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Survey of fungal diseases associated with amaranth (*Amaranthus* species) in peri-urban vegetable farms in Kumasi and Tamale metropolis of Ghana

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***Amaranthus* species is an important leafy vegetable in Ghana; however, foliar diseases of the crop reduce the marketable and edible portions as well as income to farmers. To facilitate the development of disease management strategy, there is the need to document various diseases limiting amaranth production. In view of this, surveys were carried out in forty-three peri-urban vegetable farms in the Kumasi and Tamale Metropolis of Ghana to assess the prevalence and severity of fungal diseases associated with amaranth. Farms were selected using snowball pattern and on each farm, disease incidence and severity were assessed on 45 plants. Disease incidence for any particular fungal disease was calculated as number of plants showing symptoms compared to total number of plants selected whilst disease severity was rated as extent of tissue damage using a severity scale of 1-5. Survey results revealed anthracnose; stems cankers, wilting and wet rot as most prevalent diseases on amaranth. Wilting was the most frequent disease observed; occurring in 95% of farms visited whilst anthracnose, wet rot and stem canker were observed in 91%, 40 and 47% respectively of farms visited. Similarly, wilting disease incidence ranged from 13.3 to 51% across all locations compared to 13.3 to 58.3% for anthracnose, 11.9 to 61.7% for wet rot and 18.3 to 51.7% for stem canker. This work is among few investigations that had been made into diseases affecting the production of Amaranth in Ghana.**

Key words: Disease symptoms, fungal foliar diseases, incidence, infection, severity

INTRODUCTION

Amaranthus species is one of the commonest indigenous vegetables grown in most tropical African countries. The crop, described as a poor man's vegetable has been rediscovered as a promising food crop mainly due to its high nutritional value, resistance to heat, drought and low cost of production (Das, 2016). Both seeds and leaves of the crop are known for its excellent essential micronutrients such as beta-carotene, iron, calcium, vitamin C and folic acid (Chivenge et al., 2015; Mabhaudhi et al., 2019). The overall nutritional value of

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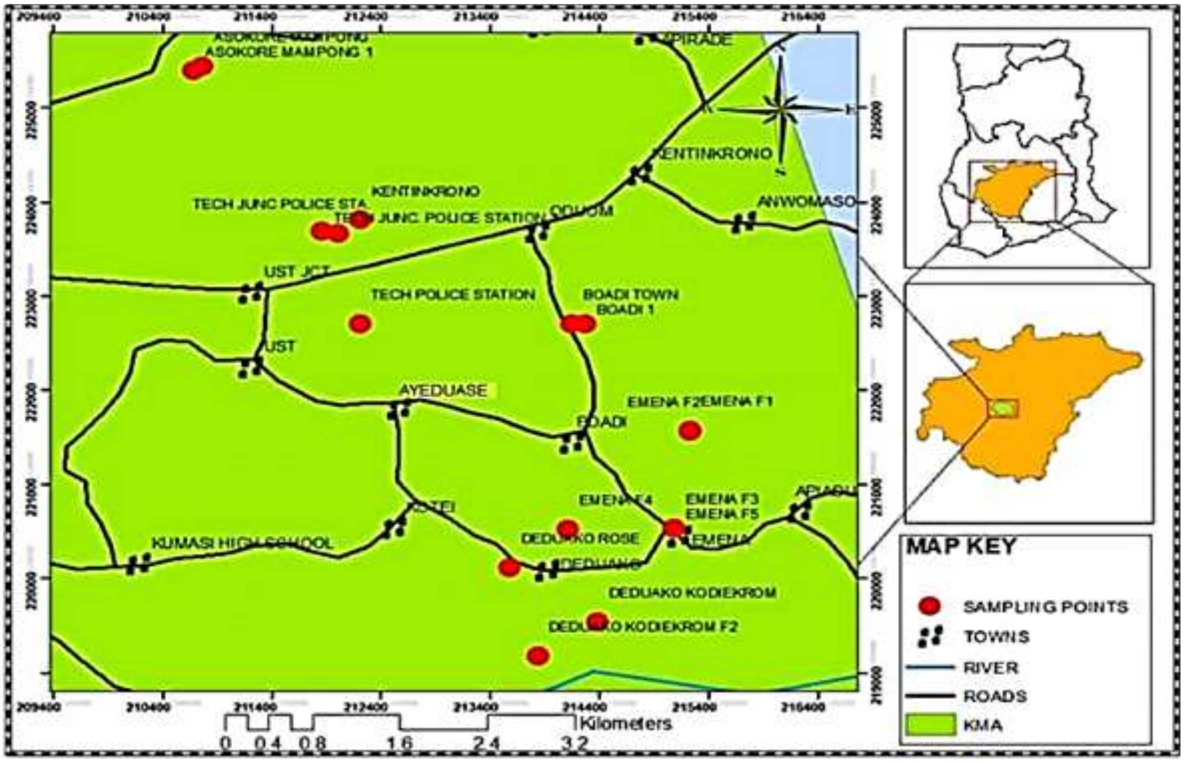

Figure 1. Sampled sites in the Kumasi metropolis.
Source: Study

amaranth is regarded significantly higher than several protein foods such as milk and soya bean and is therefore used as an important dietary supplement for HIV/AIDS patients in some African countries (Alemayehu et al., 2015). In addition, *Amaranthus* species has medicinal properties against constipation, fevers, hemorrhage, anaemia, kidney aliments and worms (Mensah et al., 2008; Koffuor et al., 2013) In Ghana, the crop is called "Aleefu" and commonly found in the Savannah, Deciduous and Forest agro-ecological zones (Dari et al., 2015). The crop plays significant role in the food security and income generation for farmers in both urban and rural settings. Despite its numerous importance, Awurum and Uchegbu, (2013), reported that production of Amaranth is greatly limited by pest and diseases. Vegetable Amaranth is susceptible to fungal diseases such as damping-off of seedlings caused by *Pythium, Rhizoctonia*, and *Aphanomyces spp*. and cankers caused by *Phoma* or *Rhizoctonia* (Stallknecht and Schulz-Schaeffer, 1993; Alemayehu et al., 2015). In Ghana, there is limited information on diseases associated with leafy Amaranth although there has been increase in the promotion of production and general usage of the crop (Darkwa and Darkwa, 2013; Asase and Kumordzie, 2019). This survey was therefore conducted to identify major fungal diseases of amaranth and determine the prevalence, incidence and severity of these diseases in peri-urban vegetable farms in Kumasi and Tamale Metropolis of Ghana. This information will guide future research on *Amaranthus* species.

MATERIALS AND METHODS

Field sampling, climate, and soil type of study areas

The surveys were conducted from July - August, 2019 at Kumasi and September - October, 2019 at Tamale to identify various fungal diseases of amaranth. Forty-three amaranth farms in peri-urban areas of Kumasi and Tamale Metropolis were selected using the snowball sampling technique where farms visited give directions to subsequent farms. Fifteen of the farms were in the Kumasi Metropolis (Figure 1) whilst 28 were in the Tamale (Figure 2). Kumasi Metropolis is in the Semi-Deciduous agro-ecological zone and is characterized by a tropical wet and dry climate with constant temperature of 24 - 26°C all year round. The area experiences bimodal rainfall pattern with a mean rainfall of about 1,400 mm per year (Drechsep and Keraita, 2014). Soil type of Kumasi metro is lateritic with sandy clay loam texture, and 12.25 CEC (cmol, kg $^{-1}$) that support production of vegetables such as amaranthus, cabbage, green pepper, carrot, spring onions, lettuce, and cabbage (Kwakye et al., 2004). Tamale metropolis is located in the Guinea Savannah agro-ecological zone and experiences a unimodal rainfall pattern around April/May to September/October. The area experiences an average rainfall of about 1,111 mm and an average annual temperature of about 27°C (Drechsep and Keraita, 2014). Soils in Tamale Metropolis are Ferric luvisol with sandy loam texture and 4.2 CEC (cmol, kg^{-1}) that support vegetables such as

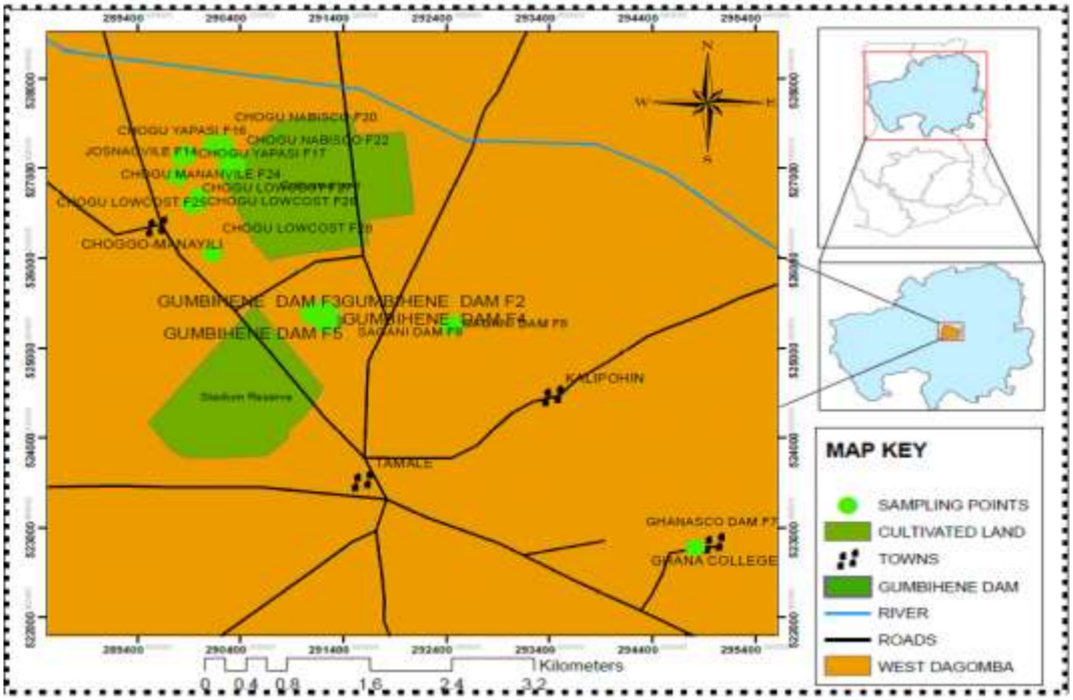

Figure 2. Surveyed communities in the Tamale Metropolis.
Source: Study

Table 1. Disease severity rating scale.

Disease rating grade	Tissue area affected (%)
1	0 infection (No symptoms)
1.5	0 – 6 area infection
2	6 – 12 area infection
2.5	12 – 25 area infection
3	25 – 50 area infection
3.5	50 – 75 area infection
4	75 – 84 area infection
4.5	84 – 90 area infection
5	More than 90 area infection

Source: Campbell and Benson, 1994; Rao et al. 2016

Amaranth, Onions, Melon, aubergine, lettuce, and Cabbage (Kwakye et al., 2004).

Disease incidence and severity assessment

Disease incidence and severity of amaranth were determined to assess the extent of disease spread in farms and the communities. Following a systemic field survey of foliar disease of amaranth; a total of 45 plants were selected in each farm using the Z-shaped method (Manandhar et al., 2016). Two horizontal and 1 diagonal paths were made across the farms in Z-shape and along each path, 15 plants were assessed visually for expression of disease symptoms. For each farm, disease incidence was calculated as the number of plants infected, expressed as a percentage of the total number of total plants assessed (Manandhar et al., 2016).

$$\text{Disease incidence (\%)} = \frac{\text{Number of plants infested}}{\text{Total number of plants assessed}} x100$$

Disease severity (area of plant tissue or organ affected by the disease) was scored using a modified 1 – 5 rating scale and Barratt and Horsfall percentage grading (Campbell and Benson, 1994). Disease severity was expressed as a percentage of the infected parts to total area plant part (Table 1) (Rao et al., 2016). Disease prevalence was determined as described by (Cooke, 2006). It is the disease incidence in a geographical area; thus if 30 farms in an area is inspected and 15 showed infection of particular disease, then prevalence for that disease is 50%.

Collection of disease specimen

Infected plant tissues of roots, stems or leaves showing symptoms of various diseases identified were collected from surveyed farms. Samples were placed in brown envelopes and brought to the laboratory for fungal identification.

Determination of mycoflora associated with amaranth roots, stems and leaves

Representative samples were cut to approximately 5 mm to contain both diseased and healthy tissues. The tissues were surface sterilized in 5% Sodium hypochlorite for 3 min, rinsed with sterile distilled water and dried under laminar hood. The dried tissues were placed on amended PDA and incubated for between 4 to 7 days at room temperature (28 ± 2°C). Standard identification manual (Barnett and Hunter, 1972) was used to identify fungal pathogens present on tissues under a compound microscope (SWIFT, USA).

Plate 1. Anthracnose leaf spots.
Source: Study

Plate 3. Leaf chlorosis.
Source: Study

Plate 2. Stem canker (arrow).
Source: Study

Plate 4. Wet rot disease.
Source: Study

The identification of the fungi was based on habit and morphological characters of the fruiting bodies on tissues and slides examination. Pure cultures of fungi growing in media were obtained from hyphal tips and identified (Ngegba et al., 2019).

Data analysis

Percentage data were transformed using the square root transformation. Data from percentage incidence and severity were analyzed with Genstat® 12th edition VSN International Ltd. statistical package. Means were separated using least Significant Difference (LSD).

RESULTS

Symptoms of major fungal diseases associated with amaranth in the study area

During the survey, four major fungal diseases namely anthracnose (plate 1), stems cankers (plate 2), wilting (plate 3) and wet rot (plate 4) were observed to be most prevalent diseases across the farms visited. Amaranth anthracnose symptoms appeared as brownish-red spots characterized by slightly sunken circular patterns

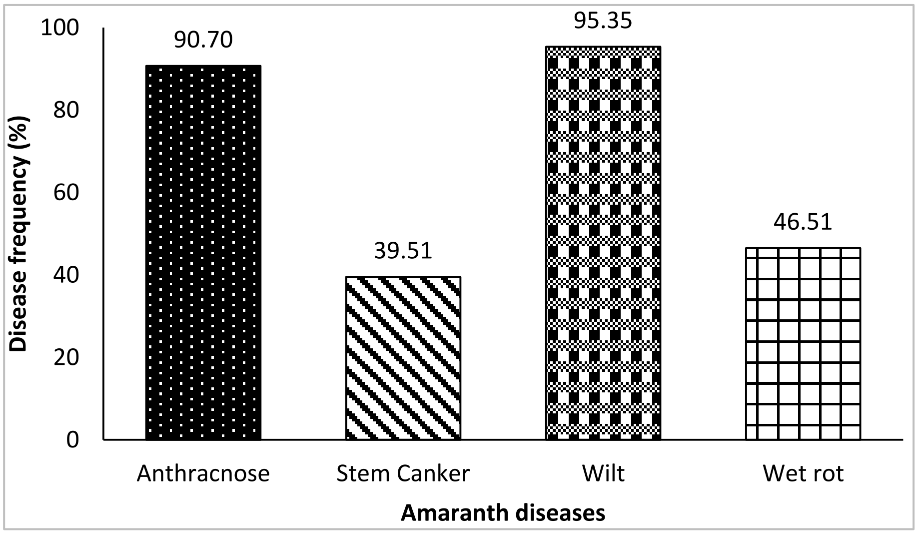

Figure 3. Frequency of distribution of major fungal diseases observed in Amaranth farms in the study area.
Source: Study

surrounded by yellow halo with blights on leaves and dieback on plants. Stem cankers appeared as scars and openings on the stem. Plants showing wilting symptoms produced chlorotic leaves with dropping of leaves and seedlings. Wet rot disease showed water-soaked rot of stems and leaves covered with white hairy silk-like threads having black tips. The disease usually leads to the falling of affected parts.

Frequency of major fungal diseases associated with amaranth at Kumasi and Tamale metropolis

Results of the survey showed that wilting was the most frequently observed symptom recorded across the farms. Generally, 95% of farms surveyed had plants showing symptoms of wilts whilst anthracnose, stem canker, and wet rot disease symptoms were observed in 91, 37, and 46% of plants in surveyed farms (Figure 3).

Incidence and severity of Anthracnose

Incidence of anthracnose disease ranges from 0 to 58.3% with the highest incidence noticed at Emina F6 in the Kumasi metropolis. Four farms showed no symptoms of anthracnose disease. In farms showing the disease symptoms, disease incidence was significantly different ($P < 0.05$) among the farms (Table 2). Severity of anthracnose disease ranges from 1 to 3.83. The percentage of damage caused ranges from 0 to 75% on the various field surveyed, posing a high risk to Amaranth production in Ghana (Table 3). Mean incidence and severity of 21 and 25%, respectively were recorded in Kumasi (Figure 4) whilst 22 and 24% respectively were recorded at Tamale (Figure 5).

Incidence and severity of wilting

Wilting and dropping of Amaranth plants with chlorotic leaves were observed in forty-one of the farms visited. The incidence of wilt ranged from 0 to 51% with significant difference ($P < 0.05$) among the farms (Table 2). Highest wilting incidence of 51.0 % were recorded at Deduako F3 and Gambihene dam F4 in the Kumasi and Tamale metropolises respectively. The severity of wilting disease ranged from 1 to 4.22 (Table 3). This result indicates the disease caused 0 to 80% damage to Amaranth crops on the various farms surveyed. Mean incidence and severity of 23 and 50% respectively were recorded in Kumasi (Figure 4) whilst at Tamale, 32 and 38% respectively were recorded (Figure 5).

Incidence and severity of wet rot

Wet rot disease incidence ranged from 0 to 61.7% with significant difference ($P < 0.05$) among the farms. Twenty of farms visited recorded wet rot disease whilst the highest incidence at Emima F3 in the Kumasi metropolis (Table 2). Severity of wet rot ranged from 1 to 3.67 (Table 3) indicating disease damage ranging from 0 to 75%, which was higher in Tamale than Kumasi. Mean incidence and severity of 15 and 11%, respectively were recorded in Kumasi (Figure 4) whilst 13 and 15% respectively were recorded at Tamale (Figure 5).

Incidence and severity of stem canker

Incidence of stem canker ranged from 0 to 51.67% with the highest incidence noticed at Emina F6 and Kakuo

Table 2. Incidence of major fungal diseases associated with amaranth at Kumasi and Tamale metropolis.

Metropolis	Farm	Disease incidence (%)			
		Anthracnose	Wilt	Wet rot	Stem Canker
Kumasi	Asokore Mampong F1	30.00	23.30	43.75	0.00
Kumasi	Asokore Mampong F2	15.00	18.00	0.00	25.00
Kumasi	Boadi	28.30	18.70	0.00	0.00
Kumasi	Deduako F1	38.30	21.70	31.67	0.00
Kumasi	Deduako F2	16.67	13.30	20.70	21.67
Kumasi	Deduako F3	13.33	51.01	0.00	45.70
Kumasi	Emina F1	0.00	28.30	0.00	0.00
Kumasi	Emina F2	15.33	28.30	16.20	28.33
Kumasi	Emina F3	20.01	21.70	61.70	0.00
Kumasi	Emina F4	2.00	0.00	0.00	0.00
Kumasi	Emina F5	30.00	25.00	0.00	38.33
Kumasi	Emina F6	58.30	33.70	0.00	51.67
Kumasi	Kentinkrono	13.67	20.00	0.00	0.00
Kumasi	Tech Police station F1	14.33	21.70	0.00	39.37
Kumasi	Tech Police station F2	18.31	26.75	55.3	0.00
Tamale	Chogu larim	16.67	28.30	23.33	0.00
Tamale	Chogu Lowcost F1	38.37	31.70	18.70	0.00
Tamale	Chogu Lowcost F2	38.33	50.00	31.33	0.00
Tamale	Chogu Lowcost F3	0.00	43.30	0.00	0.00
Tamale	Chogu Lowcost F4	15.00	25.00	0.00	38.33
Tamale	Chogu Mananyile F1	10.00	21.67	0.00	0.00
Tamale	Chogu Mananyile F2	38.33	36.67	44.50	36.67
Tamale	Chogu Nahisco F1	23.33	0.00	19.50	0.00
Tamale	Chogu Nahisco F2	0.00	28.00	0.00	18.33
Tamale	Chogu Nahisco F3	23.30	15.67	0.00	0.00
Tamale	Chugu Yapasi F1	20.00	31.67	16.20	0.00
Tamale	Chugu Yapasi F2	26.70	43.33	20.70	0.00
Tamale	Chugu Yapasi F3	24.67	33.28	0.00	0.00
Tamale	Chugu Yapasi F4	38.30	23.33	0.00	20.67
Tamale	Gambihene old/new dam F1	10.00	31.70	25.20	0.00
Tamale	Gambihene old/new dam F2	15.00	36.33	0.00	28.33
Tamale	Gambihene old/new dam F3	20.00	50.00	0.00	0.00
Tamale	Gambihene old/new dam F4	36.00	51.00	31.60	0.00
Tamale	Gambihene old/new dam F5	13.00	25.00	0.00	43.20
Tamale	Gambihene old/new dam F6	18.33	36.67	12.70	0.00
Tamale	Josnaoyile F1	0.00	31.57	38.40	0.00
Tamale	Josnaoyile F2	19.50	23.30	0.00	0.00
Tamale	Kakuo (Ghanasco dam)	49.67	31.70	11.90	51.57
Tamale	Sagani dam F1	23.33	33.30	0.00	0.00
Tamale	Sagani dam F2	23.37	23.30	16.70	30.00
Tamale	Sagani dam F3	15.00	29.67	0.00	0.00
Tamale	Sagani dam F4	30.00	47.50	0.00	0.00
Tamale	Sagani dam F5	20.01	35.33	43.60	0.00
l.s.d.		4.289	3.822	4.79	5.157
cv		10.9	9.6	10.6	9.2

Source: Study

(Ghanasco dam) in the Kumasi and Tamale metropolis respectively (Table 2). Severity of tissue damage ranges from 1 to 3.33 (Table 3) indicating 0 to 50% damage of crops on the various farms surveyed. Mean incidence

Table 3. Severity of major fungal diseases associated with amaranth production at Kumasi and Tamale metropolis.

Metropolis	Farm	Disease severity (%)			
		Anthracnose	Wilt	Wet rot	Stem Canker
Kumasi	Asokore Mampong F1	2.83	4.03	1.67	1.00
Kumasi	Asokore Mampong F2	1.83	4.03	1.00	2.33
Kumasi	Boadi	2.67	4.22	1.00	1.00
Kumasi	Deduako F1	3.67	2.38	1.83	1.00
Kumasi	Deduako F2	2.17	2.38	1.67	3.00
Kumasi	Deduako F3	2.00	3.12	1.00	1.00
Kumasi	Emina F1	1.00	2.02	1.00	1.00
Kumasi	Emina F2	2.33	2.38	3.00	3.00
Kumasi	Emina F3	2.67	2.38	2.50	1.00
Kumasi	Emina F4	1.67	1.00	1.00	1.00
Kumasi	Emina F5	2.50	4.03	1.00	2.17
Kumasi	Emina F6	2.83	2.75	1.00	2.50
Kumasi	Kentinkrono	2.33	2.38	1.00	1.00
Kumasi	Tech Police station F1	2.00	3.67	1.00	2.33
Kumasi	Tech Police station F2	2.17	4.03	2.67	1.00
Tamale	Chogu larim	2.00	2.57	2.00	1.00
Tamale	Chogu Lowcost F1	3.17	2.75	2.67	1.00
Tamale	Chogu Lowcost F2	3.00	3.12	3.17	1.00
Tamale	Chogu Lowcost F3	1.00	2.02	1.00	1.00
Tamale	Chogu Lowcost F4	1.83	2.38	1.00	2.50
Tamale	Chogu Mananyile F1	1.67	2.75	1.00	1.00
Tamale	Chogu Mananyile F2	3.00	3.30	1.83	2.17
Tamale	Chogu Nahisco F1	2.50	1.00	2.00	1.00
Tamale	Chogu Nahisco F2	1.00	2.02	1.00	2.17
Tamale	Chogu Nahisco F3	2.67	4.03	1.00	1.00
Tamale	Chugu Yapasi F1	2.17	4.03	3.00	1.00
Tamale	Chugu Yapasi F2	3.00	3.30	2.50	1.00
Tamale	Chugu Yapasi F3	2.83	2.57	1.00	1.00
Tamale	Chugu Yapasi F4	3.67	2.75	1.00	2.83
Tamale	Gambihene old/new dam F1	1.83	3.12	2.67	1.00
Tamale	Gambihene old/new dam F2	2.50	2.38	1.00	1.00
Tamale	Gambihene old/new dam F3	3.00	2.75	2.83	1.00
Tamale	Gambihene old/new dam F4	1.50	3.30	1.00	2.67
Tamale	Gambihene old/new dam F5	1.83	1.65	2.17	1.00
Tamale	Gambihene old/new dam F6	2.17	2.02	1.00	3.33
Tamale	Josnaoyile F1	1.00	1.83	3.00	1.00
Tamale	Josnaoyile F2	1.83	3.12	1.00	1.00
Tamale	Kakuo (Ghanasco dam)	3.83	2.02	2.67	2.17
Tamale	Sagani dam F1	2.33	2.75	1.00	1.00
Tamale	Sagani dam F2	2.17	3.3	3.67	2.83
Tamale	Sagani dam F3	2.17	2.57	1.00	1.00
Tamale	Sagani dam F4	2.83	2.93	1.00	1.00
Tamale	Sagani dam F5	1.83	4.03	3.67	1.00
l.s.d.		0.48	0.52	0.31	0.34
cv		12.8	12.3	10.7	13.4

Source: Study

and severity of 17 and15% respectively were recorded in Kumasi (Figure 4) whilst Tamale recorded 10 and 9%

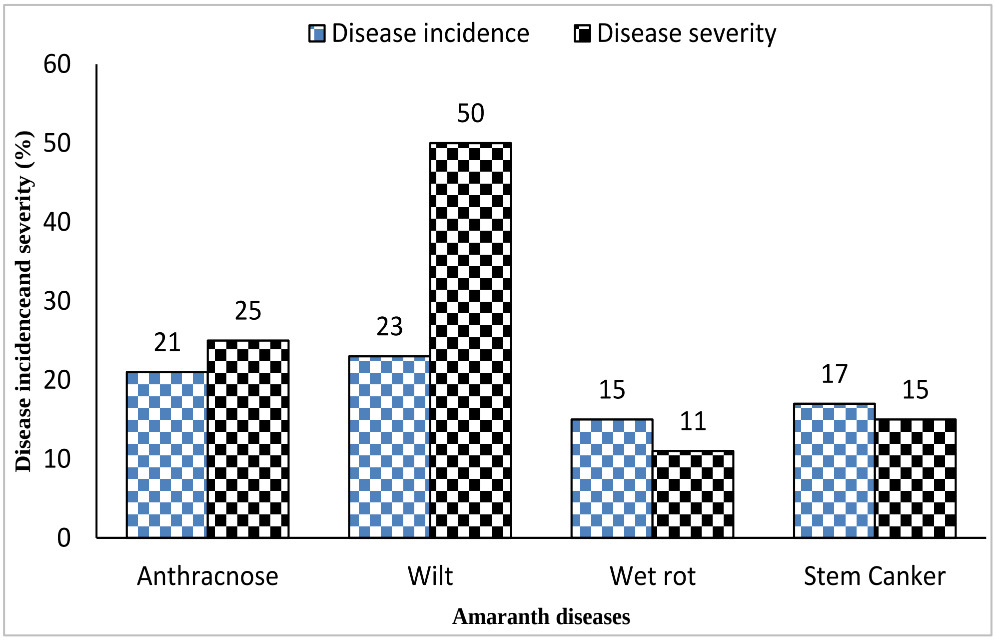

Figure 4. Mean incidence and severity of disease in Kumasi metropolis.
Source: Study

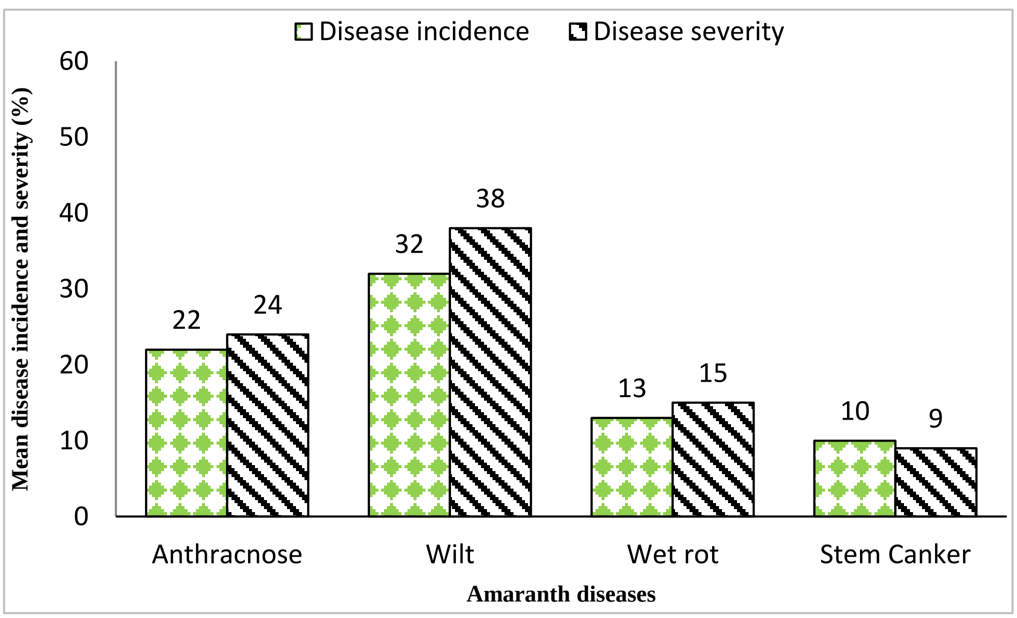

Figure 5. Mean incidence and severity of disease in Tamale metropolis.
Source: Study

respectively (Figure 5).

Mycoflora associated with amaranth roots, stems and leaves

Nine genera of fungi viz., *Fusarium, Collectotrichum*, *Cercospora*, *Choanephora*, *Alternaria*. *Phoma*, *Cloadosporium*, *Aspergillus and Penicillium* were isolated from leaves, stem and roots specimen showing symptoms of various diseases. Results of species composition (percentage) of fungi occurring on infected plant tissues are represented in Table 4. The most common organism isolated from leaves showing

Table 4. Percentages of fungi isolated from infected plant tissues.

Disease	Plant part	Organism									
		Fusarium Spp.	*Colletotrichum* Spp.	*Choanephora* Spp.	*Cercospora* Spp.	*Phoma* Spp.	*Alternaria* Spp.	*Aspergillus flavus*	*Aspergillus niger*	*Cladosporium* Spp.	*Penicillim* Spp.
Anthracnose	Leaf	1	61	2	2	1	2	5	2	2	2
Stem canker	Stem	–	59	1	–	–	–	5	5	3	–
Wet rot	Leaf, stem	–	–	85	–	–	–	–	–	–	–
Wilt	Root	55	–	–	2	2	–	5	5	2	2

– Organism not isolated.
Source: Study

symptoms of anthracnose was *Colletotrichum* species (61 %). *Colletotrichum* species (59 %) also was most frequently isolated from stems with cankers. *Fusarium* species (65 %) was the most common species isolated from roots of plants with wilt while *Choanephora* species (85 %) was most frequently isolated from leaf and stem of plants with wet rot disease.

DISCUSSION

Disease survey in the study area observed anthracnose, stem cankers, wilting and wet rot as prominent diseases in amaranth farms. Diseases such as wet rot, anthracnose, white rust, leaf spots, root rot wilting and damping off on seed beds have been reported in amaranth fields in Africa and other continents (Blodgett and Swart, 2002; Pusz et al., 2015; Manandhar et al., 2016; Nampeera et al., 2019). Anthracnose and shoot dieback diseases of amaranth in West African was reported by (Sullivan, 2003). Ebert et al. (2011) reported of anthracnose on amaranth in Taiwan and concluded that the disease could become a serious problem in many countries hence breeding for resistance cultivars is urgent. Wilting of vegetables due to seed infections and soil-borne fungi particularly *Fusarium* species is common in the sub-region (Abang et al., 2002). *Fusarium* wilt of amaranth was reported in South Africa (Blodgett et al., 1998; Blodgett and Swart, 2002). In their report, over 72% incidence of wilting and severe damage of the disease on amaranth occurred in South Africa. Wet rot is a common foliar disease in most amaranth fields worldwide (online /PlantHealth/Crops/Amaranth, 2020). The disease has been devastating in Nigeria, Tanzania and Cameroon and South Africa (Abang et al., 2002). In Nigeria, Awurum and Uchegbu, (2013) reported of up to 50% yield loss of amaranth production in due to wet rot disease, thus presence of the disease put production of the crop at risk. Incidence and severity of the diseases showed in the study were high with significant difference in levels of infection among the locations. Variations in disease incidence and severity of Amaranth diseases recorded at the various locations is a in conformity with (Zahidul Islam, 2019). Higher disease incidences and severities in the fields could be attributed to a host of factors. Weather conditions, soil type, type of cultivar and cultural practices contributes to the occurrence and multiplication of diseases in the field. Foliar diseases on vegetable amaranth often reduces the aesthetic values of the crops and negatively affect marketability of the leaves (Krishnakumary and Rajan, 2006; Zahidul Islam, 2019). Again, the high severity of these diseases implies that quantity and quality of the edible leaves are reduced. Reduction of crop quality, yield and market value due to diseases gives indication that income of farmers is compromised (Cerda, 2017). Highest incidence of all the diseases in the farms was observed in Kumasi metropolis, in the Semi-deciduous forest zone. This could be related to the high rainfall and relative humidity with warm temperatures recorded in the zone. According to Sree et al (2010) and Shanaz et al. (2015), the occurrence, severity, spreading and infection cycles of disease like Anthracnose, damping-off, wet rot and Fusarium rot are affected by amount of rainfall and relative humidity hence these diseases are common and severe in areas with heavy rains. Presence of these diseases in majority of Amaranth growing areas is most likely because of inappropriate cultural and agronomic practices such as the lack of proper field sanitation which could result in high inoculum density in the environment or the use of infected seeds. Nine genera of fungi were isolated and identified on Amaranth disease specimen and these fungi have proven to be antagonistic on

Amaranth. Choanephora species are known to cause wet rot; the most destructive disease of Amaranth species (Sullivan, 2003; Awurum and Uchegbu 2013). According to Blodgett et al. (2002), Fusarium species are associated with wilting and damping-off diseases of amaranth in the field. Phoma, and Alternaria species have been isolated as the causal agents of stem cankers and leaf spots in amaranth fields (Stallknecht and Schulz-Schaeffer, 1993). Colletotrichum species are known as the causal agent of anthracnose in amaranth (Manandhar et al., 2016).

To the best our knowledge, this study is the first report on the incidence and severity of fungal diseases affecting amaranth as well various fungal pathogens associated with the diseases in Ghana.

CONCLUSION

Results of the current study have identified wilts anthracnose, stem canker, and wet rot as the common diseases associated with amaranth in the Kumasi and Tamale Metropolis. Ninety-five percent of farms surveyed had plants showing symptoms of wilts whilst anthracnose, stem canker, and wet rot disease symptoms were observed in 91, 37, and 46% of plants in surveyed farms. High disease incidence and severity of damage crop tissues were noticed in the fields surveyed. Highest incidence of the diseases was observed in Kumasi metropolis. This result is crucial to Amaranth production in the two Metropolises of Ghana. Further work should be conducted in other amaranth growing communities in Ghana to assess fungal diseases occurring in the fields for appropriate management to be undertaken.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abang MM, Kihurani A, Srinivasan R (2002). Managing Diseases and Pests of Indigenous Vegetables for GAP Compliance in Sub-Saharan Africa. Scripta Horticulturae 15:191-232.

Alemayehu FR, Bendevis MA, Jacobsen SE (2015). The Potential for Utilizing the Seed Crop Amaranth (*Amaranthus* spp.) in East Africa as an Alternative Crop to Support Food Security and Climate Change Mitigation. Journal of Agronomy and Crop Science 201(5):321-329.

Asase A, Kumordzie S (2019). Availability, Cost, and Popularity of African Leafy Vegetables in Accra Markets, Ghana. Economic Botany pp. 450-460.

Awurum AN, Uchegbu PC (2013). Development of wet rot disease of *Amaranthus cruentus* L . caused by Choanephora cucurbitarum (Berk. and Rav.) Thax. in response to phytochemical treatments and inoculation methods. Advancement in Medicinal Plant Research pp. 66-71.

Barnett HL, Hunter BB (1972). Illustrated genera of imperfect fungi. Third Ed. Burgess Publishin Company, USA P 388.

Blodgett JT, Swart WJ (2002). Infection, colonization, and disease of *Amaranthus hybridus* leaves by the *Alternaria tenuissima* group. Plant Disease, 86(11):1199-1205.

Blodgett JT, Swart WJ, Louw SV (1998). First Report of F*usarium sambucinum, F. oxysporum* , and *F. subglutinans* Associated with Stem Decay of *Amaranthus hybridus* in South Africa. Plant Disease 82(9):1062-1062.

Campbell CL, Benson DM (1994). Spatial aspects of the development of root disease epidemics. InEpidemiology and management of root diseases 1994 (pp. 195-243). Springer, Berlin, Heidelberg.

Cerda R (2017). Assessment of yield and economic losses caused by pests and diseases in a range of management strategies and production situations in coffee agroecosystems. PhD Thesis. Biodiversité, Agriculture, Alimentation, Environnement, Terre, Eau. SupAgro, Montpellier.

Cooke BM (2006). Disease assessment and yield loss. In The Epidemiology of Plant Diseases. Kluwer Academic Publishers pp 43-80.

Chivenge P, Mabhaudhi T, Modi AT, Mafongoya P (2015). The potential role of neglected and underutilised crop species as future crops under water scarce conditions in Sub-Saharan Africa. International Journal of Environmental Research and Public Health 12(6):5685-5711.

Dari L, Nenguwo N, Afari-Sefa V (2015). Packaging of indigenous vegetables in the Northern Region, Ghana. Acta Horticulturae. International Society for Horticultural Science 1102:179-181.

Darkwa S, Darkwa AA (2013). The Use of Indigenous Green Leafy Vegetables in the Preparation of Ghanaian Dishes. Journal of Food Processing and Technology 4(12).

Das S (2016). Amaranthus: A promising crop of future. Amaranthus: A Promising Crop of Future. Springer Singapore pp. 1-208.

Drechsep P, Keraita B (Eds) (2014). Irrigated Urban Vegetable production in Ghana: Characteristics, Benefits and Risks. 2nd edn, International Water Management Institute - Colombo, Sri Lanka. doi: 10.5337/2014.219.

Ebert AW, Wu T, Wang S (2011). Vegetable amaranth (*Amaranthus* L.). AVRDC Publication pp. 1-9.

Koffuor GA, Ainooson GK, Addotey JN, Amponsah IK, Afriyie VA, Tutu R (2013). Preliminary pharmacological investigation of the ischuretic property and safety of a hydro-ethanolic extract of *Amaranthus spinosis* (Fam: Amaranthaceae). International Journal of Basic & Clinical Pharmacology 2(5):517.

Krishnakumary K, Rajan S (2006). Seasonal influence on leaf spot disease in amaranth. International Journal of agricultural Science 2(2):324-326.

Mabhaudhi T, Chimonyo VGP, Hlahla S, Massawe F, Mayes S, Nhamo L, Modi AT (2019). Prospects of orphan crops in climate change. Planta, 250(3):695-708. doi: 10.1007/s00425-019-03129-y.

Manandhar HK, Timila RD, Sharma S, Joshi S, Manandhar S, Gurung SB, Sthapit S, Palikhey E, Pandey A, Joshi B, Manandhar G, Gauchan D, Jarvis D, Sthapit B (2016). A field guide for identification and scoring methods of diseases in the mountain crops of Nepal, Bioversity International. Bioversiy International, Pokhara, Nepal 134 p.

Mensah JK, Okoli RI, Ahaju-Obodo JO, Eifediyi K (2008). Phytochemical, nutritional and medical properties of some leafy vegetables consumed by Edo people of Nigeria. African Journal of Biotechnology 7(14):2304-2309.

Nampeera EL, Nonnecke GR, Blodgett SL, Tusiime SM, Masinde D, Wesonga JM, Murungi LK, Baidu-Forson JJ, Abukutsa-Onyango MO (2019). Farmers'Knowledge and Practices in the Management of Insect Pests of Leafy Amaranth in Kenya. Journal of Integrated Pest Management 10(1):1-12.

Ngegba PM, Ololade AE, Clement GA, Aderonke KA, Ayotokunbo OE, Salia MK, Alusaine ES (2019). Evaluation of some plant extracts on mycelial growth and sporulation density of fungal pathogens of groundnut (*Arachis hypogaea* L.). International Journal of Development Research pp. 13808-13814.

Ntow WJ (2008). The use and fate of pesticides in vegetable-based agro-ecosystems in Ghana. PhD Thesis. UNESCO-IHE Institute for Water Education P 112.

Online /PlantHealth/Crops/Amaranth (2020). Plant Health (/crops-fruits-veg)/ Crops Fruits & Vegetables (/crops-fruits-veg) / Amaranth Crops. Infonet Biovision pp. 1-12.

Pusz W, Pląskowska E, Yildirim İ, Weber R (2015). Fungi occurring on the plants of the genus *Amaranthus* L. Turkish Journal of Botany 39(1):147-161. doi: 10.3906/bot-1403-106.
Rao S, Danish S, Keflemariam S, Tesfagergish H, Habtemariam T (2016). Pathological Survey on Disease Incidence and Severity of Major Diseases on Tomato and Chilli Crops Grown in Sub Zoba. International Journal of Research Studies in Agricultural Sciences 2(1):20-31.
Shanaz Y (2015). Studies on Fungal Foliar Diseases of Cucumber (*Cucumis sativus* L.) in Kashmir Valley. PhD Thesis. University of Agricultural Sciences and Technology of Kashmir.
Sree S, Texas U, Mohan M, Ricetec C (2010). Bioefficacy of endophytes in the management of leaf blight disease of amaranth. In Plant Growth Promotion by Rhizobacteria for Sustainable Agriculture pp. 524-532. doi: 10.13140/RG.2.1.2767.0564.
Stallknecht GF, Schulz-Schaeffer JR (1993). Amaranth Rediscovered, Amaranth Grain Production Guide and the 4th National Amaranth Conference proceedings 1993.
Sullivan P (2003). Amaranth Production. pp. 3-5. https://attra.ncat.org/wp-content/uploads/2019/05/amaranth.pdf
Zahidul Islam M (2019). Surveillance and management of white rust (*Albugo candida*) disease of red Amaranth for seed production. MSc Thesis. Sher-e-Bangla Agricultural University.