tolerant faba bean varieties were identified Tumsa, Dosha, and Obse varieties that when grown under natural infection with FBG [28] shown that if faba bean were generally slower to present disease on the host, produce fewer, smaller galls and yield better than the susceptible agro-ecological landraces. So, there has been some progress, there are no faba bean varieties with complete resistance, and all (the majority) of improved lines yield to disease under severe inoculum pressure regardless of tolerance ratings, or continue to grow for long periods of time in conditions favorable to FBG. At this point, EIAR and universities in the country had started participatory varietal selection (PVS), where farmers select to adopt more tolerant cultivars that fit their agroecological conditions [25]. There is much potential, still we encourage the application molecular breeding and genomic technologies to confer new resistances on the breeding programs, most breeding still continues to focus on conventional breeding. Ultimately, we are trying to breed faba bean with more durable resistance to FBG.

Table 1. *Host Resistance Varieties against Faba Bean Gall (FBG).*

Variety	Tolerance Level	Key Features / Observations	Reference
Tumsa	Highly tolerant	Slower disease development, fewer and smaller galls, better yield under natural infection	[28]
Dosha	Moderate tolerance	Reduced gall formation compared to susceptible landraces, improved yield performance	[28]
Obse	Highly tolerant	Delayed symptom expression, fewer galls, more suitable for farmers' agroecological zones	[28]
Local landraces	Susceptible	Faster disease onset, more numerous and larger galls, lower yield	[28]

2.6.3. Chemical Control

Chemical control strategies have been considered to manage FBG; however, adoption in an agricultural production system is limited by the location of the pathogen within the plant and in the soil. As P. viciae is a chytrid fungus, which is present in the epidermal layers and cortex, fungicides rarely penetrate past the structural barriers if the plant is already infected. Overall, protectant fungicides for P. viciae, those that are applied before or during high-risk periods, have showed some effectiveness whether it be through Mancozeb (contact), Copper Oxychloride and, Chlorothalonil, applied early and on an interval [25]. Spraying a preventative latent spray shortly after emergence will stop the start of an infection from day one especially if wilting was previously present in the field. However, the economic cost, limited access to some fungicides, dilution and/or transport limitations, time frame of application, concern for residues, and, environmental safety provide little inspiration for a smallholder farmer to apply fungicides with confidence, therefore fungicides should be considered as part of a greater IDM system in combination with cultural and varietal resistant options.

Table 2. Chemical Control of Faba Bean Gall (FBG).

Fungicide / Chemical	Mode of Action	Application Timing / Notes	Effectiveness	Reference
Mancozeb	Contact protectant	Apply before or during high-risk periods, preventative latent spray shortly after emergence	Moderate; limited penetration into infected tissues	[25]
Copper Oxychloride	Contact protectant	Early and interval applications	Moderate; primarily protective	[25]
Chlorothalonil	Contact protectant	Early and interval applications	Moderate; preventive only	[25]

2.6.4. Biological Control and Awareness

Biological control is a field with huge potential; however, it is relatively nascent with respect to the control of FBG. Initial studies have shown some suppressive ability from well-studied antagonistic fungi (*Trichoderma harzianum* and *T. viride*), and bio-composts containing microbial consortia, which decreased disease severity and the number of galls produced [29]. These biocontrol agents work by colonizing roots by their associated micro-biome, and producing enzymes or secondary metabolites that inhibit or prevent germination or penetration of *P. viciae* spores, when applying a biocontrol microbe. The other biocontrol agent may be the combination of compost and farmyard manure (FYM) in the field which is likely to increase soil health and state of microbial diversity around the roots to potentially enhance the ability of the biological agent to naturally suppress the pathogen. More work and validation will need to occur to develop field-scale applications and success products for biological control so that will be proactive in the application under changing agro-climatic conditions. Training and developing awareness of farmers are equally important. Many smallholders still did not properly diagnose faba bean gall or have missed the visible symptoms of their first opportunity to intervene and suppress the disease. Extension services and on-farm demonstration trials are two very useful and potentially complementary means of supporting farmers to understand integrated management practices and to organize collectively as an agricultural community to respond to the disease [25]. However the coverage levels of extension services is still modest, especially in geographically isolated rural communities.

Table 3. Biological Control and Awareness Practices for Faba Bean Gall (FBG).

Biocontrol Agent / Practice	Mechanism / Mode of Action	Observed Benefits	Reference
Trichoderma harzianum	Colonizes roots, myco-parasitism, enzyme and metabolite production inhibiting spore germination	Decreased gall number and disease severity	[29]
Trichoderma viride	Root colonization, secondary metabolite production	Reduced disease severity and gall formation	[29]
Bio-composts with microbial consortia	Enhance soil micro-biome, suppress pathogen naturally	Lower incidence of FBG, improved soil health	[29]

Biocontrol Agent / Practice	Mechanism / Mode of Action	Observed Benefits	Reference
Farmyard manure (FYM) + compost	Improve soil microbial diversity, enhance pathogen suppression	Potential synergistic effect with biocontrol agents	[29]
Farmer training and extension	Awareness and early diagnosis	Improved adoption of IDM practices, timely interventions	[25]

2.7. Integrated Management of Faba Bean Gall (FBG)

Integrated management of faba bean gall (FBG) caused by *Physoderma viciae* in the Ethiopian highlands relies on a combination of host resistance, chemical control, biological agents, and farmer awareness to effectively reduce disease incidence and severity. The use of tolerant varieties such as Tumsa, Dosha, and Obse has been shown to delay symptom development, reduce gall formation, and improve yield compared to susceptible local landraces, although no cultivar exhibits complete resistance [28, 25]. Chemical control through protectant fungicides, including Mancozeb, Copper Oxychloride, and Chlorothalonil, can reduce disease if applied preventively during high-risk periods; however, penetration into infected tissues is limited, and economic and environmental constraints reduce their practical use for smallholder farmers [25]. Biological control agents, particularly *Trichoderma harzianum*, *T. viride*, and bio-composts with microbial consortia, have demonstrated the ability to colonize roots, inhibit spore germination, and enhance soil microbial diversity, thereby suppressing disease development [29]. Complementing these strategies with farmer training, extension services, and participatory varietal selection ensures timely recognition of symptoms, adoption of tolerant cultivars, and application of both chemical and biological measures in an integrated disease management (IDM) framework. Collectively, integrating these approaches provides a sustainable, environmentally friendly, and context-specific strategy for managing FBG in the Ethiopian highlands, particularly under smallholder farming conditions [25, 29].

3. Conclusion

Faba bean gall disease caused by *Physoderma viciae* is a growing and significant threat to food security and rural income in the Ethiopian highlands. The disease is widespread and is exacerbated by prevailing conditions in humid high-altitude regions of Ethiopia. Despite many attempts to manage the disease, effective management of faba beans gall (FBG) disease in Ethiopia is limited by insufficient resistance, a lack of reliable and proven chemicals for use in the field, and the lack of knowledge and awareness of the disease. The most practical way to ultimately manage faba beans gall disease in Ethiopia is through an actively integrated disease management system, which includes cultural control of faba beans gall disease, improved varieties of faba beans, and the application of fungicide where it is warranted. Research and development of durable resistance and sustainable and efficient biological control, and ongoing investment and capacity building through farmer training, enhanced surveillance systems where early warning systems are utilized, and rapid response plans should all be priorities for future research planned within the scope of faba beans FBG disease. The continued funding from the government and collective research between the relevant institutions and organizations, extension professionals and farming community, to contain the impact of the faba beans gall disease and improve the long-term management of faba bean gall disease is vitally important to ensure the sustainable production of faba beans as a food security crop for many people in Ethiopia.

Abbreviations

CSA	Central Statistical Agency
EIAR	Ethiopian Institute of Agricultural Research
FAOSTAT	Food and Agriculture Organization Statistic
FGB	Faba Bean Gall
FYM	Farmyard Manure
IDM	Integrated Diseases Management
PVS	Participatory Varietal Selection
SNNPR	Southern Nations, Nationalities, and Peoples' Region

Conflicts of Interest

The authors declare no conflicts of the interest.

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