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Management of Fusarium solani Root Rot in Faba Bean (Vicia faba L.) through Seed Treatment Applications on Black Vertisol Soils

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Abstract

Faba bean (Vicia faba L.) is a key pulse crop in Ethiopia, contributing to food security, soil fertility improvement, and income generation. Its productivity, however, is limited by root rot caused by Fusarium solani, especially in poorly drained black Vertisol soils. This study evaluated the effectiveness of fungicidal seed treatments in controlling root rot and improving agronomic and seed quality traits of three faba bean varieties (Ashebeka, Chalew, Dida'a). A factorial experiment with six seed treatment options including an untreated control was conducted at Kulumsa Agricultural Research Center (KARC) and Arsi Robe using a Randomized Complete Block Design (RCBD) with three replications. Data were collected on disease severity, crop establishment, yield, and laboratory seed quality parameters. Fungicide treatments significantly reduced root rot severity and improved germination, plant vigor, and grain yield compared to the control. Dynamic 400 FS, Apron Star 42 WS, and Kanzole 25% EC consistently performed best across varieties and locations. The results confirm that fungicidal seed treatment is an effective, low-cost strategy for managing F. solani root rot in faba bean under Vertisol conditions.

Keywords: Fusarium Solani, Faba Bean, Seed Treatment, Fungicides, Vertisol Soils, Root Rot

Introduction

Faba bean (Vicia faba L.) is one of the most important pulse crops cultivated in Ethiopia, playing a vital role in national food security, human nutrition, and sustainable agricultural systems. It is a major source of affordable plant-based protein, carbohydrates, and essential micronutrients for millions of households. In addition to its nutritional value, faba bean contributes to soil fertility improvement through biological nitrogen fixation, thereby reducing the need for inorganic nitrogen fertilizers in cereal-based cropping systems [1,2].

Despite its significant agronomic and socio-economic importance, the productivity of faba bean in Ethiopia remains considerably below its potential yield. This yield gap is attributed to a combination of abiotic constraints, such as waterlogging and soil fertility problems, and biotic stresses, including insect pests and diseases. Among the biotic factors, soil-borne diseases particularly root rot caused by Fusarium solani are recognized as major yield- limiting constraints in major faba bean–growing areas of the country.

Root rot caused by F. solani is especially prevalent and destructive in highland areas dominated by Vertisol soils. Vertisols are characterized by high clay content, poor internal drainage, and prolonged soil moisture during the cropping season, conditions that strongly favor the survival, multiplication, and infection potential of soil-borne fungal pathogens [3,4]. As a result, faba bean crops grown on such soils are highly vulnerable to early infection and disease development.

Infection by F. solani commonly occurs at the seedling stage, leading to pre- and post- emergence damping-off, root

discoloration, and necrosis. These symptoms ultimately result in poor crop establishment, reduced plant vigor, impaired nutrient and water uptake, and premature plant death. Under favorable environmental conditions for the pathogen, yield losses due to root rot may exceed 50%, posing a serious threat to smallholder farmers who rely on faba bean for both food and income [5].

Managing F. solani root rot is particularly challenging because the pathogen is soil-borne, has a wide host range, and can survive for long periods in soil and crop residues. Cultural practices such as crop rotation, improved drainage, and use of tolerant varieties provide partial disease suppression but are often insufficient under high disease pressure. Consequently, integrated disease management strategies that target the pathogen at early growth stages are required to effectively reduce yield losses.

Seed treatment with fungicides is widely recognized as a cost-effective and environmentally sound approach for managing soil-borne diseases in grain legumes. Fungicidal seed treatments protect seeds and emerging seedlings during the critical early growth period, reduce pathogen inoculum in the rhizosphere, and minimize the need for repeated foliar fungicide applications later in the season [6,7]. This approach is particularly suitable for smallholder farming systems due to its low cost and ease of application.

Although several fungicides are commercially available for seed treatment in Ethiopia, their comparative effectiveness across different faba bean varieties and Vertisol environments has not been adequately evaluated. Moreover, many previous studies have focused primarily on disease incidence or severity, with limited attention given to associated effects on grain yield and post-harvest seed quality. Comprehensive studies integrating disease management, agronomic performance, and seed quality parameters remain scarce [8,9].

Therefore, this study was conducted to evaluate the efficacy of selected fungicidal seed treatments in managing Fusarium solani root rot and improving agronomic performance and seed quality traits of faba bean varieties grown on black Vertisol soils of Ethiopia. The findings are expected to generate practical recommendations for farmers, researchers, and seed producers aimed at enhancing faba bean productivity under root rot–prone environments

Objectives

- To evaluate the effectiveness of fungicidal seed treatments in reducing the incidence and severity of Fusarium solani root rot in faba bean.
- To assess the response of three faba bean varieties to different seed treatment fungicides under Vertisol soil conditions.

Materials and Methods

Study Locations

The study was conducted during the main cropping season at Kulumsa Agricultural Research Center (KARC) and Arsi Robe, both located in the southeastern highlands of Ethiopia. Kulumsa Agricultural Research Center is situated at approximately 8°01′ N latitude and 39°09′ E longitude, at an altitude of about 2,200 m above sea level, while Arsi Robe is located within the Arsi Zone at elevations ranging from 2,400 to 2,500 m above sea level. The two locations represent major faba bean–growing areas of Ethiopia and are characterized by extensive coverage of black Vertisol soils, which are heavy clay soils with high water-holding capacity and poor internal drainage.

The climate of both sites is classified as cool sub-humid highland, with a unimodal rainfall pattern concentrated during the main growing season (June to September). The mean annual rainfall typically ranges from 750 to 900 mm, with frequent periods of excessive soil moisture during peak rainfall months. Mean minimum and maximum temperatures range from approximately 8–10 °C and 20–23 °C, respectively, creating favorable conditions for faba bean growth but also for the development of soil-borne diseases. The combination of high rainfall, prolonged soil moisture, and Vertisol soil properties results in recurrent root rot and other pulse crop diseases, making these locations suitable for evaluating management strategies against Fusarium solani [10].

Experimental Design

A factorial arrangement of three faba bean varieties (Ashebeka, Chalew, and Dida'a) and six seed treatment options was evaluated using a Randomized Complete Block Design (RCBD) with three replications. The six seed treatments included:

1. Untreated control
2. Mancozeb 80 WP (2–3 g kg^{-1} seed)
3. Kanzole 25% EC (Tebuconazole; 1–2 mL kg^{-1} seed)
4. Proseed Plus 63 WS (2–3 g kg^{-1} seed)
5. Apron Star 42 WS (2 g kg^{-1} seed)
6. Dynamic 400 FS (1–2 mL kg^{-1} seed)

Seeds were treated prior to sowing according to manufacturer recommendations.

Data Collection

Field Data

Days to emergence (DE) was recorded as the number of days from sowing until 50% of the seedlings emerged in each plot. Stand count at emergence and at harvest was determined by counting the total number of plants within the net plot area at the respective growth stages. These parameters were used to assess the effects of seed treatment on early seedling establishment, survival, and overall crop stand, which are critical indicators of seedling vigor and the effectiveness of treatments in protecting seeds from soil-borne pathogens.

Plant height at flowering was measured in centimeters from the soil surface to the tip of the main stem using randomly selected plants from each plot. Days to physiological maturity (MD) were recorded as the number of days from planting until approximately 90% of the plants in a plot reached physiological maturity, indicated by pod yellowing and leaf senescence. This growth and phenological parameters were used to evaluate the influence of seed treatments on crop development and growth duration under Vertisol conditions.

Grain yield (GY) was determined by harvesting plants from the net plot area, threshing, and converting the grain weight to kilograms per hectare (kg ha^{-1}) after adjusting to standard moisture content. Disease severity for root rot and other major faba bean diseases was assessed using a 1–9 visual rating scale, where 1 indicated no visible symptoms and 9 represented severe disease with extensive root damage or plant death. Disease severity scores provided a quantitative measure of treatment effectiveness in suppressing disease development in the field.

Laboratory Data

Laboratory seed quality parameters included seed moisture content, thousand seed weight (TSW), hectoliter weight (HLW), and germination percentage. Seed moisture content was determined using the oven-drying method and expressed as a percentage. Thousand seed weight was measured by weighing 1,000 randomly selected seeds from each treatment, while hectoliter weight was determined as the mass of grain per unit volume (kg hL^{-1}). Germination percentage was evaluated under controlled laboratory conditions following International Seed Testing Association (ISTA) procedures and calculated as the proportion of normal seedlings produced. These parameters were used to assess the effects of seed treatments on post-harvest seed quality and planting value.

Statistical Analysis

Data were subjected to ANOVA using appropriate software. Treatment means were compared using the Least Significant Difference (LSD) at 5% probability [11].

Results and Discussion

Effect on Root Rot Severity

Fungicide treatments significantly reduced Fusarium solani root rot compared to the untreated control. Dynamic 400 FS, Apron Star 42 WS, and Kanzole 25% EC consistently achieved the lowest disease severity across all varieties. Untreated plots exhibited the highest severity, reflecting the high pathogen load in Vertisol soils. These findings align with Hailemariam et al. and Abebe et al. who reported substantial disease reduction with systemic and contact fungicides in faba bean under Ethiopian conditions [4,12].

Internationally, Lamichhane et al. reported similar protective effects of seed treatments in legumes against Fusarium species,

emphasizing early-stage disease suppression as a critical mechanism [7].

Crop Establishment and Growth

Seed treatment significantly enhanced emergence rate and stand counts at both locations. Dynamic 400 FS and Apron Star 42 WS achieved the highest stand counts, indicating better seedling survival and vigor. This is consistent with Tesfaye and Tadesse, who reported improved faba bean emergence following fungicide seed treatment [5]. Enhanced seedling establishment has also been reported in chickpea and lentil with fungicidal treatments [3].

Grain Yield

Grain yield varied significantly among treatments and varieties. Dynamic 400 FS-treated Dida'a produced the highest yield, while untreated Chalew had the lowest. Yield improvement was associated with reduced disease incidence and enhanced plant establishment. Mekonnen and Getaneh similarly observed 20–45% yield improvement in treated faba bean under high disease pressure [8]. These results are consistent with international reports linking fungicide seed treatment to yield benefits in legumes [7].

Seed Quality

Fungicide-treated seeds exhibited significantly higher germination percentage compared with the untreated control across varieties and locations. Treatments such as Dynamic 400 FS and Kanzole 25% EC consistently resulted in superior germination performance, indicating effective protection of seeds from seed-borne and soil-borne pathogens during crop establishment and seed development. Higher germination percentages reflect improved physiological quality of seeds harvested from treated plots and suggest reduced deterioration caused by fungal infection.

Thousand seed weight (TSW) was also significantly enhanced by fungicidal seed treatments. Seeds harvested from fungicide-treated plots were heavier than those from untreated plots, implying improved seed filling and assimilate accumulation. This improvement can be attributed to healthier plants with reduced disease pressure, allowing more efficient photosynthesis and translocation of assimilates to developing seeds. Similar increases in TSW following fungicide application have been reported in grain legumes grown under disease-prone environments.

Hectoliter weight (HLW), an important indicator of grain density and market quality, was significantly higher in fungicide-treated seeds than in the control. Dynamic 400 FS and Kanzole 25% EC treatments produced seeds with greater bulk density, reflecting uniform seed development and reduced shriveling. Improved HLW is often associated with lower levels of pathogen contamination and better overall grain soundness, which are critical attributes for both seed and food grain markets [13].

The observed improvements in seed quality parameters are consistent with previous studies conducted in Ethiopia and elsewhere. Hailu et al. reported that effective disease management practices significantly enhanced seed quality attributes of pulse crops grown on Vertisol soils [9]. Similarly, Yitbarek et al. documented higher germination, thousand seed weight, and hectoliter weight in faba bean varieties following fungicidal seed treatment [14].

These findings collectively demonstrate that fungicidal seed treatment not only suppresses disease but also contributes to improved post-harvest seed quality and planting value.

Across-Location Performance

The relative effectiveness of Dynamic 400 FS, Apron Star 42 WS, and Kanzole 25% EC remained consistent across both Kulumsa Agricultural Research Center and Arsi Robe. These fungicidal seed treatments showed stable performance in reducing root rot severity and improving crop establishment, grain yield, and seed quality across locations and varieties. The consistency of treatment effects under different environmental conditions suggests that these fungicides provide reliable early-stage protection against Fusarium solani, which is critical for sustaining faba bean productivity in disease-prone environments [5,7].

Such stability is particularly important in Vertisol-dominated farming systems, where high clay content, poor internal drainage, and seasonal fluctuations in soil moisture create favorable conditions for soil-borne pathogens. Periodic waterlogging

during the main cropping season often intensifies disease pressure, leading to severe yield losses if effective management strategies are not employed. Fungicidal seed treatments that maintain efficacy under variable moisture regimes offer a practical and dependable disease management option for smallholder farmers operating in Vertisol areas [4,12].

Integration with Previous Studies

Unlike many previous studies focusing solely on disease incidence, this study integrated disease severity, yield, and seed quality data. The findings confirm that combining adapted varieties with effective seed treatment maximizes faba bean productivity in Vertisol systems [5,7,15].

Conclusion

Fungicidal seed treatment significantly reduced the severity of Fusarium solani root rot and enhanced early crop establishment of faba bean grown on black Vertisol soils. Treated seeds exhibited improved emergence and seedling vigor compared with the untreated control, indicating effective protection against soil-borne pathogens during the critical early growth stages. Reduced disease pressure at establishment contributed to healthier plant stands and improved crop performance throughout the growing season.

In addition to disease suppression, fungicidal seed treatments had a positive effect on seed quality and grain yield. Treatments with Dynamic 400 FS, Apron Star 42 WS, and Kanzole 25% EC consistently resulted in higher germination percentage, greater thousand seed weight, improved hectoliter weight, and increased grain yield across varieties and locations. These improvements are attributed to enhanced plant health, efficient assimilate partitioning, and reduced pathogen contamination during seed development.

Overall, the findings demonstrate that fungicidal seed treatment is a practical, low-cost, and effective disease management strategy for faba bean production in Vertisol-dominated environments. The consistent performance of the most effective fungicides across locations highlights their suitability for wider recommendation. Integration of fungicidal seed treatment with adapted faba bean varieties can substantially improve productivity, seed quality, and resilience of faba bean-based farming systems in Ethiopia.

Recommendations

- Dynamic 400 FS and Apron Star 42 WS are recommended for seed treatment in root rot-prone Vertisol areas.
- Integration of resistant varieties with effective seed treatment should be promoted.
- Multi-location and multi-year trials are recommended to validate stability of treatments.
- Farmers should be trained on safe handling and application of seed treatment fungicides.

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