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GREENHOUSE TOMATO FARMERS' KNOWLEDGE, PERCEPTIONS, AND MANAGEMENT OF TOMATO BACTERIAL WILT (*RALSTONIA SOLANACEARUM*) DISEASE

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ABSTRACT

A major constraint to tomato cultivation is bacterial wilt disease. The use of greenhouses to cultivate tomato is vital to controlling the bacterial wilt disease. Bacterial wilt can be successfully managed when farmers are well-informed with better knowledge of bacterial wilt in tomatoes. This study was conducted to assess farmers' knowledge and experiences on the cultivation practices, prevalence, detection, spread, and control of bacterial wilt disease in tomato in greenhouses in the Volta, Eastern, Central, and Greater Accra regions of Ghana. Questionnaires were administered for fifty (50) greenhouse farmers, purposefully selected using a database of greenhouse tomato producers in southern Ghana provided by the Ministry of Food and Agriculture (MOFA). Frequency data was analyzed using descriptive statistical analysis. The majority (86%) of respondents had formal education. Most of the greenhouses in operation were in the Greater Accra Region, and none was under cultivation in the Volta region at the time of the study. Most respondents have been involved in greenhouse tomato cultivation for barely three years. The frequency of greenhouse tomatoes production varied from one region to the other. Only 28% of greenhouse farmers knew the test to detect the disease with 64% of greenhouse farmers without any knowledge about how the disease spreads. 62% of respondents used roughing and burying of the infected plants to control the disease. Out of the 54 greenhouses (domes) surveyed, 12 were infected with the bacterial wilt disease. Greenhouse farmers had little knowledge on the spread, detection, and control of the bacterial wilt disease of tomato. The findings of this study would lead to the design of targeted training programs on cultivation practices, detection, spread and management of bacterial wilt of tomato to increase yield and boost income levels of greenhouse tomato farmers in Ghana.

Key words: bacterial wilt, tomatoes, spread, detection, control, greenhouse, farmers, constraints

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INTRODUCTION

Tomato (*Solanum lycopersicum* L) is a very important vegetable with enormous health benefits [1, 2, 3]. Tomato fruits and products are described as "protective foods," owing to the presence of lycopene, and other anticarcinogenic and antioxidant compounds in the tomato fruit. Tomato is regarded as a high-value crop cultivated mainly by smallholder farmers in all agro-ecological zones in Ghana [4]. The monetary expenditure on tomatoes exceeds that of any other vegetable in the country [5]. The global tomato production in 2012 was 161,793,834 tons. In Ghana, the total land area under tomato production in 2012 was 44,750 ha and yielded 321,000 tons, with a monetary value of US$118,630,000 [6].

Tomato cultivation in Ghana has been carried out mainly under open field cultivation. Despite its importance in Ghana, the average estimated tomato yield in the country is 7.5 tons ha^{-1}, which is far below the potential yield of 20 tons ha^{-1}. Low tomato yield in Ghana is attributed to biotic, including pests and diseases and abiotic factors. The impact of biotic factors, especially that of Bacterial wilt and other diseases on tomato cultivation in Ghana has resulted in a high net annual importation of fresh tomatoes from neighbouring countries, such as Burkina Faso [7]. Therefore, successive administrations in Ghana since 2007 have made efforts through several initiatives to enhance and sustain a steady yearly production and supply of tomatoes in Ghana. One of the significant initiatives to boost tomato production in Ghana is the adoption of greenhouses for tomato production. Use of greenhouses for vegetable production is a sustainable way of growing these crops worldwide [8, 9, 10, 11]. According to Hochmuth [12], tomatoes are very popular for cultivation under greenhouse production systems compared with lettuce and cucumber. In Ghana, greenhouses were introduced to reduce and/or control the incidence of tomato diseases in a controlled environment to produce healthy and safe tomatoes for human consumption with limited, and if possible without pesticide application [13].

The Government of Ghana in collaboration with relevant stakeholders launched the Export Marketing and Quality Awareness Project (EMQAP) under the Ministry of Food and Agriculture (MoFA) in 2007, which led to the setting up of the first greenhouses in parts of the country. Similarly, the Forest and Horticultural Crops Research Centre (FOHCREC) of the University of Ghana, under the Envirodome project in 2012 also established some domes at the Centre, and later in other parts of the country, all with the goal to boost tomato yields and the yields of other vegetables. In 2016, the World Bank through the West African Agricultural Productivity Programme (WAAPP) provided support for the Greenhouse Project to increase vegetable production in Ghana. The move by the World Bank to support the greenhouse project led to the construction and operation of greenhouses

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across Ghana. According to Elings *et al.* [13] cultivation of tomato in a greenhouse have two major advantages. Greenhouses protect the crop from adverse weather conditions, such as strong winds and heavy rains, and protect the crop against pests and diseases.

Subedi *et al.* [14] reported high incidence and severity of Bacterial wilt disease of tomato in Ghana. Bacterial wilt is classified as an A2 quarantine pest for European Plant Protection Organization [15], thus, endangering the export of tomatoes from Ghana internationally. Mansfield *et al.* [16] also ranked the bacterium, *Ralstonia solanacearum* in 2012 as the second most scientifically, and economically important phyto-pathogenic bacterium, only after Pseudomonas syringae. Therefore, there was need to collect data from greenhouse tomato growers on the many aspects of the disease in Ghana for effective and efficient management of the bacterial wilt disease in tomatoes. The objective of the study was to assess farmer knowledge, experiences and perceptions on the cultivation practices, prevalence, spread, detection, and management of the Bacterial wilt disease of greenhouse tomato.

MATERIALS AND METHODS

A survey was conducted between August and December 2017 in the Volta, Greater Accra, Eastern and Central regions of Ghana, to obtain information on Bacterial wilt disease from greenhouse tomatoes farmers. Greenhouses in each region were selected using a database, West African Agricultural Productivity Programme (WAAPP) with assistance from Agricultural Extension Agents (AEA's). The number of greenhouses selected for the survey was based on greenhouse operators known to produce tomatoes. Fifty (50) greenhouse farmers (respondents) (Table 1) were selected from the study area across four regions (Greater Accra, Eastern, Central and Volta regions) of Ghana. The study areas in the Greater Accra Region are associated with temperatures of 24.9 °C to 28.6 °C with an annual precipitation of 691 mm. The temperature in the Eastern Region ranges from 24.2 °C to 27.4 °C with an annual precipitation of 1413 mm. The temperature in the Central Region ranges from 24°C to 27.2 °C with an annual precipitation of 979 mm. The Volta Region has temperatures in the range of 24.9 °C to 28.6 °C and an annual precipitation of 1412 mm. Apart from Kade in the Eastern region, which has February and July as the warmest and coolest months, respectively, the other regions have March and August as the warmest and coolest months, respectively [17, 18].

A semi-structured questionnaire was designed, pre-tested, and administered to farmers in the study area who willingly provided information on their operations. Data were collected on their demographics, knowledge, experiences, and

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perceptions on the prevalence, spread, detection, and control of bacterial wilt disease of tomato. Data were collected and analysed (descriptive statistical - means and percentages) with EPI INFO (version 7.2 by Centers for Disease Control and Prevention, Atlanta, Georgia, USA).

RESULTS AND DISCUSSION

Greenhouses were mainly owned and operated by male farmers (70%), with females representing 30%. Majority (92%) of all greenhouse tomato farmers had formal education. Sixty percent (60%) of the majority (92%) had tertiary education, and 26% had Senior High School education. The percentage of respondents with Junior High School education was 2% and 4% had primary education.

Most greenhouse tomato farmers in Ghana have been engaged in greenhouse tomato production for one to 3 years. Eight percent (8%) of the greenhouse farmers surveyed had been in production for 4 to 6 years, and 6% had been in production for 7 to 9 years. There was no operational greenhouse in the Volta region, but the majority of greenhouses in operation were in the Greater Accra (Figure1).

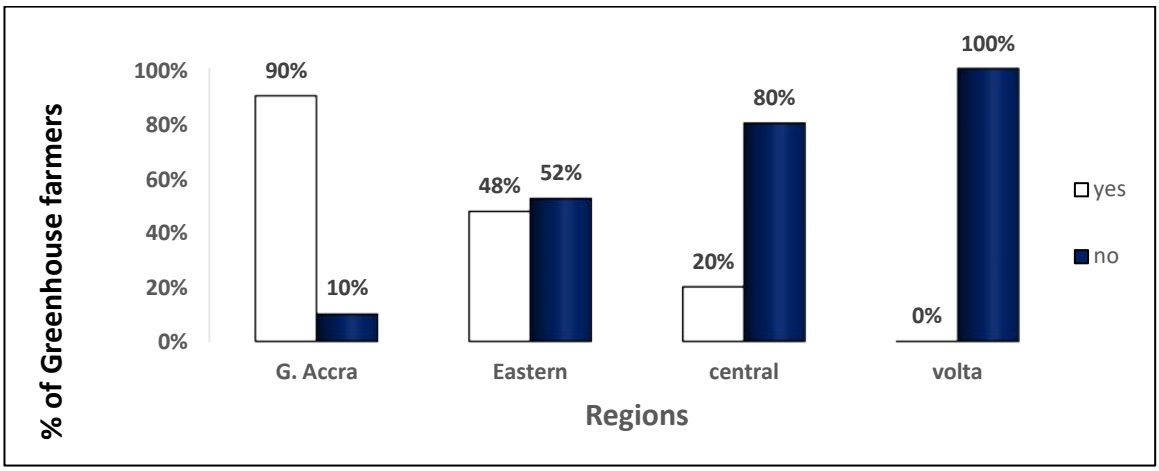

Figure 1: Percent of greenhouses in operation by region

Cropping frequency and sources of plant material used by greenhouse tomato farmers

In the Central region of Ghana, 80% of respondents grew tomatoes once a year and 20% grew tomatoes twice a year. In the Eastern region, 67% and 33% of respondents grew tomatoes once and twice a year, respectively. Thirty-three percent (33%) of respondents in the Volta region grew tomatoes once a year and 67% twice a year. Respondents in the Greater Accra region have multiple cropping seasons annually. Five percent (5%) of tomatoes farmers grew tomatoes once a year, with 68% growing tomatoes twice a year, 11% three times a year, and 16% of respondents grew tomatoes all year round.

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Tomato farmers in the study area indicated that they obtained their planting materials from more than one source. The majority of greenhouse tomato farmers obtained their planting material from Dizengoff Gh Ltd (92%) and Agrimat Gh Ltd (26%). The other sources where respondents obtained their seeds were East West Gh Ltd (12%), Imported (8%), other Agro dealers (14%), and Local market (8%).

Major greenhouse pests and diseases affecting tomatoes in the study area

The survey indicated that whitefly was the most prevalent pest (94%) infesting greenhouses in the study area. This was followed by Fusarium wilt disease (76%), and blossom end rot (70%). Leaf curl, leaf miner and powdery mildew followed with the following percentages 46%, 46%, 44%, respectively. Bacterial wilt disease was reported by 44% of greenhouse tomato farmers (Table 2).

Sources of irrigation water used by greenhouse tomato farmers

Fifty percent (50%) of respondents indicated that they use borehole water as the source of irrigation water. This was followed by pipe water (28%), which is provided and owned by Ghana Water Company Limited for irrigation. On the other hand, 20% and 2% of respondents use water from rivers and dams, respectively, which are mostly pumped into tanks and distributed via irrigation pipes within the greenhouses.

Susceptibility of commonly grown tomato varieties in greenhouse to bacterial wilt disease

The most cultivated tomato varieties in greenhouses across the study areas were: Eva, Nimonecta, Tatiana, Pectomech, Anna, and Padma. However, the Eva tomato variety, which was mostly grown by greenhouse farmers because of its good fruit characteristics such as redness of fruits, was mentioned to be the most susceptible to the bacterial wilt disease (Table 3).

Perception and experiences of greenhouse farmers concerning prevalence, symptoms, and awareness of bacterial wilt disease of tomato

Half (50%) of respondents had heard about the bacterial wilt disease of tomato with 44% reported observing the disease in their greenhouses. Some of the respondents had observed sudden wilt of tomatoes as symptoms of the disease in their greenhouses. Some respondents also observed low tomato yield in infected plants. Stunting of tomato plant, discoloration of vascular tissue, and sudden death were also reported by respondents as other notable symptoms of the BW disease known to respondents (Table 4).

Growth stage of greenhouse tomato at which bacteria affect tomatoes

From the survey, most (60%) respondents did not know the growth stage of tomatoes at which bacteria wilt affect tomatoes. However, some of them had

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observed bacteria wilt on their tomatoes at all growth stages of the tomato plant (Figure 2).

Seasonal prevalence of bacterial wilt of tomatoes in greenhouses

Respondents were generally not aware of the season in which the disease was prevalent. Some of them were of the view that the disease occurred during the wet seasons or when humidity was high (Figure 3).

Proportion of greenhouse tomatoes affected by bacterial wilt disease

Approximately 45.5% of greenhouse farmers observed 25%-50% of their tomatoes were affected by bacterial wilt disease. Others (18.2%) observed 50%-75% of their tomatoes were affected by the disease and 36% observed less than 25% of tomato plants affected by the disease.

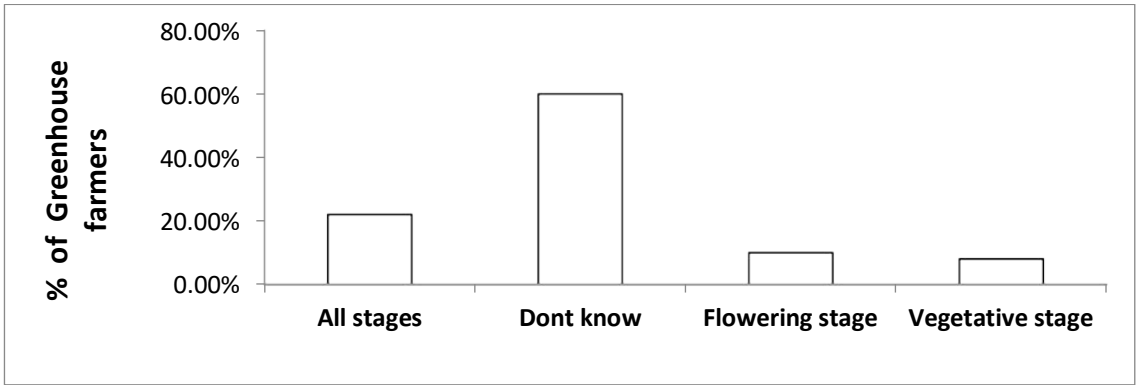

Figure 2: Perception of greenhouse tomato growers on growth stages of the plant where disease occurs

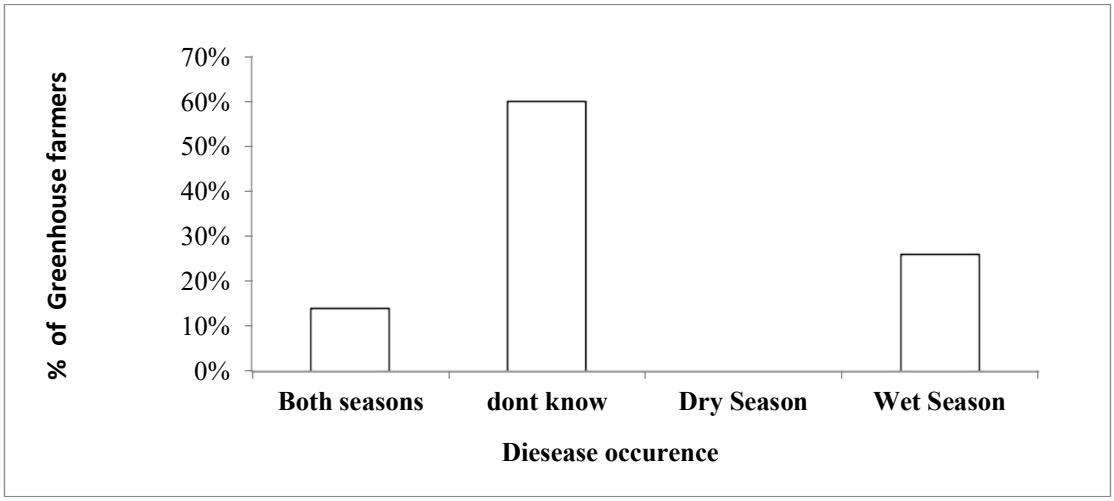

Figure 3: Greenhouse tomato farmer knowledge on season when bacterial wilt of tomato occurs

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Awareness of greenhouse tomato farmers about the bacterial wilt disease of tomato

Almost half (46%) of the respondents mentioned they had not heard about bacteria wilt (BW) of tomatoes. Fifteen farmers, representing 30 % of respondents stated that they had heard about the BW disease from school. Eight (8) and two (2) respondents indicated that their sources of information about the disease were from Extension Officers and their fellow farmers, respectively. A respondent also became aware of the disease through workshop with non-governmental organizations (NGO) and personal experience.

Knowledge, perception and experiences of greenhouse tomato farmer's concerning the detection of BWD

Majority (72%) of respondents had no knowledge on how the disease was detected on tomato, whereas a lesser number (16%) of respondents detected using the streaming test technique. Other respondents relied on other means of detection of the disease (Table 5).

Greenhouse tomato farmers' knowledge on the spread of BW disease

Most respondents (60%) had no knowledge of how the disease spreads. Other respondents (36%) attributed the spread of the disease to poor sanitation, 22% to infected seeds, 20% to contaminated tools, and 18% to irrigation water. Six percent (6%) of respondents attributed the transmission of the disease to insects and 4% and 2% of the respondents mentioned extreme temperatures and dust, respectively.

Greenhouse farmers' sources of information on the detection of BW disease

Sixty-six (66%) of respondents did not know of any source of information on the detection of BW disease, and 10% learned about its detection from school. Other greenhouse tomato farmers learned about the disease detection through personal experience (8%), from extension officers (12%), from colleague farmers (2%) or NGO/Workshop (2%).

Perception of greenhouse tomato farmers on the causes, spread, and control of bacterial wilt disease

Tomato farmers in the study attributed the cause of bacterial wilt (BW) disease to several factors (Fig. 4). Most of the greenhouse farmers (70.83%) attributed the cause of the disease to bacteria, while 29.17% do not know the cause of the disease. No farmer attributed the cause to fungi, nematode or insects.

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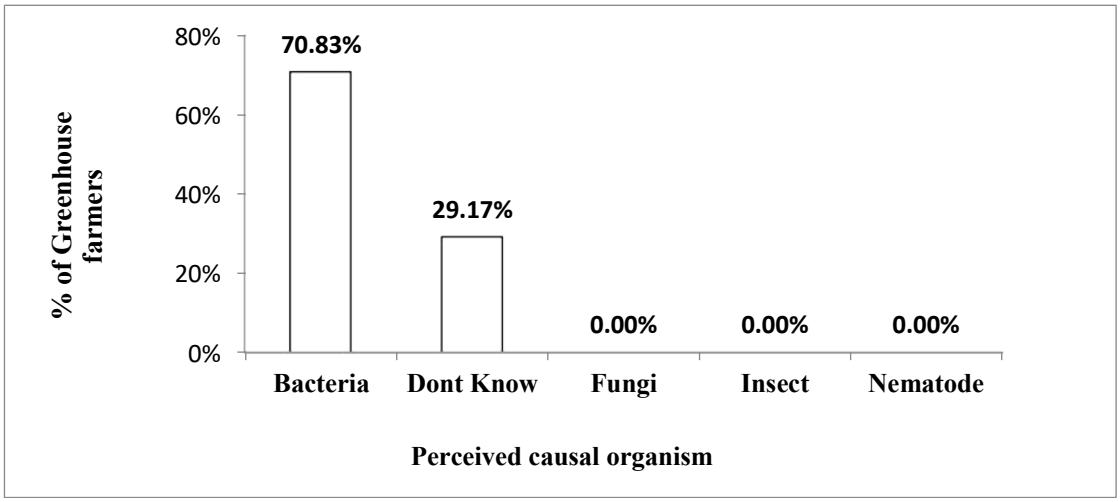

Figure 4: Perception of greenhouse tomato farmers on causal agent of BW disease

Knowledge of greenhouse tomato farmers on disease spread in the study area

Less than half (50%) of the respondents knew how the disease spreads. Some of the respondents attributed the spread of the disease to poor sanitation, infected seeds, infected tools and through irrigation water.

Greenhouse tomato farmers' source of information on spread of BW disease

Sixty-two percent (62%) of respondents did not know how the disease spreads, with 14%, 12%, and 8% learning from their own experience, school, and extension officers, respectively.

Greenhouse tomato farmer's knowledge on the control of BW disease

Eighty-two percent (82%) of the respondents perceived bacterial wilt of tomatoes as controllable, whilst 12% did not know how the disease is controlled. Two percent (2%) of greenhouse farmers believed the bacterial wilt disease could not be controlled. Respondents use rouging and burying of infected plant, crop rotation, and sterilization of their growth medium as means of controlling the disease (Table 6).

Greenhouse tomato farmers' source of information on control of BW disease

Respondents in the study had varied sources of information on BW disease control. Forty-eight percent (48%) of the respondents indicated that they obtained information on the control of the disease from school, whilst 32% and 12% of greenhouse tomato farmers attributed their source of information on how to control the disease to personal experience and extension officers, respectively. The rest sourced their information from NGOs/Workshops (6%) or fellow farmers (2%).

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Challenges faced by greenhouse tomato farmers in the production of tomatoes

Greenhouse tomato farmers face numerous challenges, ranging from cattle invasion of greenhouse environment to pest and disease-related problems (Table 7). Pest and disease-related problems were major challenges in greenhouse tomato production in Coastal humid climatic region of Kenya [19] and Kisii County in Kenya [20]. Similar findings were made in Jaipur district of Rajasthan state, India [21], where farmers listed pests and diseases as the major constraint in vegetable production under polyhouse conditions.

Majority (86%) of greenhouse tomato farmers in the study area had been in greenhouse production for less than four years with tomato as the main crop grown, followed by cucumber. Although tomatoes have a high capital input, high returns could be easily achieved due to high market demands for good and high-quality crops [13]. Tomato varieties grown by the greenhouse farmers were Eva, NimoNecta, Tatiana, Pectomech, Anna and Padma, which were all susceptible to the bacterial wilt disease. The sources of seeds for greenhouse tomato farmers in Ghana were from certified agro-dealers such as Dizengoff Gh. Ltd. (also suppliers of the Amiran greenhouse farmer's kit), Agrimat Gh. Ltd, East-West Gh. Ltd with a few greenhouse farmers sourcing their planting materials from the local market. Famers in Malawi, for example, had no available source of seeds with most farmers using seeds from their own production. Those seeds, however, were latent sources of the bacterial wilt disease [22].

Majority (56%) of greenhouse farmers had heard about the bacterial wilt disease but had little knowledge on its spread, detection, and effective control. Similar observations were made by Sood and Singh [23]. The causal organism was perceived to be a bacterium, and this could be due to the high literacy rate of the farmers, which was a criterion for the selection and distribution of the greenhouse kits by WAAPP and EMQAP projects.

Most greenhouse farmers attributed the spread of the bacteria wilt disease to poor sanitation practices in greenhouses. A high incidence of the disease was also observed in greenhouses in Kenya due to poor hygiene practices [24]. *Ralstonia solanacearum* is a soil-borne bacterium and may survive for prolonged periods in soil, water, and plant materials, and thus to prevent pathogens from spreading amongst greenhouses, Meng [25] stressed on the use clean seeds, soil, water and tools.

There was poor disease identification amongst greenhouse tomato growers, which led to wrong disease management practices. Bacterial stream test can be an effective diagnostic tool in detecting bacterial wilt disease in fields [26]. However,

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De Boer and Lopez [27] have recommended the use of immunostrips for rapid and accurate identification of disease-causing organism in the field.

Greenhouse farmers also had inadequate information on the management and control of the disease, and so practiced the removal and burning of infected plants with few farmers adopting sterilization of substrate before use and crop rotation. Similar BW disease management methods such as uprooting, burying or burning infected plants are practiced by farmers in Malawi [22]. Adoption of good sanitation practices including the use of disinfectants in footbath at entrance of greenhouses, sterilization of substrates and the cleaning of equipment before and after use has been reported to reduce spread of diseases [25, 28].

CONCLUSION, AND RECOMMENDATIONS FOR DEVELOPMENT

Majority of greenhouse tomato farmers in Ghana had formal education, with few of them obtaining their seeds from the local market. Farmers ranked pests and diseases as the major constraint to greenhouse tomato production. Bacterial wilt disease was not known by many farmers, with some other farmers reportedly observing the disease in their greenhouses. Some farmers attributed the cause of tomato wilt disease to bacteria, a situation, which could enhance adoption if bacteria wilt disease management protocols are developed and implemented. Famers had little knowledge on how the disease was detected thus requiring training on methods such as streaming and use of immunostrips. The means of spread of the disease was unknown to the farmers, requiring an urgent need for training of farmers on methods of spread, sources of inoculums, importance of using resistant varieties and other preventive measures for effective and efficient disease management. There is equally an important need to conduct more research on resistance or susceptibility of some common varieties so as to prevent crop loss to farmers and to ensure sustainability of greenhouse tomato production in the country.

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Table 1: Regions, districts and communities selected for the survey, and number of greenhouses in tomato production at time of the survey and number respondents interviewed

Region	District	Communities	No. of greenhouses	No. of respondents
Greater	Ningo Prampram	Dawhenya	5	7
Accra	Adenta Municipal	Amrahia(Dairy farms)	1	1
	Tema-West	Borteyman	5	10
	Ashiaman Municipal	AdjeiKojo	13	3
Central	KEEA[a]	Nsadwir	4	8
Eastern	New Juabeng	Akwadum	10	10
	Nsawam/Adoagyiri	Praso	1	2
	Denkyembour	FOHCREC[b]	1	1
	Shai Osudoku	Natriku	5	6
Volta	South Dayi	Adidome	2	1
		Dzemeni	2	1
	North Dayi	Vakpo	4	-
Total			53	50

[a] KEEA= Komenda Edina Eguafo Abirem District

[b] FOHCREC= Forest and Horticultural Crops Research Centre, Kade

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Table 2: Diseases, insect pests, and disorders affecting greenhouse tomatoes in the study areas

Disease/Pest/Disorder[a]	Frequency	Percent
Whitefly	47	94
Fusarium wilt	38	76
Blossom end rot	35	70
Leaf curl	23	46
Leafminer	23	46
Powdery mildew	22	44
Bacterialwilt	22	44
late blight	21	42
Nematodes	13	26
Spider mite	5	10
Aphids	5	10
Worms	4	8
Fruit cracking	2	4
Caterpillar	1	2

[a] Respondents had multiple responses

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Table 3: Susceptibility levels of commonly grown tomato varieties by greenhouse tomato farmers in the study areas

Varieties grown in greenhouse[a]	Percent occurrence	Susceptibility (%)
Eva	88	28
NimoNecta	60	8
Tatiana	54	14
Pectomech	46	10
Anna	34	10
Padma	22	-
Napoli	12	-
Roma	10	8
8014	6	6
2013-4	6	6
ABM 152	6	6
Jingping	4	-
Bigguy	4	-
Martima	2	-
Jaguar	2	-
Money maker	2	-
Platinum	2	-
NKansah HT	2	-
Inlay	2	-

[a] Respondents had multiple responses

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Table 4: Knowledge of greenhouse tomato farmers on symptoms of bacterial wilt disease

BWD symptom criterion described by respondents [a]	Frequency	Percent
Sudden wilt of plant	23	46
Do not know	22	44
Low production	20	40
Stunting of plants	13	26
Sudden death	7	14
Discoloration of vascular bundle	3	6
Green and appears cooked	3	6
Oozing of whitish substance	0	0

[a] Respondents had multiple responses

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Table 5: Knowledge, perception and experiences of greenhouse tomato farmers on detection of BWD

Criterion for detection of TBW by farmers[a]	Frequency	Percent of farmers
no idea	33	66
Wilting of plants	15	30
Streaming test	8	16
Low production	5	10
Sudden death	3	6
Stunting of plants	3	6
oozing of whitish substance	3	6
Green and appears cooked	2	4
Brown discolouration of tissues(CS)	2	4

[a] Respondents had multiple responses

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Table 6: Greenhouse tomato farmers' responses to control measures of BWD

TBW control criterion mentioned [a]	Frequency	Percent
Rouging and burying of infected plant	31	62
Crop rotation	29	58
Sterilizing medium	18	36
Drenching with bactericides or fungicides	18	36
Planting resistant variety	18	36
disposing of infected medium	10	20
Does nothing/ Don't know	7	14
Using healthy seeds	5	10
Chlorination of irrigation water	3	6

[a] Respondents had multiple responses

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Table 7: Challenges faced by greenhouse tomato farmers in the study area

Challenges faced by greenhouse farmers [a]	Frequency	Percentage (%)
Pest and disease problems	49	98
High maintenance cost	38	76
Lack of capital	22	44
High temperatures	21	42
No power source	20	40
Lack of irrigation water	19	38
Theft	13	26
Flooding	8	16
fire outbreak	1	2
wind destruction	1	2
Cattle invasion	1	2

[a] Respondents had multiple responses

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REFERENCES

1. **Ishida BK and MH Chapman** A comparison of carotenoid content and total antioxidant activity in catsup from several commercial sources in the United States. *Journal of Agricultural and Food Chemistry,* 2004; **52(26):** 8017-8020.

2. **Rao AV and LG Rao** Carotenoids and human health. *Pharmacological Research,* 2007; **55(3):** 207-216.

3. **Alam MS, Kaur G, Jabbar Z, Javed K and M Athar** Erucasativa seeds possess antioxidant activity and exert a protective effect on mercuric chloride induced renal toxicity. *Food and Chemical Toxicology*, 2007; **45(6):** 910-920.

4. **Diao X** Economic importance of agriculture for sustainable development and poverty reduction: Proceedings Ghana global forum on agriculture. Policies for agricultural development, poverty reduction and food security. Organization for Economic Co-operation and Development, Paris. 29-30 November, 2010.

5. **Osei CK Banful B and F Nimoh** A study on postharvest loss management and women empowerment. Final report submitted to Ghana Agricultural Workers Union (GAWU) of the Trade Union Congress (TUC) of Ghana, Accra, Ghana. 2010.

6. **FAO.** United Nations Food and Agriculture Organization, Statistical Yearbook: World Food and Agriculture. FAO, Rome. 2013.

7. **Robinson EJZ and SL Kolavalli** The case of Tomato in Ghana: Processing. International Food Policy Research Institute, Washington, USA.2010.

8. **Fami HS, Sharifi O, Ghasemi J, Pouratashi M and MS Moghadasian** Perceptions of Greenhouse Vegetable Growers Regarding Use of Biological Control Practices: A Case Study in Jiroft County, Iran. *International Journal of Agricultural and Biosystems Engineering,* 2016; **10(7):** 416-420.

9. **Frangu B, Popp JS, Thomsen M and A Musliu** Evaluating Greenhouse Tomato and Pepper Input Efficiency Use in Kosovo. *Sustainability*, 2018; **10:** 2768. https://doi.org/10.3390/su10082768

10. **Hemming S, Zwart de F, Elings A, Petropoulou A and I Righini** Cherry Tomato Production in Intelligent Greenhouses—Sensors and AI for Control of Climate, Irrigation, Crop Yield, and Quality. *Sensors,* 2020; **20:** 6430. https://doi.org/10.3390/s20226430

11. **Ofori PA, Owusu-Nketia S, Opoku-Agyemang F, Agbleke D and JN Amissah** Greenhouse Tomato Production for Sustainable Food and Nutrition Security in the Tropics. Eds: Pranas Viškelis, Dalia Urbonavičienė and Jonas Viškelis. IN: Tomato - From Cultivation to Processing Technology. *IntechOpen.* 2022. http://dx.doi.org/10.5772/intechopen.105853

12. **Hochmuth GJ** Production of Greenhouse Tomatoes—Florida Greenhouse Vegetable Production Handbook, 2018; **Vol 3,** HS788, Horticultural Sciences Department, UF/IFAS Extension' https://edis.ifas.ufl.edu

13. **Elings A, Saavedra Y and GO Nkansah** Strategies to support the greenhouse horticulture sector in Ghana. Wageningen UR Greenhouse Horticulture. Report GTB-1353. Wageningen. Netherlands.2015.

14. **Subedi N, Gilbertson RL, Osei MK, Cornelius E and SA Miller** First report of bacterial wilt caused by *Ralstonia solanacearum* in Ghana, West Africa. *Plant Disease*, 2014; **98(6):** 840–840. https://doi.org/10.1094/PDIS-09-13-0963-PDN

15. **EPPO.** *Ralstonia solanacearum.* European and Mediterranean Plant Protection Organization Bulletin, 2004; **34(2):** 173-178.

16. **Mansfield J, Genin S, Magori S, Citovsky V, Sriariyanum M, Ronald P and GD Foster** Top 10 plant pathogenic bacteria in molecular plant pathology. *Molecular Plant Pathology,* 2012; **13(6):** 614-629. https://doi.org/10.1111/j.1364-3703.2012.00804.x

17. https://compare.climate-data.org/rates/search/index.php? *Accessed: April 19, 2021.*

18. https://www.climatestotravel.com/climate/ghana/accra *Accessed: November, 2021.*

19. **Sanzua LJ, Saha HM and J Mwafaida** Status of Greenhouse Farming in the Coastal Humid Climatic Region of Kenya. *Universal Journal of Agricultural Research*, 2018; **6(5):** 165-172. https://doi.org/10.13189/ujar.2018.060504

20. **Wayua FO, Ochieng V, Kirigua V and L Wasilwa** Challenges in greenhouse crop production by smallholder farmers in Kisii County, Kenya. *African Journal of Agricultural Research*, 2020; **16(10):** 1411-1419. https://doi.org/10.5897/AJAR2020.15086

21. **Choudhary R, Jain S and PS Shekhawat** Constraints in production and marketing of vegetables under polyhouse and normal field conditions in Jaipur district of Rajasthan state. *The Pharma Innovation Journal,* 2022; **11(2):** 798-802.

22. **Kagona JDZ** The incidence of bacterial wilt (*Ralstonia solanacearum*) in informal potato planting material used by farmers in Dedza and Ntcheu districts of Malawi. Department of International Environment and Development Studies, Norwegian University of Life Sciences (UMB), Norway.MS Thesis. 2008.

23. **Sood AK and BM Singh** Prevalence of bacterial wilt of solanaceous vegetables in the mid-hill subhumid zone of Himachal Pradesh, India. Proceedings Australian Centre for International Agricultural Research (ACIAR) Kaohsiung, Taiwan, 28-31, October 1992.

24. **Onduso JN** Management of bacterial wilt of tomato by use of resistant rootstock. Crop Protection, Department of Plant Science and Crop Protection, Faculty of Agriculture, University of Nairobi, Nairobi, Kenya. MS thesis. 2014.

25. **Meng F** The virulence factors of the bacterial wilt pathogen *Ralstonia solanacearum. Journal of Plant Pathology Microbiology,* 2013; **4(168):** 10-4172.

26. **Champoiseau PG, Jones JB and C Allen** *Ralstonia solanacearum* Race 3 Biovar 2 causes tropical losses and temperate anxieties. *Plant Health Progress,* 2009; 10:1-10. https://doi.org/10.1094/PHP-2009-0313-01-RV

27. **De Boer SH and MM López** New grower-friendly methods for plant pathogen monitoring. Annual Review of Phytopathology, 2012; **50:** 197-218.

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28. **Dudek TA** Sanitation strategies, Cornell University, New York state Agricultural Experimental Station Extension Service, Geneva, New York. 2008. http://www.nysaes.cornell.edu/cals/nysaes/bp/shops/greenhouse/sanitation strategies.cm *Accessed: November, 2021.*