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Peri-urban lettuce production in the Kumasi metropolis: diseases and farmers' management strategies

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ABSTRACT

Lettuce (*Lactuca sativa* L.), an annual leafy herb belonging to the family Compositae, is one of the most popular salad crops, and occupies the largest production area among salad crops in the world. Often times, its production is hindered by diseases particularly, leaf blight diseases, referred to by farmers as "dot disease". The study was carried out in four major lettuce growing communities (KNUST, Boadi, Gyinyase and University of Education, Winneba-Kumasi campus) and comprised a survey where questionnaires were administered to catalogue diseases associated with peri-urban vegetables production, management strategies employed by the farmers and laboratory experiment for isolation and identification of pathogens associated with the diseases. Leaf blight, leaf spot and powdery mildew were the major diseases mentioned by the farmers. Samples of leaf blight disease of lettuce were collected from each community for isolation of causative organisms. Pathogenicity test was done by inoculating young potted lettuce plants and detached leaves with actively growing pure cultures of the isolates. After six days, it was observed that all the isolates except *A. niger* and *A. flavus* caused symptoms of the disease on the leaves. However, Lesions produced by *Curvularia lunata* resembled field symptoms of leaf blight. The survey also revealed challenges like unidentified bacterium causing leaf lesions, downy mildew, and damping-off diseases. Recommendations include developing seed treatment strategies, addressing reasons for youth disinterest, and conducting further studies on isolated bacteria. Enhancing peri-urban vegetable production is crucial for economic stability, food security, and environmental sustainability.

Keywords: *A. flavus*; *aspergilus nige; collectotrichum dematium;* crop disease; *curvularia lunata; lactuca sativa* L.; lettuce leaf blight; peri-urban agriculture; vegetable production
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Introduction

In West Africa, the urban population has increased for the last 20years. According to the World Bank reports in 2009, the sub-Saharan Africa's population increase in both rural and urban areas were the highest in the world (Bryceson & Potts, 2006). The principal cause of urbanization is rural-urban migration (Beauchemin & Bocquier, 2004), although it has slowed down (Potts, 2009). The growth in the size and proportion of the urban population raises the demand for food and hence the need for peri-urban agriculture (Moustier & Page, 1997). Coffie *et al*. (2003) identified peri-Urban Agriculture (PUA) as a beneficial source of food including fresh vegetables for many cities in sub-Saharan Africa. Enormous proportion of fresh vegetables such as lettuce, cabbage, green pepper, spring onions and carrots which are in high demand due to the cosmopolitan nature of the cities has been credited by PUA in Ghana (Coffie *et al*., 2005).

While satisfying the dietary requirements of the over-increasing population of cities, PUA also serves as a source of employment for several smallholder farmers who are into this venture thereby improving their livelihoods and alleviating poverty (Cofie *et al*., 2003; FAO, 2007). PUA can be grouped into two in the Kumasi Metropolis: they are backyard gardening and open space farming (Adeoti *et al.,* 2012). According to (Adeoti *et al*., 2012), backyard gardening is estimated to cover an area of 50-70 ha which is distributed over 80,000 small backyards and it occurs in and around homes within the Metropolis. It is estimated that about 680 ha of land are used for open-space farming of which dry season irrigated vegetable production consist of about 100 hectares (Obuobie *et al*., 2006). Obuobie *et al*. (2006) reported that, peri-urban farmers in the Kumasi Metropolis have plot sizes ranging between 0.01-0.02 ha per farmer and about 1500 vegetable growers are involved in this venture.

According to (Drechsel & Dongus, 2010), 70% of peri-urban farmers have been cultivating their plots for 10-20 years while 80% of open-space farmers cultivate the same piece of land every year. These intensive cropping regimes of urban farmers producing vegetables on the same piece of land usually lead to the build-up of diseases and pests in the production sites. This persists on farms and reduces production because farmers depend on their own seeds, year in and year out (Drechsel & Dongus, 2010). Majority of these farmers depend on PUA to care for their families and so cannot tolerate losses due to diseases, which in some cases can lead to crop failure. PUA farmers therefore, reportedly adopt both conventional and unconventional disease control methods, which at times are inappropriate and also not effective.

In the general absence of certified seeds for peri-urban vegetable production and the continuous cropping on the same piece of land for several years, disease incidence and severity are often high leading to low productivity. In any attempts to help these farmers to control diseases in their production areas and increase yields and quality of their produce, the problems that confront them need to be understood. This study was therefore conducted to help document the diseases encountered by farmers in PUA with the aim of improving their productivity. The specific objectives were to;

i) identify the prevalent diseases that affect vegetable farming in the Kumasi Metropolis

ii) isolate and identify pathogens associated with lettuce blight diseases

Materials and Methods

Study area

The selected communities were located within latitude 6.35^0-6.40^0 and longitude 1.30^0-1.35^0, an elevation of 250-300m above sea level in the transitional zone. It has an area of 254 square kilometers (KMA, 2006). The mean temperature range is 21.5^0C-30^0C (KMA, 2006). The population in Kumasi by the year 2013 was estimated as 2,069,350 (GSS, 2013). Kumasi Metropolis features a rainy and dry climate throughout the year. The areas feature two distinct rainy seasons, a longer rainy season which starts from March and ends in July and a shorter rainy season from September to November. It has an average rainfall of 1400mm per annum.

Data collection

The study was carried out in two stages. The first stage was a questionnaire administration to document knowledge and disease management practices of farmers. The second stage involved collection of samples of diseased tissues for identification and pathological analyses. Documentation of diseases that affect field production of vegetables. Samples of diseased tissues were collected for identification and pathological analyses.

Surveys

Surveys were conducted between August-November, 2015 in four vegetables growing communities within peri-urban areas of Kumasi metropolis in Ashanti region of Ghana

Farmer's knowledge on prevalent diseases

A questionnaire was employed for the documentation of farmer's knowledge on prevalent diseases associated with peri-urban vegetable production. Sampling for the questionnaires was done through purposive sampling technique. With the help of Ministry of Food and Agriculture, 100 farmers from four communities: University of Education-Winneba, Kumasi Campus, KNUST Campus, Boadi and Gyinyase (all in Kumasi Metropolis) were selected and interviewed using questionnaires to find out their knowledge of vegetables disease.

Leaf sampling for laboratory analysis

Twelve Samples of lettuce leaves with symptoms of diseases were collected from the four communities. In each community, four farms were sampled and three diseased leaf samples collected randomly during the wet season when diseases incidence were high on the farm. The collected diseased samples were stored in a refrigerator at 4^0C in the laboratory until required.

Preparation of culture media, isolation and identification of pathogens from diseased lettuce leaves

Preparation of Potato Dextrose Agar (PDA) was done by dissolving 39 g of the powder in 1000 ml of distilled water in a conical flask. The conical flask together with the content was stirred, covered with aluminum foil and autoclaved at 121^oC. It was then allowed to cool and then poured into Petri dishes for it to solidify. The same procedures were used in the preparation of Nutrient Agar (NA). Pieces of diseased tissues cut from margins of lesion on lettuce leaves of each site were surface-sterilized in sodium hypochlorite solution for five minutes. The surface sterilized diseased tissues were rinsed separately three times with sterile distilled water. The tissues placed on sterile tissue paper were allowed to air dry in sterile lamina flow hood. The dried diseased tissues were plated on Potato Dextrose Agar (PDA) and Nutrient Agar (NA) media for fungal and bacterial growth. Mycelia and bacterial colonies that grew from the plated leaf tissues after five days of incubation were sub-cultured onto fresh PDA and NA respectively.

Several sub-culturing was done until pure cultures of the fungal and bacterial isolates were obtained. Inocular of different isolates were obtained from these pure cultures for pathogenicity tests. Characteristics of fungal isolates such as colony texture, spore shapes, pigment production and spore or conidia-producing structures were documented.

Depending on the fungal species, after one to two weeks these characteristics were observed from fungal tissues grown on PDA. A compound microscope was used to examine spores and mycelium characteristics of these isolates. Mathur & Kongsdal (2003); Barnett & Hunter (1972) reference manuals were used to identify the fungal organisms based on the observed features. Bacterial isolate was not identified due to limited facilities and cost constraint.

Experimental design

The experimental design was complete randomized design with four replicates. Each replicate consisted of the isolated pathogens on wounded and non-wounded leaf surfaces. In the control, the potted plants and detached leaves in Petri dishes were not inoculated with the pathogens.

Pathogenicity studies

Pathogenicity studies were done at the plant house behind Plant Pathology Section, Council for Scientific and Industrial Research-Crops Research Institute (CSIR-CRI), Fumesua-Kumasi. Pure cultures of four different fungal isolates and one bacterial isolate obtained from diseased leaf tissues were plated on PDA and NA respectively. Seven-day old cultures of the isolates were used as inocular in the pathogenicity studies. Seeds of lettuce (Eden variety) were nursed for two weeks and then transplanted into pods filled with sterilized top soil. Three-weeks after transplanting, some of the leaves of potted plants were detached and plated in petri dishes. Spores of fungal tissues obtained from the actively growing cultures were used to inoculate healthy detached leaves in petri dishes and potted plants by placing the inocular on the surface of the leafs. Two kinds of inoculations were done. In the first, the leaves were wounded with sterile needle before inoculation whiles in the second, leaves were not wounded. Sterile inoculating needle dipped into colonies of the actively growing bacterium isolate was used to inoculate the leaves. The inoculated plants were incubated under plastic hoods created to generate high relative humidity around plants and were examined six days after incubation.

Data analysis

Statistical Package for Social Science (SPSS) version 16.0 for Windows were used to analyse the socio-economic data.

Results and Discussion

34% of the farmers indicated that “Dot disease” (Leaf blight) (Plate 1.1) was the most common disease that affected their crops. 35% of the farmers had their crops affected by leaf spot diseases. Other diseases mentioned by farmers as constraint included wilting, root rot and powdery mildew.

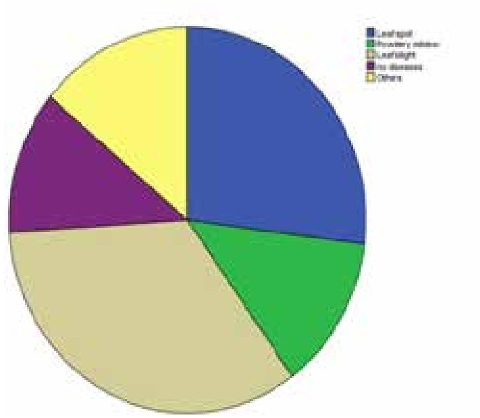

Fig. 1.0: Distribution of diseases that affect farmers

Fig. 2.0: Lettuce plants infected by blight disease at Gyinyase

Identification of pathogens

Isolated pathogens	Basic features
Curvularia lunata	It is usually a brownish or black-brownish pigment with curvy or lunate rounded end conidia and usually with 3-5 septa.
Colletotrichum dematium	It exhibits dark, melanised structures such as conidia and setae. It also produces one-celled asexual spores and dark colonies
Aspergilus niger	It appears as black or dark green mold with powdery colonies
A. *flavus*	It produces aflatoxins, potent mycotoxins that can contaminate crops like peanuts and corn. It also produces yellow-green colonies

Four fungal pathogens isolated were identified as *Curvularia lunata* (Wakk.) Boedijn, *Colletotrichum dematium* (Van Tieghem), *Colletotrichum dematium* (Van Tieghem), *Aspergilus niger (*Link*)* and *A. flavus*. The bacterium isolate was not identified due to limited facilities and cost constraint.

Pathogenicity studies

Leaves of lettuce plants six days after inoculation with *C. lunata* developed necrotic lesions which resembled lettuce leaf blight reported by several lettuce producing farmers in the Metropolis. Necrotic lesions developed in both wounded and unwounded leaves (Figure 3.0). Lesions were absent from the leaves that were not inoculated. In the detached leaf assay, the inoculated leaves developed necrotic lesions similar to what was observed in the potted plants (Figure 4.0). In both the potted plants and detached leaf assays, leaves inoculated with *C. dematium* developed spotted lesions six days after inoculation (Figure 5.0 and 6.0). Leaves inoculated bacterium culture developed spotted lesions similar to lesions caused by *C. lunata* and *C. dematium* six days after inoculation (Plate 1.6). Lesions developed by inoculated leaves in the pathogenicity studies resembled necrotic lesions on the diseased leaves from which the isolates were obtained. No characteristic lesions were observed on leaves inoculated with *A. niger* and *A. flavus.*

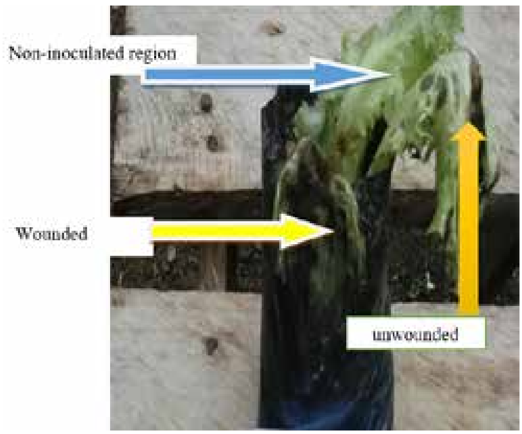

Fig. 3.0: Potted lettuce plant six days after inoculation with Curvularia lunata: lesion on the wounded (light yellow arrow) and unwounded (deep yellow arrow) regions. No lesion on non-inoculated region (blue arrow)

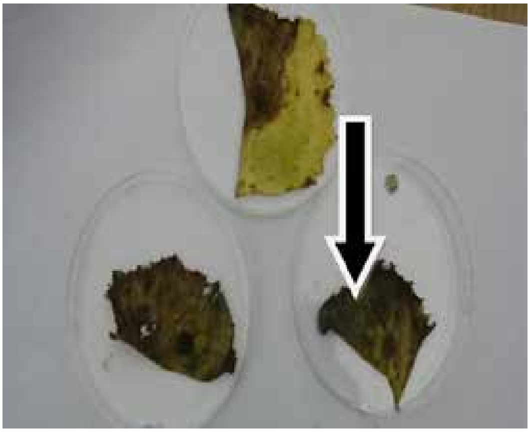

Fig. 4.0: Lesions on the wounded and non-wounded regions of detached leaves inoculated with Curvularia lunata

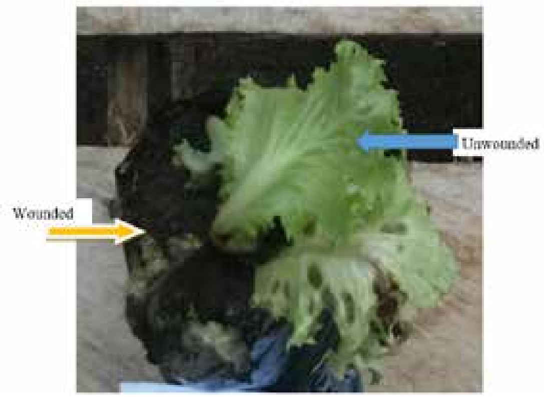

Fig. 5.0: Potted Lettuce plant six (6) days after inoculated with Colletotrichum dematium (yellow arrow) and non-inoculated leaf (blue arrow)

Fig. 6.0: Blight on detached leaves six days after inoculation with Colletotrichum dematium

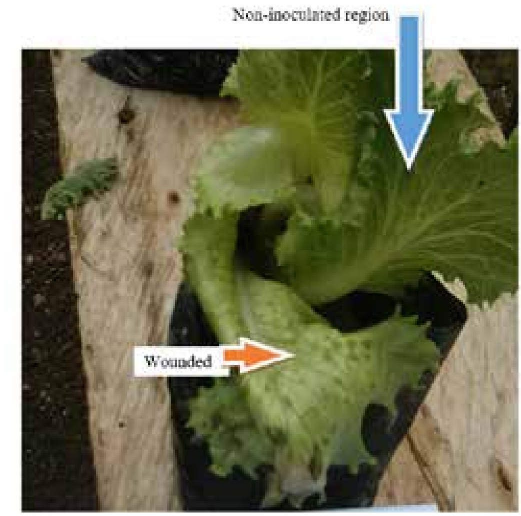

Plate 1.6: Potted lettuce plant six days after inoculation with bacterium (arrow red is inoculated region and blue arrow is non inoculated region)

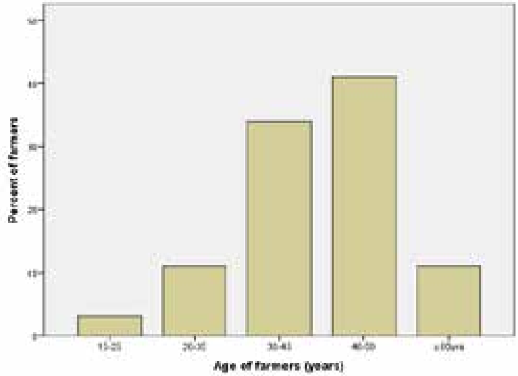

Fig. 7.0: Age distributions of vegetable farmers interviewed during the surveys. The age distributions of the 100 vegetable farmers who responded to questionnaires were as shown. The majority of farmers interviewed were between 46-59 years of age, followed by those of 36-45 years old

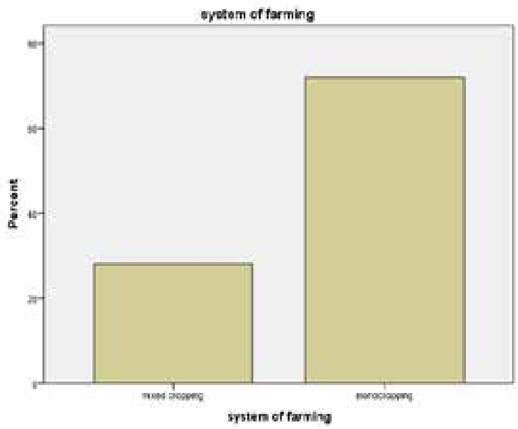

Fig. 8.0: System of farming practices of peri- urban farmers. Majority of farmers (72%) practices mono-cropping system of farming compare to few farmers (28%) who practice mixed-cropping

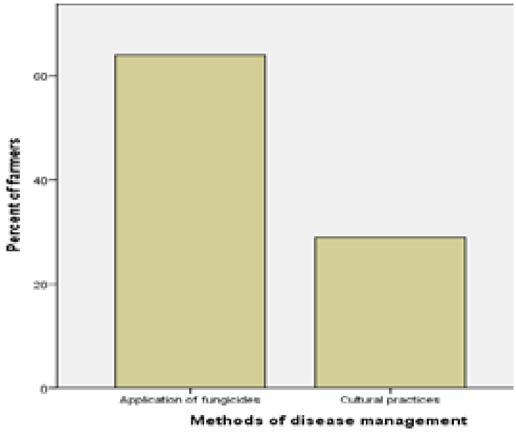

Fig. 9.0: Disease management practices of peri- urban farmers

85% of the farmers interviewed responded that diseases affected their yields and quality of their produce while 15% stated that diseases had no effects on their crops. 68% of farmers used fungicides such as Dithane M-45 or Dithane M-45 solution (80% Mancozeb), Furada (carbofuran 3 % G), Cobox or Funguran (Copper hydroxide) and Champion (copper hydroxide) to manage diseases of their crops regularly. (Fig.9.0). About 28% used cultural practices such as thinning-out, mix cropping and roguing to manage diseases, while 4% did not manage diseases on their fields.

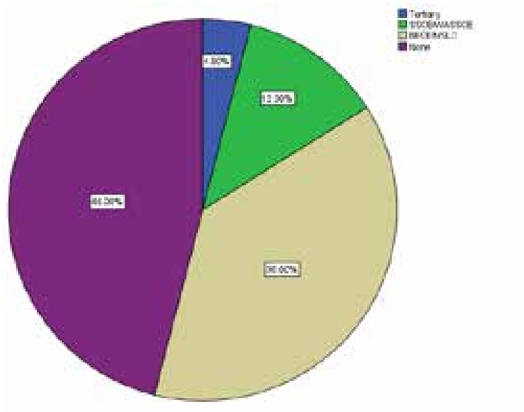

Fig. 10.0: Distribution of farmers in the different educational levels. Results of the surveys indicated that 46% of the farmers had never been to school, while very few farmers had education to the tertiary level

The results from the surveys revealed that more than half of the farmers who were involved in peri-urban vegetable productions in the surveyed areas were elderly in the age range of 36-59years. This indicates that strong and youthful people in their twenties and early thirties are not much interested in peri-urban vegetable production in the Kumasi Metropolis. This is probably because the youth who have the vigor to take up agricultural production do not believe or have the knowledge that agricultural production can really be a lucrative venture. It may also be due to the low income from farming. This was reiterated by (Chikezie *et al*., 2012) that agricultural activities are not attractive to young people.

Identifying and addressing these challenges can help to bring more youth and adults into agriculture to reduce urban unemployment. It was also found that peri-urban vegetable production in the Kumasi Metropolis was dominated by male farmers. This is in consonance to Food and Agriculture Organization finding that males form over 60% of the agricultural labor force in many sub-Saharan African countries (FAO, 2010). This observation is not surprising because the labor-intensive nature of peri-urban vegetable production will surely keep more females away from this industry. It is however common to find more females than males involved in marketing of the produce of peri-urban farmers (FAO, 2010). Result of the survey indicated that peri-urban vegetable farmers depend more regularly on the use of fungicides to manage diseases on their farms and they apply the fungicides at the sight of the diseases. According to (Ahmed, 1995); (Ntow *et al*., 2001), this poor agronomic practice can result in the development of resistance in the targeted pathogens.

Moreover, the farmers may use wrong fungicides against the targeted diseases, or they might be misusing the fungicides due to their low educational background. This may have contributed to the high incidence of damage documented in the study area due to ineffectiveness of the fungicides against the diseases of lettuce. The use of chemical fungicides in controlling diseases in vegetable production in Ghana is common (Wolff, 1999). Farmers in vegetable production depend on chemical pesticides to produce tomato and pepper, and in several instances they abuse the use of these chemicals (Robinson & Kolavalli, 2010c; Clottey *et al.,* 2009). A reasonable number of farmers involved in the surveys reportedly did not manage diseases on their vegetable farms. This situation was reported by Moses *et al.* (2015). Moses (2009) reported that farmers who produce cassava in Ghana for example did nothing to manage diseases of their crops even though they experienced losses.

The study revealed that mono-cropping system of farming was practiced by majority of the farmers, whereas few farmers practiced mixed-cropping. Mono-cropping is characterized by crowded populations with genetic homogeneity and as a result, once a disease becomes established, it can easily spread to epidemic proportions (Arya, 2002; Obeng-Ofori *et al*., 2007). This could account for the predominance of lettuce leaf blight damage in peri-urban farms within the Kumasi Metropolis. The results further showed that most of the farmers interviewed had low educational background, which might have contributed to their poor agronomic practices. High illiteracy rate among farmers could have detrimental impact on their level of understanding of fundamental disease management principles or the adoption of appropriate agronomic practices such as rogueing of diseased plants, and proper disposal of crop residue (Lewis & Miller, 2004). Mugo (2012) reported that knowledge about the management of a disease is very important in the incidence and control of that particular disease.

Identification of pathogens associated with lettuce blight disease and pathogenicity studies

The results of the study indicated that *Culvularia lunata* and *Colletotrichum dematium* isolated and inoculated into leaves of lettuce plant produced necrotic lesions similar to leaf blight and leaf spot diseases found in lettuce fields in the study areas. Smith *et al*. (1989) reported that *Culvularia* spp. caused blight diseases in white clover and zoysia grass. The species of these pathogens are disseminated by wind driven rain and dew to adjoining plants and nearby lettuce plants (Jackson, 1999). The diseases can also be spread by planting diseased materials and the fungus has been reported as surviving actively on planting material for three weeks after harvest (Jackson, 1999). Lettuce leaf blight and leaf spot diseases were very widespread in lettuce production in the Kumasi Metropolis. Several farmers have reported leaf blight and leaf spot diseases of lettuce in peri-urban lettuce production in Kumasi Metropolis in recent years. It is possible that leaf blight and leaf spot diseases reported by farmers are caused by *Colletotrichum dematium* and *Curvularia lunata.* These are seed-borne pathogens and therefore farmers can control field diseases of these pathogens effectively through seed treatment. Controlling seed borne pathogens of lettuce such as *Colletotrichum dematium* and *Curvularia. lunata* can reduce some of the necrotic diseases reported by farmers in the Metropolis. The unidentified bacterium also caused necrotic lesion after inoculation. According to (Elliott, 1951), *Xanthomonas* and *Erwinia* species cause leaf lesion on lettuce leaves.

Conclusion and Recommendation

The results of the survey indicated that farmers in peri- urban vegetable production are affected by leaf blight, leaf spot and powdery mildew and greater number of them depended on chemical pesticides especially fungicides to manage these diseases. Few farmers used cultural practices to manage diseases. It was also found that downy mildew and damping-off diseases affected their production although they did not mention. The study also indicated that majority of the farmers are elderly (36-59 years) and have low educational backgrounds. The pathogenicity test also revealed that each of the causative organisms isolated: *Culvularia lunata, Colletotrichum dematium* and the unidentified bacterium caused necrotic leaf lesions when inoculated unto healthy lettuce leaves. Lesions caused by *Culvularia lunata* resembled lettuce leaf blight reported by several lettuce producing farmers in the Metropolis.

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