A Survey on Common Horticultural Diseases in Matabeleland South and Bulawayo Metropolitan Provinces of Zimbabwe

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ABSTRACT

In many farming communities across Zimbabwe, plant diseases often go unnoticed and unmanaged due to limited farmer knowledge and a shortage of skilled government agricultural extension officers. This study investigated the prevalence and management of horticultural crop diseases in Matabeleland South and Bulawayo Metropolitan Provinces through a questionnaire survey conducted in 2024 and 2025. A stratified random sampling design, incorporating Probability Proportional to Size (PPS) sampling, was used to select 300 farmers, ensuring adequate statistical power to assess variations in knowledge, perceptions, and practices. Although most farmers could recognize disease symptoms, significant knowledge gaps were observed in accurate diagnosis and effective disease management. A total of 11 horticultural diseases were identified in the study areas. The majority of farmers (69%) relied on chemical applications for disease control, while 26.3% practiced roguing of infected plants. Only 2% adjusted irrigation frequency as a control measure. Notably, 57% expressed a preference for chemical disease control. A Pearson Chi-Square test revealed no significant association between farmers' education levels and their ability to identify plant diseases ($\chi^2 = 5.08$, df = 6, p = 0.53). This suggests that misdiagnosis and inappropriate use of fungicides, bactericides, viricides, and nematicides are common. There is need to deploy and adequately equip trained extension officers in both rural and urban farming communities. Regular disease surveillance, including field scouting and early detection systems, is also critical to identifying emerging threats and supporting timely, effective disease management.

Keywords: access to extension services, horticultural crops, farmer knowledge, plant disease diagnosis, disease surveillance

INTRODUCTION

Zimbabwe's extension-worker coverage for smallholder farmers is well above the ideal threshold (400–500), and highly under-resourced. The nationwide agricultural extension to farmer ratio in the smallholder and communal areas is approximately 650 farmers per extension officer. This ratio indicates that extension workers are overstretched, especially in smallholder and communal areas. Government policy data (National Agriculture Policy Framework 2019–2030) cites about 4 200 extension workers serving around 1.8 million farmers, giving a ratio near 800 farmers per worker. Additionally, the extension workers are under-resourced, do not offer practical solutions, are not always readily available and in some cases, they do not provide farmers with agricultural marketing extension support (Muchesa et al. 2019). Smallholder farmers in Zimbabwe therefore lack access to timely and reliable agriculture extension services (FAO, 2018). In contrast, in developed countries, the agricultural extension worker to farmer ratio is much lower than in countries like Zimbabwe (Tables 1 and 2). Farmers in developed countries therefore have better access to professional advisory services**.**

Table 1. Extension-to-farmer ratios in developed countries

Country/Region	**Typical Ratio**	**Notes**
United States	1:50 – 1:200	Public-funded Cooperative Extension Service through universities; specialized agents (crops, livestock, marketing).
European Union (average)	1:100 – 1:250	High variance: Western Europe has lower ratios, Eastern Europe slightly higher. Significant private sector participation.
The Netherlands	1:40 – 1:100	Very intensive extension; strong integration with farmer cooperatives and agribusiness advisory services.
Australia	1:100 – 1:200	Combination of government and private extension agents, especially for commercial farms.
Canada	1:100 – 1:300	Mix of public extension and private consulting services; high mechanization reduces demand for routine extension.
United Kingdom	1:40 – 1:100 (private)	Limited public extension; farmers rely heavily on paid private consultants and agricultural advisors.

Table 2. Comparison with Zimbabwe

	Zimbabwe (smallholders)	**Developed Countries**
Ratio	1:600 – 1:800	1:50 – 1:300
Extension Type	Mostly public, overstretched	Mix of public, private, and cooperatives
Tech Use	Low to moderate	High (apps, AI, remote sensing)

High extension officer to farmer ratios imply that extension officers often work beyond capacity, and are less able to offer timely targeted advice**,** field demonstrations, and market facilitation, especially critical for emerging technologies and climate-smart farming. Critical routine farm practices such as scouting for pests and diseases, which require regular agricultural extension interventions, often become neglected. Unlike in developed countries where farmers have access to modern technological tools for plant pest and disease detection and monitoring, farmers in Zimbabwe typically lack access to modern technological tools for plant pest and disease detection and monitoring. Instead, they often rely on traditional or low-technology detection methods, which are less effective and result in delayed diagnosis and intervention (FAO, 2021). In developed countries, advanced molecular and sensor-based technologies such as polymerase chain reaction (PCR), reverse transcription PCR (RT-PCR), loop-mediated isothermal amplification (LAMP), and enzyme-linked immunosorbent assay (ELISA) are widely used for early and accurate pathogen detection (Agrios, 2022). Limited adoption of these technologies in Zimbabwe increases the risk of late disease detection, subsequently heightening crop vulnerability to outbreaks (FAO, 2021).

In Zimbabwe's communal farming areas, smallholder farmers and extension officers apply practical methods to identify plant diseases, such as visually inspecting crops, regularly walking through fields to examine leaves, stems, and fruits for disease symptoms. They can also share knowledge about pests and diseases amongst themselves. Farmers share observations and remedies through community meetings, field days, or local farmer groups. In some cases, they use traditional indicators which include seasonal disease patterns, for example, blight after heavy rains. In some cases, where resources and road access permit, agricultural extension officers visit farmers and help them to identify diseases. The extension officers use their expertise or field diagnostic guides, posters, or manual charts to identify plant diseases (Table 3). They can confirm suspected cases and recommend management strategies (especially for notifiable diseases). The growing access to mobile phones can allow farmers to use mobile phone consultations. Farmers and agricultural extension officers can create or join WhatsApp groups. Using these platforms, farmers can share photos of affected plants for peer or expert review. The mobile telecommunications giant, Econet Wireless, has introduced a mobile platform named EcoFarmer where farmers can access SMS-based advisory services (Mabika et al. 2025). Farmers can also utilize Non-Governmental Organisations (NGOs) and Development Project Interventions. Projects run by development partners such as the FAO, Amalima Loko (USAID/Bureau for Humanitarian Assistance) and World Vision often offer seasonal disease alert workshops and posters. Community demonstration plots have been established in some parts of Zimbabwe where extension officers can showcase disease control methods.

In Bulawayo, a semi-arid region of Zimbabwe with urban and peri-urban horticulture, and in Matabeleland South Province, farmers face several horticultural diseases due to the combination of climatic stress, limited resources, and improper pest and disease management (Table 4). Under moderate to severe infection, diseases such as common bacterial blight cause yield losses of 40 to 70% (Karavina et al. 2011).

Table 3. Sample of a plant disease identification guide

Disease	**Crop**	**Image**	**Main symptoms**
Late blight (*Phytophthora infestans*)	Tomato		Brown leaf spots, fruit rot
Early blight (*Alternaria solani*)	Tomato		Target-shaped lesions
Damping off (*Pythium*, *Rhizoctonia*)	Leafy veg		Seedling collapse

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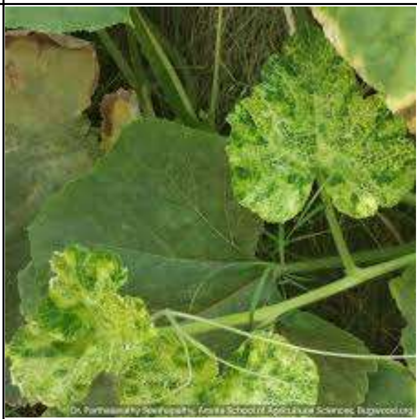
Disease	**Crop**	**Image**	**Main symptoms**
Powdery mildew	Cabbage, Beans		White powder on leaves
Mosaic virus			Leaf mottling and curling
Citrus canker (*Xanthomonas axonopodis*)	Citrus		Corky leaf/fruit spots
Root rot	Tomatoes, onions		Wilting, brown roots

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Table 4. Some diseases which typically occur in Matabeleland South and Bulawayo Metropolitan Province

Disease	**Crops Affected**	**Symptoms**	**Control Measures**
Fungal			
Powdery Mildew (*Oidium* spp.)	Tomatoes, cucurbits (e.g., pumpkins), beans	White powdery coating on leaves and stems	Use sulfur-based fungicides, plant spacing
Early Blight (*Alternaria solani*)	Tomatoes, potatoes	Concentric brown spots on lower leaves	Remove infected debris, use fungicides (e.g., Mancozeb)
Downy Mildew (*Peronospora* spp.)	Leafy greens (e.g., spinach), cucurbits	Yellowing leaves with greyish growth underneath	Copper-based sprays, improve air circulation
Bacterial Diseases			
Bacterial Wilt (*Ralstonia solanacearum*)	Tomatoes, potatoes, eggplants	Sudden wilting without yellowing, brown vascular tissues	Use resistant varieties, crop rotation, remove infected plants
Bacterial Leaf Spot (*Pseudomonas* and *Xanthomonas* spp.)	Leafy greens, tomatoes	Small dark lesions, leaf drop	Copper-based sprays, avoid overhead irrigation
Common bacterial blight *Xanthomonas campestris* pv. *phaseoli*	Common bean, cowpea and leguminous vegetables	Water-soaked spots on leaf margins expanding and turning brown with yellow halos, blighting, premature leaf drop. Stem lesions, discoloured seeds which shrivel and germinate poorly.	Cultural, chemical, sanitation, tolerant crop varieties
Viral Disease			
Tomato Yellow Leaf Curl Virus (TYLCV)	Tomatoes	Leaf curling, stunting, yellowing	Use virus-free seedlings, control whiteflies
Cucumber Mosaic Virus (CMV)	Cucurbits, tomatoes, peppers	Mottled leaves, fruit distortion	Remove infected plants, control aphids
Soil-Borne and Root Diseases			
Root Knot Nematodes (*Meloidogyne* spp.)	Tomatoes, carrots, okra, leafy vegetables	Root galls, stunted growth	Solarisation, organic amendments, crop rotation
Damping-Off (*Pythium* and *Rhizoctonia* spp.)	Seedlings of all vegetables	Seedling collapse, rotting stems	Sterilize soil, improve drainage, use seed treatments

Local horticultural disease risk factors in Bulawayo and Matabeleland South provinces

Water scarcity is a significant constraint in Bulawayo and the broader Matabeleland South region, characterized by semi-arid climatic conditions and frequent droughts. These water limitations have profound effects on horticultural crop health and disease prevalence, affecting both smallholder and commercial farming systems. Water scarcity imposes physiological stress on horticultural crops such as tomatoes, leafy vegetables, and fruit trees, leading to weakened plant defense mechanisms (Jones, 2007). Stressed plants are more vulnerable to opportunistic pathogens, including fungal agents causing wilt and rot diseases common in these regions (Kriel and Kfir, 2006). Dry conditions associated with water scarcity tend to reduce soil moisture, affecting the survival and spread of some water-dependent pathogens like *Phytophthora* species. However, pathogens adapted to dry environments, such as powdery mildew (*Leveillula taurica*) and bacterial wilt (*Ralstonia solanacearum*), may proliferate (Muthoni et al., 2016). These changes alter disease incidence and severity patterns in horticultural fields. Water scarcity restricts irrigation and sanitation practices critical for disease control. For example, adequate irrigation can reduce stress and minimize the vulnerability to diseases, but limited water availability hampers this (Maphosa et al., 2020). Additionally, washing of tools and application of foliar sprays become less feasible, increasing disease risks. In both Bulawayo and Matabeleland South, farmers often resort to using marginal water sources such as untreated borehole water or wastewater for irrigation, which can introduce pathogens to crops or soil (Manzungu & Manzungu, 2018). This contributes to the spread of soil-borne and foliar diseases, exacerbating crop losses. Water scarcity in Bulawayo and Matabeleland South significantly influences the epidemiology of horticultural diseases by increasing plant stress, shifting pathogen prevalence, limiting disease control methods, and increasing reliance on potentially contaminated water sources. Integrated water management and disease control strategies are essential for sustainable horticultural production in these regions.

Drainage and waterlogging can affect land use efficiency (Chikwanda et al. 2025). In many backyard gardens, the land used for horticultural crop production has poor drainage due to municipal construction regulations requiring soil compaction for structural stability of houses, sewer lines, roads and stormwater and drainage systems. The regular movement of machinery such as graders, trucks and rollers always compact the topsoil. Additionally, limited green spaces result in repeated foot traffic causing impervious surfaces nearby. Soil microbes help plants by enhancing nutrient cycling and preventing diseases. In compacted soils, microbial activity is reduced. The numbers of beneficial microbes also tend to decline in compacted soils due to poor conditions such as reduced aeration. Compacted soils reduce growth of the root systems, restricting root penetration of the soil, which increases water and nutrient stress. This stresses horticultural crops by reducing plant root penetration into the soil, increases surface water runoff and denies the plants the required moisture necessary for growth and development. Reduced drainage as a result of soil compaction can result in waterlogging, creating anaerobic conditions which favours diseases such as *Phytophthora* in tomatoes (Abuarab et al. 2019; Ma et al. 2023).

Waterlogging and anaerobic conditions in soils can lead to several horticultural diseases (Topali et al. 2024; Tyagi et al. 2024; Das et al. 2025; Zhang et al. 2025), especially in crops like tomatoes, cabbages, and other vegetables commonly grown in urban gardens or low-lying fields. These conditions reduce oxygen in the root zone, creating a favourable environment for soilborne pathogens, including Pythium root rot or damping off (*Pythium* spp.) which affects tomatoes, cabbage seedlings, lettuce and spinach. Phytophthora root and crown rot (*Phytophthora capsici* and *P. nicotianae*) which affect tomatoes, peppers, cabbage and cucurbits can also be widespread in waterlogged conditions and are characterized by sudden wilting, root rot, crown lesions and sudden plant death. Fusarium wilt caused by *Fusarium oxysporum*, which is characterized by wilting, yellowing of leaves and vascular browning, is not anaerobic but symptoms in susceptible plants such as tomatoes, lettuce and cabbage are severe in stressed or waterlogged plants can affect. Other diseases associated with waterlogged soil conditions include bacterial soft rot caused by *Erwinia carotovora*, now called *Pectobacterium carotovorum*, which affects cabbage, carrots, tomatoes and onions; clubroot (*Plasmodiophora brassicae*) of cabbages and other brassicas; and Rhizoctonia root rot (*Rhizoctonia solani*) of lettuce, beans, tomatoes and carrots.

Bulawayo and Matabeleland South provinces are threatened with aphids and whiteflies. Horticultural diseases transmitted by aphids and whiteflies pose significant challenges to crop production in Zimbabwe, particularly in key horticultural regions such as Bulawayo Metropolitan and Matabeleland South. Aphids, primarily *Aphis gossypii* and *Myzus persicae*, are efficient vectors of several devastating viruses including cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), and potato virus Y (PVY), which cause symptoms like mosaic patterns, leaf distortion, and yellowing, resulting in substantial yield and quality losses in cucurbits, tomatoes, peppers, and leafy vegetables (Munyadzwe et al., 2022; Gwavava et al., 2023). These viruses are transmitted via a non-persistent or persistent mode, allowing aphids to spread pathogens rapidly as they probe or feed on multiple plants in urban and peri-urban farms where crop diversity and density favor vector population build-up (Munyadzwe et al., 2022). Similarly, whiteflies, especially *Bemisia tabaci*, are major vectors of begomoviruses such as tomato yellow leaf curl virus (TYLCV) and cassava mosaic disease viruses, which induce leaf curling, chlorosis, stunting, and fruit malformation in tomatoes, okra, and cassava (Chigumira et al., 2023; Nhiwatiwa and Matengaifa, 2021). These whitefly-transmitted viruses are semi-persistent to persistent, facilitating prolonged virus retention and dispersal across cropping seasons, exacerbated by Zimbabwe's warm climate and inadequate vector management strategies (Chigumira et al., 2023). The combined pressures of aphid- and whitefly-transmitted viruses are particularly acute in peri-urban areas around Bulawayo and Matabeleland South, where limited diagnostic capacity and restricted access to certified virus-free planting materials hinder timely disease control (Munyadzwe et al., 2022). Recent integrated pest management research emphasizes the importance of regular vector monitoring, resistant cultivars, and farmer training to mitigate these viral diseases (Gwavava et al., 2023; Chigumira et al., 2023). As urban horticulture expands in Zimbabwe, addressing aphid- and whitefly-mediated virus transmission remains critical for sustainable crop production and food security. Some of the diseases transmitted by these insects are listed below (Table 5).

Table 5. **Diseases spread by aphids and whiteflies** *Lipaphis erysimi*

Disease	Pathogen	Vector	Symptoms
Tomato Yellow Leaf Curl Virus (TYLCV)	Begomovirus	Whiteflies (Bemisia tabaci)	Leaf curling, yellowing, stunted growth, poor fruit set
Potato virus Y (PVY)	Potyvirus	Green peach aphid (Myzus persicae), other aphids	Mottling, yellowing, fruit deformation
Turnip Mosaic Virus (TuMV)	Potyvirus	M. persicae, cotton aphid (Aphis gossypii), cabbage aphid (Brevicoryne brassicae), mustard aphid (Lipaphis erysimi)	Yellow mosaic on leaves, reduced head formation
Cauliflower Mosaic Virus (CaMV)	Caulimovirus	M. persicae, B. brassicae, L. erysimi	Leaf mottling, vein clearing, poor growth
Cucumber Mosaic Virus (CMV)	Cucumovirus	Over 80 aphid species	Leaf distortion, stunted plants, malformed fruits
Pepper Yellow Leaf Curl Virus	Begomovirus	B. tabaci	Yellowing and curling of leaves, stunted fruits
Zucchini Yellow Mosaic Virus (ZYMV)	Potyvirus	M. persicae, A. gossypii, cowpea aphid (Aphis craccivora)	Mosaic and yellowing, fruit malformation
Squash Leaf Curl Virus	Begomovirus	Whiteflies Bemisia tabaci	Leaf curling, thickening, reduced fruiting

Horticultural production plays a crucial role in enhancing food security and income generation in semi-arid regions such as Matabeleland South. In the Bulawayo Metropolitan Province, horticulture is not just about growing food, but a strategy for survival, resilience and income generation. With urban expansion, water scarcity, and economic challenges, horticulture offers a practical and scalable solution to improve urban livelihoods and food systems. It is also a tool for empowering the youth, apart from providing educational and

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research opportunities.

MATERIALS AND METHODS

Study sites

The surveys were conducted in Matabeleland South and Bulawayo Metropolitan Provinces (Figures 1 and 2). Matabeleland South Province, which is located in the southwestern part of Zimbabwe, shares international borders with Botswana and South Africa**,** and domestic borders with Matabeleland North, Midlands, and Masvingo provinces. It serves as a gateway for cross-border trade and migration, making it geopolitically significant. It has a **s**emi-arid climate, with low and erratic rainfall, making it highly prone to droughts. Thorny bushes, grasses and acacia trees constitute the mainly savanna vegetation. Predominant soils are mostly sandy and loamy soils with limited fertility. Gold found mainly in Filabusi and Gwanda, is the major mineral resource in the province. Agriculture is predominantly livestock-based (cattle, goats, donkeys). There is limited crop production due to the dry climate and erratic rainfall. Irrigated horticulture is practised in irrigation schemes. Some dryland cropping of sorghum, millet, maize (mainly in better-rainfall pockets) is done. The GPS coordinates of the centre of the province, which falls between Gwanda and Makhado, is Latitude 21.0000° S and Longitude 29.0000° E. GPS coordinates of major towns in Matabeleland South are shown in Table 6.

Table 6. GPS coordinates of major towns in Matabeleland South

Town/City	Latitude (S)	Longitude (E)
Gwanda	20.9333°	29.0000°
Beitbridge	22.2167°	30.0000°
Plumtree	20.4833°	27.8167°
Esigodini	20.2833°	28.9333°
Filabusi	20.5333°	29.2833°
Kezi (Maphisa)	20.7500°	28.4833°

Figure 2. Matabeleland South Province

Source: Wikimedia Commons, 2006

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Bulawayo Metropolitan Province is the smallest province in Zimbabwe and consists almost entirely of the City of Bulawayo, the second-largest city in the country. It is surrounded by Matabeleland North and Matabeleland South Provinces, but is administratively distinct. The central GPS Coordinates of Bulawayo City, from near the central business district (CBD), are latitude 20.1575° S, and longitude 28.5847° E. GPS coordinates of some of the key locations in Bulawayo are shown in Table 7.

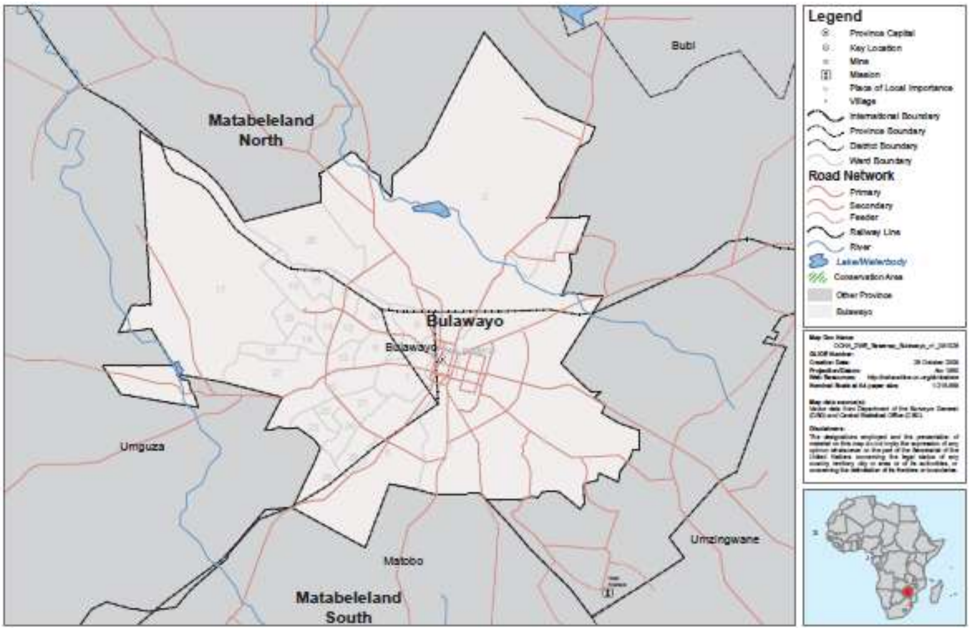

Figure 3. Bulawayo Province

Source: OCHA, 2009

Table 7. GPS coordinates of some of the key locations in Bulawayo

Location	Latitude (S)	Longitude (E)
City Centre (CBD)	20.1575°	28.5847°
Luveve (Suburb)	20.1083°	28.5589°
Nkulumane (Suburb)	20.2539°	28.5083°
Belmont Industrial Area	20.1692°	28.6050°
Hillside (Suburb)	20.2058°	28.6153°
Joshua Mqabuko Nkomo International Airport	20.2176°	28.6358°

Ethical considerations: Government clearance and farmer consent

Prior to conducting the questionnaire survey, clearance to carry out the surveys in the two provinces was sought from the Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement through the Department of Research and Specialist Services, and granted. This was done to ensure that the research was legal, ethical, coordinated, culturally and politically sensitive. Prior to the surveys, each farmer completed a consent form in which they confirmed that they were willing to voluntarily participate in the surveys, and that there was no coercion in taking part in the research. The respondents were told about the purpose of the research, how it was going to be conducted, and their rights during and after the surveys. In the consent form, farmers were guaranteed that the information that they were going to provide would be kept confidential, and be used only for academic purposes. Generally, this was done to ensure that the research was conducted ethically, legally, and transparently.

Questionnaire pretesting

Prior to the actual data collection, a pretest survey involving 10 respondents who were representative of respondents who were to be interviewed in the main survey was conducted, as described by Tibugari et al. (2012). This was meant to check if questions were properly phrased so as to be understood and interpreted as intended by the objectives of the study (Crawford 1997; Czaja 1998) and to check how long it took to interview one farmer. After the pre-test, the questionnaire was then revised before conducting the main survey, as described by Tibugari et al. (2020). The questionnaire used in the survey was developed in English. Two research assistants were trained on professional questionnaire administration, and they administered the questionnaires under supervision by the researchers. To ensure quality data during fieldwork, all questionnaires were checked for any inconsistency prior to data entry.

Data Collection and analysis

A stratified random sampling approach was employed to ensure a representative selection of farmers across the eight irrigation schemes in Matabeleland South and Bulawayo backyard gardeners, where 30 farmers were randomly selected from each site. Existing farmer registers within each irrigation scheme served as the sampling frame, a common practice in survey research. Probability Proportional to Size sampling was applied, considering the population of farmers in each scheme to ensure equitable representation. Using this approach, farmers were randomly selected within each scheme, maintaining proportionality to the total farmer population in the respective schemes. 300 farmers were interviewed. Interviewing such a large number of respondents was meant to increase accuracy and reliability of data, increase generalizability of results, give strong statistical power and enhance credibility of the study. Quantitative data obtained from the farmer survey were analyzed using the Statistical Package for the Social Sciences (IBM SPSS) version 29. Descriptive statistics were used to interpret and summarize farmers' knowledge, perceptions, and practices relating to seed treatment, irrigation routines, and disease control strategies.

RESULTS AND DISCUSSION

The results show that farmers in Bulawayo Metropolitan and Matabeleland South provinces grow a wide range of horticultural crops (Table 8).

Table 8. Some of the crops grown in the two study areas

Common name	Vernacular name	Scientific name	Family
Tomatoes	Itamatisi	Solanum lycopersicum L.	Solanaceae
Irish potato	Amagwili	Solanum tuberosum L.	Solanaceae
Cabbage	Ikhabitshi	Brassica oleracea var. capitata L.	Oleraceae
Carrots	Imqwente	Daucus carota L.	Apiaceae
Onion	Ihanyanisi	Allium cepa L.	Liliaceae
Broccoli	ibrokholi		
Sweet potato	Imbambayila	Ipomoea batatas	Convolvulaceae
Okra	Idelele	Abelmoschus moschatus Medik.	Malvaceae
Common bean	Indumba	Phaseolus vulgaris L.	Fabaceae
Garden cucumber	Umqumbi	Cucumis sativus L.	Cucurbitaceae

Common name	Vernacular name	Scientific name	Family
Green pepper	Ibilebile	Capsicum annuum L. var. annuum	Solanaceae
Butternut squash	Amathanga	Cucurbita moschata Duchesne	Cucurbitaceae
English giant rape	Imibhida emikhulu	Brassica napus L. var. napus	Brassicaceae
African horned melon	Amagage	Cucumis metuliferus E. Mey. Ex Naud.	Cucurbitaceae
Cowpea	Indumba	Vigna unguiculata (L.) Walp.	Fabaceae
Pawpaw	Amaphopho	Carica papaya L.	Caricaceae
Lemon	Ama Lamula	Citrus limon (L.) Osbeck	Rutaceae
Sweet orange	Orenji	Citrus sinensis (L.) Osbeck	Rutaceae
Naartjies	Ama natshisi	Citrus reticulata Blanco	Rutaceae
Peaches		Prunus persica (L.) Batsch	Rosaceae
Guava	amaGwava	Psidium guajava L.	Myrtaceae
Mango	iMango	Mangifea indica L.	Anacardiaceae
Apple		Malus domestica Borkh.	Rosaceae
Macadamia	ama Makadamia	Macadamia integrifolia Maiden & Betche	Proteaceae
Watermelon	amaGalikazi	Citrullus lanatus (Thunb.) Matsum. & Nakai	Cucurbitaceae
Avocado	iAvokhado	Persea Americana Mill. var. americana	Lauraceae
Banana	amaBhanana	Musa spp. Largely M. acuminata	Musaceae

Crop diversification is widely recognized as a key strategy for mitigating the risks associated with climate variability, market instability, and pest and disease outbreaks. According to Fujimoto and Suzuki (2025), diversification reduces the risk of total crop failure by spreading production across multiple species with differing stress tolerances. Furthermore, it contributes significantly to household food and nutrition security, as well as income stability (Mihrete and Mihretu, 2025; FAO, 2021). In the context of Zimbabwe's semi-arid provinces, particularly Bulawayo Metropolitan and Matabeleland South, farmers have increasingly embraced horticultural crop diversification despite environmental constraints. A combination of climatic, socio-economic, and cultural factors drives this trend. While the region experiences frequent droughts and erratic rainfall patterns, smallholder and urban farmers make use of water sources such as boreholes, rivers, wells, and smallholder irrigation schemes to sustain year-round horticultural production. This is especially true in peri-urban zones and resettlement areas where land access is comparatively better and water infrastructure, though limited, is locally managed (Moyo et al., 2023; Chikobvu and Zingore, 2020).

The proximity of these farming areas to urban centers such as Bulawayo provides a reliable and expanding market for fresh produce. High consumer demand for perishable vegetables and fruits such as tomatoes, leafy greens (e.g., covo, spinach), onions, cabbages, and peppers creates an incentive for farmers to grow high-value, fast-maturing crops. These crops are not only adaptable to small-scale irrigation but also generate quick returns, making them especially attractive in regions where landholdings are small and cash flow is essential for livelihood sustainability (Ncube et al., 2022; FAO, 2020). In Matabeleland South, where rainfall is often insufficient for staple crop production such as maize or sorghum, horticulture plays a vital role in enhancing household dietary diversity and buffering against food insecurity during lean seasons. Women and youth, in particular, have become key participants in small-scale horticulture, using the income generated for school fees,

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health care, and reinvestment in agricultural inputs (Mutambara and Dube, 2021). Thus, crop diversification through horticulture is not only a climate risk management strategy but also a pathway toward more resilient livelihoods and inclusive economic growth in Zimbabwe's marginal environments.

Furthermore, increased support from non-governmental organizations (NGOs), government extension programs, and agricultural input schemes has enhanced farmers' access to quality inputs, knowledge, and market linkages, thereby encouraging crop diversification (FAO, 2022; Chagwiza et al., 2021). The adoption of protected cultivation technologies, such as shade nets, alongside small-scale drip irrigation systems, has enabled farmers in semi-arid regions to successfully grow high-value horticultural crops, including herbs and exotic vegetables (Mavhura et al., 2023; Ncube et al., 2021). Fruit trees contribute essential vitamins, minerals, and dietary fiber, improving the nutritional status of rural and peri-urban communities (FAO & WHO, 2021). In drought-prone areas like Matabeleland South, where staple crop yields are often unreliable, fruit production provides a valuable alternative and more stable food source (Mujuru et al., 2020). Crops such as mangoes, guavas, pawpaws, and citrus fruits represent high-value commodities with strong demand in local and urban markets, including Bulawayo (Mashingaidze et al., 2022). The integration of fruit trees diversifies income streams beyond traditional crop and livestock farming, contributing to poverty alleviation and economic resilience (Mujeyi & Fraser, 2021). Many fruit tree species are drought-tolerant and adapted to the semi-arid climate of these provinces; their deep root systems stabilize soil, reduce erosion, and improve microclimates by providing shade and enhancing soil organic matter (Mapfumo et al., 2020). These characteristics make fruit trees particularly suitable for smallholder, backyard, and peri-urban farming systems that dominate Bulawayo and Matabeleland South (Mavhura et al., 2023).

Once established, fruit trees require relatively low maintenance and can be seamlessly integrated into homestead gardens, supporting sustainable intensification (Chagwiza et al., 2021). Furthermore, fruit cultivation, harvesting, processing, and marketing generate employment opportunities along the value chain, fostering local economic growth and encouraging youth participation in agriculture (Mashingaidze et al., 2022). Fruit trees also hold cultural significance, being integral to traditional ceremonies, culinary practices, and medicinal uses, thus strengthening community identity and heritage (Mujuru et al., 2020). Given the diversity of garden and fruit crops cultivated in Bulawayo and Matabeleland South, farmers are at risk of infestations by a wide range of pests and diseases. Therefore, investing in effective horticultural disease prevention and control measures is critical to minimizing crop losses and safeguarding livelihoods (FAO, 2022; Mapfumo et al., 2020).

Key informant interviews revealed that the following horticultural diseases often occurred in the two study areas (Figure 3).

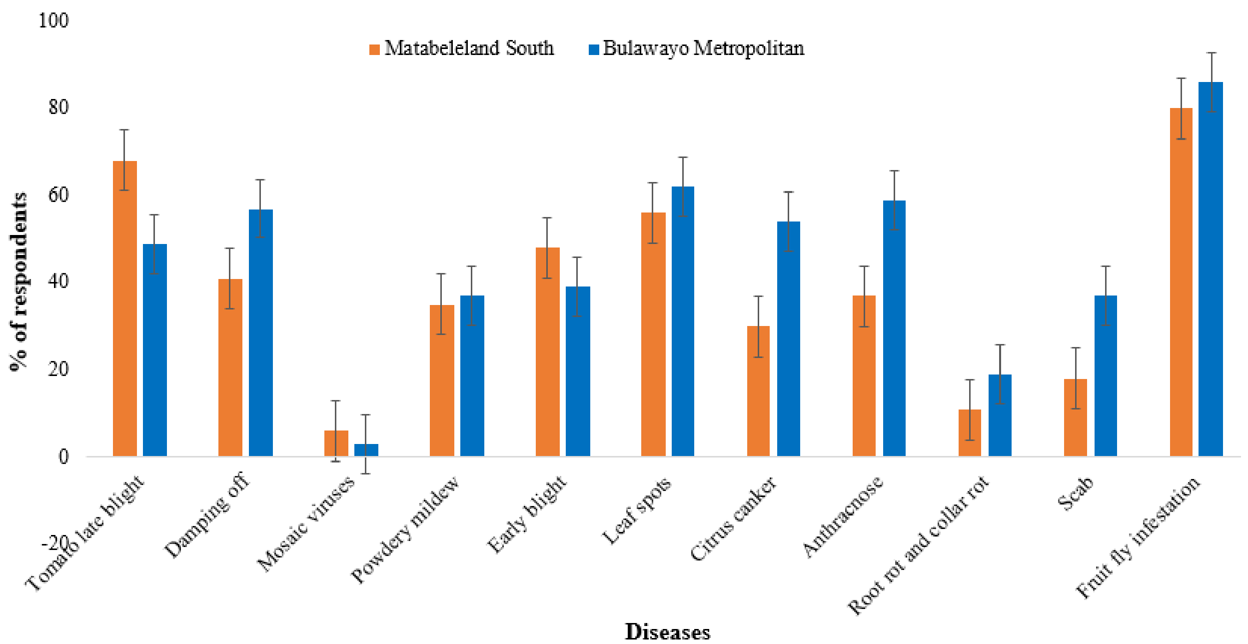

Figure 4. Diseases reported to infest horticultural crops in the two study areas

Fruit fly infestation was identified as the most widespread pest problem affecting horticultural crops in both Matabeleland South and Bulawayo Metropolitan Provinces. Tibugari et al. (2013), found that the pest was also highly prevalent in Mashonaland East Province of Zimbabwe. Musasa et al. (2019) found that the large population size, the polyphagous nature of one of the dominant fruit fly species, *Bactrocera dorsalis* (Hendel), and the continuous availability of suitable host fruit species during the year complicates the eradication of this species. The high prevalence of fruit fly underscores the urgent need to implement targeted fruit fly management and control programmes in these regions. Fruit flies (family Tephritidae) are notorious for causing significant damage to a wide range of fruit and vegetable crops by laying eggs inside the fruit, leading to larval development that ruins the produce and reduces marketability (Ekesi and Billah, 2007). If left unmanaged, infestations can result in severe yield losses and economic hardship for smallholder farmers who depend on horticulture for income and food security (Mwatawala et al., 2006). Moreover, the presence of fruit flies can restrict access to both local and export markets due to quarantine restrictions and increased phytosanitary requirements (Sivinski et al., 2013). Effective control strategies may include integrated pest management (IPM) approaches combining cultural methods such as field sanitation and crop rotation, biological control using natural enemies, and the judicious use of bait traps and selective insecticides (Manrakhan et al., 2008). Additionally, community-wide coordination is critical to ensure area-wide suppression, as fruit flies can easily migrate between farms and neighboring areas (Shelly et al., 2014). Given the importance of horticultural production to livelihoods in these provinces, government and extension services should prioritize resource allocation, farmer education, and continuous monitoring to curb the spread and impact of fruit fly infestations. Without timely intervention, the economic and food security consequences for smallholder farmers in Matabeleland South and Bulawayo Metropolitan provinces and the wider community could be substantial.

Diseases more Prevalent in Bulawayo Metropolitan are citrus canker (54 vs 30), Scab (37 vs 18), damping off (57 vs 41), anthracnose (59 vs 37), and root and collar rot (19 vs 11). These may indicate more humid urban microclimates, denser planting, or poor drainage and seedling management practices. Diseases more prevalent in Matabeleland South include tomato late blight, early blight (48 vs 39), and leaf spots (56 vs 62, though slightly more in Bulawayo). This suggests more open-field tomato production with higher exposure to pathogen-conducive conditions. Mosaic viruses and Root/collar rot were low incidence diseases showing the lowest numbers in both provinces, which may reflect either, less visibility or underreporting, or less conducive environments for viral vectors and root pathogens.

The results imply that tailored interventions are needed for each province. In Bulawayo Urban, disease management, nursery hygiene (damping off), and citrus care must be emphasized. In Matabeleland South, open field fungicide scheduling and growing late blight resistant varieties should be encouraged. Monitoring and control of fruit flies is critical across both provinces due to its top-ranking prevalence. Farmer training in disease identification and integrated pest and disease management would help address most of these issues.

Recognition of plant diseases

A large majority of respondents (87%) reported experiencing plant diseases in their crops, indicating the widespread prevalence of horticultural diseases in Matabeleland South and Bulawayo Metropolitan Provinces. Most farmers relied on visible symptoms to identify diseases in their crops. Farmers also identified leaf spot in tomatoes and spinach through the appearance of small brown or black spots surrounded by yellow rings on the leaves, which often leads to early leaf drop. In choumollier, powdery mildew was said to be common, and farmers identified it through white powder-like patches on the leaf surfaces.

In rape and cabbage, farmers recognized downy mildew by noticing pale yellow patches on the upper side of the leaf and grey mold underneath. Onion farmers in Filabusi reported encountering soft rot or neck rot, especially post-harvest, when bulbs become mushy and start to emit a foul smell. Farmers reported that okra, though it is hardy, was affected by leaf spot and yellow vein mosaic virus, observed through yellowing, distorted leaves, and stunted pods. While carrots were generally reported to be less susceptible to diseases, some farmers mentioned alternaria leaf blight, identified by dark brown spots with ring patterns on old leaves.

Across the region, farmers emphasized that their primary method of disease identification was visual, informed by years of experience and community knowledge. One elderly farmer remarked, *"We were never taught this in* *school, we just learn from what we see and what others tell us."* Unfortunately, this traditional approach is not always accurate, and farmers admitted to lacking access to formal training or technical support from agricultural extension officers. Compounding the issue was the sourcing of seeds. The study revealed that many smallholder farmers in the study areas obtained seeds from informal markets. Others used seeds recycled from previous harvests, or obtained the seeds from neighbours. The prohibitive cost of hybrid seed has constrained its adoption among smallholder farmers in Zimbabwe (Tibugari et al., 2019). As a result, these farmers remain highly vulnerable to seed-borne diseases due to continued reliance on uncertified or recycled seed.

Watering frequency practices among farmers

A majority of respondents (53.3%) reported watering their horticultural crops every three days, while 26.7% did so once a week. A smaller proportion (15.7%) watered every two days, and only 4.3% irrigated their crops daily. The study found a statistically significant association between farmers' experience in crop production and their watering frequency ($\chi^2 = 21.002$, df = 9, p = 0.013), suggesting that irrigation practices vary according to the level of farming experience. A majority of respondents (53.3%) reported watering their horticultural crops every three days, while 26.7% did so once a week. A smaller proportion (15.7%) watered every two days, and only 4.3% irrigated their crops daily. The study revealed a statistically significant association between farmers' experience in crop production and their watering frequency ($\chi^2 = 21.002$, df = 9, p = 0.013), indicating that irrigation practices vary with farming experience. These variations in irrigation frequencies likely reflect differences in crop water requirements, as crops such as tomatoes and leafy vegetables typically demand more frequent watering than hardier crops like onions or cabbages (Mugabe et al., 2020; FAO, 2017). Tailoring irrigation schedules to crop-specific needs is essential for optimizing water use efficiency and maintaining crop health. Due to their semi-arid climate, Bulawayo and Matabeleland South provinces are characterized by high temperatures that significantly increase evapotranspiration rates, thereby intensifying water loss from both soil and plant surfaces. Elevated temperatures in horticultural production systems lead to higher evapotranspiration rates, necessitating more frequent irrigation scheduling to sustain optimal plant water status and minimize yield losses.

Approaches to managing crop diseases

A large proportion of respondents (69%) used chemical methods to control horticultural diseases, while 26% relied on removing diseased plants from the field (roguing) as their primary control strategy. The high preference for chemical use may be attributed to the immediate and visible results that chemical treatments offer, which are often perceived by farmers as more effective and reliable than other methods (Popp et al., 2013). In many cases, smallholder farmers in developing countries tend to prioritize short-term efficacy over long-term sustainability, especially when under pressure to minimize crop losses and maximize yields (Pretty and Bharucha, 2015). However, this reliance on chemical control is also likely influenced by a combination of structural and knowledge-based factors. These include limited access to extension support, aggressive marketing by agro-dealers, the widespread availability of chemical pesticides, and a lack of awareness or training on alternative disease management strategies such as cultural, biological, mechanical, and genetic approaches (Williamson et al., 2008; Isin and Yildirim, 2007). For instance, cultural methods such as crop rotation, sanitation, and spacing are often underutilized due to insufficient technical support, while biological control options remain largely unexplored due to lack of awareness and limited access to bio-based products (Waichman et al., 2007).

The widespread use of chemical pesticides, as observed in this study, underscores the horticultural sector's dependence on pesticide-based disease management. While chemical control can be effective for short-term suppression of pathogens, overreliance poses serious risks, including the development of pesticide-resistant strains of pathogens, contamination of soil and water resources, loss of beneficial organisms, and adverse effects on farmer and consumer health (Carvalho, 2017; Damalas and Koutroubas, 2016). These risks are particularly concerning in urban and peri-urban farming systems, such as those found in Bulawayo, where pesticide drift and misuse may directly impact densely populated communities.

Given these concerns, it is imperative to promote Integrated Disease Management (IDM) approaches that combine chemical control with sustainable, non-chemical strategies tailored to the local context (Kumar et al., 2020). Such approaches not only reduce environmental and health risks but also enhance the resilience of farming

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systems to emerging plant health threats. Strengthening farmer training, increasing access to extension services, and regulating the distribution and use of pesticides through policy interventions are essential steps toward reducing dependency on chemical controls and promoting safer, more sustainable plant health management practices.

Association between educational level and ability to identify diseases

The Pearson Chi-Square test yielded a non-significant result ($\chi^2 = 5.08$, df = 6, p = 0.53), indicating that there was no statistically significant association between the respondents' level of education and their ability to identify plant diseases. This finding suggests that formal education alone may not directly influence the practical ability of farmers to recognize symptoms of plant diseases in the field. Similar observations have been reported in other studies, which highlight that hands-on farming experience, extension support, and access to agricultural training often play a more critical role in enhancing farmers' diagnostic skills than general formal education (Bett et al., 2017; Mudege et al., 2021).

In many rural farming contexts, particularly in sub-Saharan Africa, farmers rely on indigenous knowledge, peer learning, and experiential observations rather than formal schooling to manage plant health (Ajani, 2009; Davis et al., 2012). The non-significant association also underscores the importance of strengthening farmer-targeted extension programmes that focus specifically on plant disease identification and management, regardless of farmers' educational background. As such, building farmer capacity through participatory methods, visual aids, and practical demonstrations may be more effective than relying solely on written materials or training models geared toward literate audiences (Lwoga et al., 2020).

CONCLUSIONS

Farmers in Matabeleland South and Bulawayo Metropolitan Provinces grow a wide variety of horticultural crops, which are highly susceptible to a broad spectrum of plant pathogens, including fungal, bacterial, viral, and nematode agents. However, most smallholder farmers exhibit limited diagnostic capacity and primarily rely on traditional or experiential knowledge to identify and manage diseases. This knowledge gap often leads to delayed or inappropriate responses, increasing the risk of crop failure and economic losses. The findings underscore an urgent need for strengthened, inclusive, and sustainable plant health support systems tailored to the needs of smallholder farmers. Key areas for intervention include farmer training, improved access to diagnostic services, and promotion of integrated disease management strategies that reduce overreliance on chemical control.

RECOMMENDATIONS

From the study, the following recommendations can be made:

1. The Government of Zimbabwe must increase investment in training and deployment of well-equipped extension officers, especially in remote and peri-urban farming areas, to support timely disease diagnosis and management.
2. Extension officers must encourage the adoption of holistic approaches that combine cultural, biological, mechanical, genetic, and chemical methods to manage plant diseases sustainably.
3. Government, the business community, development partners and other stakeholders must provide farmers with practical, low-cost diagnostic aids such as pictorial field guides, mobile-based image recognition apps, and community plant health clinics.
4. Government must enhance implement participatory farmer education programs (e.g., Farmer Field Schools) focused on disease identification, safe pesticide use, and alternative control strategies.

Further research is needed to:

1. Assess the accuracy and reliability of farmer-based disease identification methods and how these compare to laboratory or digital diagnostic tools.

2. Evaluate the effectiveness and adoption of non-chemical disease control strategies (e.g., biocontrol, resistant varieties, crop rotation) under smallholder conditions in semi-arid environments.

3. Investigate the role of agro-dealers and informal knowledge networks in influencing farmers' disease management decisions.

4. Develop and pilot low-cost digital tools (e.g., mobile apps, image recognition platforms) for early disease detection and farmer training in local languages.

5. Explore the socio-economic barriers such as gender, access to credit, and market access, that affect farmers' ability to implement recommended plant health practices.

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