NJB, Volume 35 (1), June, 2022

SURVEY OF FUNGAL DISEASES ASSOCIATED WITH AERIAL STEMS AND LEAVES OF POTATO (*SOLANUM TUBEROSUM* L.) IN SOME IRRIGATED FIELDS IN KADUNA AND KATSINA STATES OF NIGERIA

[1]Abdu, S., [1]Dangora, D. B. and [2]*Suleiman*, A. B.

[1]Department of Botany, Ahmadu Bello University, Zaria, Nigeria

[2]Department of Microbiology, Ahmadu Bello University, Zaria, Nigeria

Correspondence: abusuhaibibasma@gmail.com

Received 23rd June, 2021; accepted 17th July, 2021

ABSTRACT

A survey was conducted to determine the incidence of fungal diseases associated with aerial stems and leaves of Irish potato (*Solanum tuberosum* L.) in some irrigated fields in Kaduna and Katsina states. The fields were selected based on systematic random sampling method and the samples were collected using stratified random sampling (SRDS) techniques. Disease symptoms were identified using CABI and CIP description of potato diseases. A total of four fungal diseases were found to be associated with aerial stems and leaves that included early blight (17.8%), leaf blight (48.7%) Fusarium wilt (21.1%) and Sclerotinia wilt (12. 29%). The fungi were identified based on standard mycological methods. The colonies observed were distinguished microscopically and macroscopically. Six genera of fungi were isolated from the wilted aerial stems and blighted leaves as *Fusarium* sp (18.7%), *Sclerotium* sp (18.7%) and *Alternaria* sp (18.7%); *Helminthosporium* sp (18.7%) had the highest frequency of occurrence. *Botrytis* sp (17.7%) and *Stemphylium* sp (5.6%) had the least frequency of occurrence. The results of this study could be used for further studies in plant protection and disease management.

Keywords: Aerial stems; Fungal Diseases; Potato; Irrigation;

https://dx.doi.org/10.4314/njbot.v35i1.1

INTRODUCTION

The potato (*Solanum tuberosum L.*) is grown worldwide in continental, temperate, subtropical and tropical climates. It is the world's most widely grown tuber crop (Were *et al*., 2013) and the fourth major food crop after rice, wheat and maize (Guchi, 2015). Potato originated from South America and was brought to Africa in the 20th century. Since then, the crop has spread around the world and has been incorporated into the food of nearly every region of the world (CIP, 2011). Potato is now an important crop and invaluable food source all over the world. Potatoes are rich in carbohydrates, which are important for energy (Visser *et al*., 2009). While potatoes are low in proteins, they contain large amount of vitamins B and C as well as ascorbic acid. Currently in Nigeria, the crop is being cultivated in commercial quantities in Cross River, Plateau, Taraba and Borno states (NRCRI, 2012). Also during the cold months of hamattan, potato can be grown in eleven Northern states of Nigeria, namely Borno, Bauchi, Jigawa, Gombe, Kaduna, Katsina, Kano, Kebbi, Sokoto, Yobe and Zamfara under irrigation. Many countries in sub-Saharan Africa such as Nigeria are in the process of expanding their potato production, and with the effect of climate change leading to floods especially in the rainy seasons, irrigation seems to be a better alternative. Muhammad (2009) noted that over 50,000 hectares of land have been under potato irrigation on the Plateau every dry season by individuals, cooperative groups and government agencies.

The potato business in Nigeria is estimated at 300 billion naira (FAO, 2012; NRCRI, 2012). Potato plays an important role in employment creation, poverty alleviation, food security as well as a source of revenue to government. The bulk of potato production in Nigeria comes from the Jos-Plateau due to favourable climatic conditions.

Most of the work done on etiology of the diseases of Irish potato in the areas of study carried out on potato tuber were either in the store or market sources. Little or no work has been done on both the aerial stem and leaves

of potato from irrigated fields. This study reports the identification of different fungal diseases affecting aerial stems and leaves of Irish potato as well as fungal isolates associated with the diseases.

MATERIALS AND METHODS

Survey area

During 2015 and 2016 growing seasons, a survey was conducted in some irrigated fields of potato in Kaduna and Katsina States to determine the incidences and prevalence of fungal diseases associated with aerial stems and leaves of potato. The sampling collection techniques were designed and developed based on the size and disease distribution in the fields. A total of eight (8) villages and 32 fields were surveyed in the two states. In both states, two Local Government Areas and four villages were visited. Based on the interview with potato growers and physical observations of all the fields, qualitative data such as seed sources, potato varieties grown, seed cutting process, cultural practices, crop rotation and source of irrigation water were collected in order to track the source of infections.

Sample Collection

Samples were collected from fields based on the stratified random sampling technique (SRSD) (Cochran, 1977). The entire field was divided into sectors (6-8) with the help of quadrant (10 x10). The infected leaf samples were collected and put in polyethylene bags for further analyses.

Hand books (CIP, 2009; CABI, 2013) containing an overview and description of the disease symptoms were used in identifying the symptomatic potato plants. Also, coordinates of sampling areas were determined using hand-held Global Position System (GPS) Magella Trailblazer XL GPS Handheld Receiver. The disease incidence was calculated using the following formula:

$$\text{Disease incidence} = \frac{\text{No. of infected plants}}{\text{Total no.of plant observed}} \times 100$$ (Foster and Tailor, 2006)

Isolation of Fungi from Diseased Samples

The fungi were isolated from infected tissues as described by Jha (1995), Pitt and Hocking (1997) and Nelson and Nabulie (2000) for diseased potato plants. The infected areas of the tissues were washed with sterilised distilled water prior to isolation. The infected area was removed or cut into 5 mm with the help of sterilised blade. The cut tissues containing both the healthy and infected portions were immersed in 1% sodium hypo chloride (NaOCl) for 2-3 minutes and rinsed 3 times with sterilised distilled water, then transferred into Petri dishes containing fresh PDA and incubated for 3-5 days at room temperature. The representative colony types were picked and sub-cultured on the fresh PDA until pure culture was obtained. The isolated fungi were identified based on colonial characteristics on culture plates and microscopic features.

Identification and Characterisation of Isolated Fungi

Fungal isolates were identified based on macroscopic and microscopic characteristics. Wet mounts of fungal colonies were prepared following standard mycological procedures. Lactophenol in cotton blue was used for direct examination of specimens of fungi; 1-2 drops of lactophenol was placed on a slide and small tuff of the fungus was picked up with a sterilised needle and placed into the drop. The fungal material was then teased out, covered with a cover slip and examined under the microscope under x 10 and x40 objectives. Identification was done based on the Bannet and Hunter (1972) method.

Statistical Analysis

Data obtained were subjected to descriptive statistics to determine the incidence of diseases as well as frequency of occurrence of fungal isolates. Values were expressed in percentages after transformation. Also, Student's T test was used to compare the disease incidence among the fields and between the states. All analyses were performed using SAS V.9.2 (2008).

RESULTS

Incidence of Fungal diseases affecting the aerial stems and leaves of irrigated field potatoes in Kaduna and Katsina States

The incidence of aerial stem diseases induced by fungi was observed in all fields under study as shown in Figure 1. Among the diseases, early blight was highest in Bakori (40.0%) followed by Gwamusawa (30.8%) and Mahuta had the least incidence (20.0%). The incidence of *Fusarium* wilt was highest in Karfe (33.3%) followed by Bakori (26.7%) then Gwamusawa (23.1%), Mahuta (20.0%) and the least was found in Dan -Danga (17.7%). Hunkuyi had the highest incidence of leaf blight (100%) among all the fields visited, followed by Karfe (66.7%) and Dan – Danga (58.9%), Mahuta (50.0%), Gwamusawa (30.8%) and Bakori had the least (20.0%). Sclerotinia wilt was found to be highest in Dan-Danga (23.5%) followed by Gwamusawa (15.4%) and Bakori (13.3%) and the least was observed in Mahuta (10.0%).

Frequency of occurrence of isolated fungi from aerial stems and leaves of irrigated potato fields in Kaduna and Katsina States

Results showed that *Alternaria* sp was isolated from leaves with early blight disease symptom. The occurance of the fungi was highest in Bakori (41.9%) followed by Gwamusawa (38.9%) and Mahuta had the least (25.0%). Hunkuyi had the highes*t Botrytis* sp. (40.0%) followed by Karfe (27.3%), Mahuta (12.5), Dan-Danga (12.5) Gwamusawa (11.1%) and Bakori had the least (8.3%).The results showed that *Fusarium* sp was highest in Karfe (27.3%) followed by Bakori (25.0%), Gwamusawa (22.2%) and Dan-Danga (18.8%). The least was observed in Mahuta (12.5%). The frequency of occurrence of *Helminthosporium* sp was highest in Hunkuyi (30.0%) followed by Karfe (27.3%), Mahuta (25.6%), Dan-Danga (18.8%) and Gwamusawa (11.1%); the least was observed in Bakori (8.3%). Similarly *Sclerotium* sp was isolated from potato samples with *Sclerotinia* wilt disease in all the fields visited with Hunkuyi having the highest frequency of *Sclerotium* sp (30.0%) followed by Dan-Danga (18.8%), Karfe (18.1%), Mahuta (12.5%) and Bakori (8.3%); Gwamusawa (5.6%) had least frequency of occurrence (Figure 2).

Comparison of incidence of fungal diseases affecting aerial stems and the leaves among irrigated potato fields in Kaduna and Katsina states

Table 1 shows the comparison of incidence of fungal diseases among the irrigated fields in both Kaduna and Katsina states. Early blight disease in Gwamusawa (2.67) and Bakori (2.00) were significantly higher ($p<0.05$) than in Mahuta (0.67), while the fields in Karfe, Hunkuyi, Dan- Danga had no disease incidence. Leaf blight was significantly higher in Hunkuyi (3.33) and Dan-Danga fields (3.33) when compared with fields in Gwamusawa (2.67), Karfe (2.67), Mahuta (1.67) and Bakori (1.00). The incidence of *Fusarium* wilt in Gwamusawa (2.00) and Karfe fields (2.67) was significantly higher than Hunkuyi fields (0.00), in comparison to the fields of Bakori (1.33), Mahuta (1.67) and Dan-Danga (1.00). However, for *Sclerotinia* wilt disease, Hunkuyi (2.00) was significantly higher than in Gwamusawa and Dan-Danga (1.33) followed by Bakori fields (0.67). The disease was not observed in Karfe.

Comparison of incidence of fungal diseases and frequency of occurrence of isolates associated with aerial stems and leaves of irrigated potato field in Kaduna and Katsina States

The comparison of fungal disease incidence and frequency of occurrence of isolates associated with aerial stems and leaves of potato field in Kaduna and Katsina states is shown in Table 2. Early blight in Kaduna State (0.67) was low compared to Katsina State (4.67) but the difference was not significant ($p<0.05$). Similarly, leaf blight in Kaduna (7.67) and Katsina States (7.00) did not differ significantly. *Fusarium* wilt infection in Kaduna State was significantly (2.00) lower ($p<0.05$) than that of Katsina State (4.33). Sclerotinia wilt infection in Katsina (3.33) was higher than that of Kaduna State (0.33). The distribution of fungal isolates in Kaduna and Katsina States is shown in Table 2. There was significant difference in fungal counts between Kaduna and Kastina States. *Alternaria* sp. in Kaduna (0.67) was less compared to in Katsina States (4.00). In Kaduna state, *Botrytis* sp (2.67) had a higher count than in Katsina (1.67). *Fusarium* sp in Kaduna State was

1.33 while Katsina State had(3.33). *Helminthosporium sp*. isolates in Kaduna State had a mean count of 2.67 while Katsina State had 2.00. *Stemphylium* sp. in Kaduna State (2.00) was slightly higher than in Katsina State. The frequency of occurrence of *Sclerotium* sp. in Kaduna and Katsina States was 0.33 and 2.67, respectively.

Plate **A**: Early Blight symptom

Plate **B**: Leaf blight symptom

Symptoms of the various diseases associated with blighted leaves of potato: Plates A-B

Plate **C**: Fusarium wilt symptom

Plate **D**: Sclerotinia wilt symptom

Key: Arrow showing site of infection area

Symptoms of the various diseases associated with wilted aerial stems of potato: Plates C- D

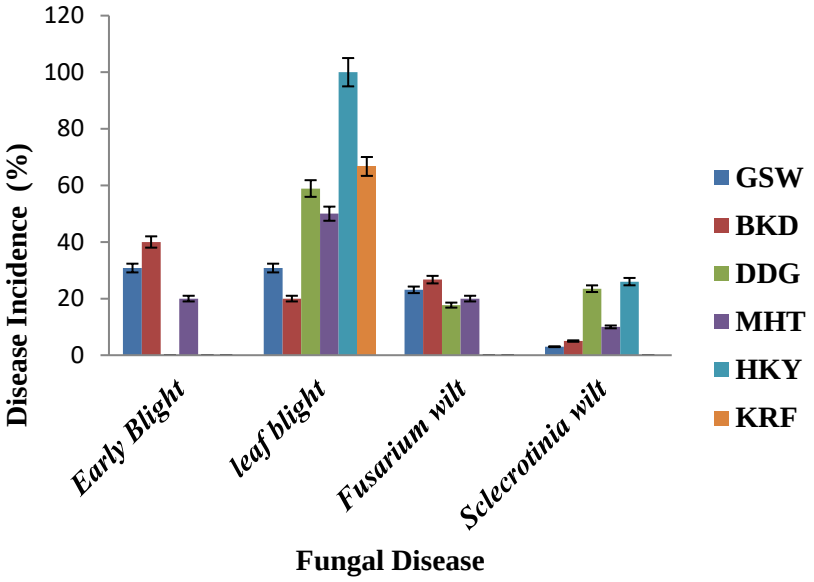

Figure 1. Incidence of fungal diseases affecting the aerial stems and leaves of irrigated potato fields in Kaduna and Katsina states

Key: GSW – Gwamusawa, BKD- Bakori, DDG- Dan-Danga, MHT- Mahuta, HKY- Hunkuyi, KRF- Karfe

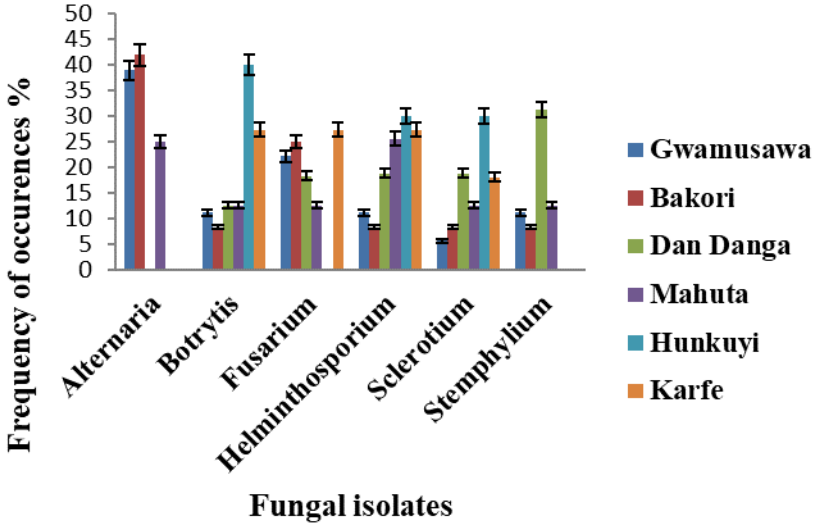

Figure 2: Percentage of occurrence of isolated fungi from aerial stems and leaves of irrigated potato fields in Kaduna and Katsina States

Table 1. Comparison of incidence of fungal diseases affecting aerial stems and leaves among the irrigated fields of potato in Kaduna and Katsina States

	Disease Incidence (%) of the field			
Location	**Early Blight**	**Leaf blight**	**Fusarium wilt**	**Sclerotinia wilt**
Gwamusawa	2.67±0.67^{a}	2.67±0.33^{ab}	2.00±0.58^{a}	1.33±0.33^{ab}
Bakori	2.00±0.58^{a}	1.00±0.58^{b}	1.33±0.33^{ab}	0.67±0.33^{bc}
Mahuta	0.67±0.33^{b}	1.67±0.33^{ab}	1.67±0.33^{ab}	0.00±0.00^{c}
Karfe	0.00±0.00^{b}	2.67±0.88^{ab}	2.67±0.88^{a}	0.00±0.00^{c}
Hunkuyi	0.00±0.00^{b}	3.33±0.33^{a}	0.00±0.00^{b}	2.00±0.58^{a}
Dan-Danga	0.00±0.00^{b}	3.33±0.67^{a}	1.00±0.58^{ab}	1.33±0.33^{ab}
P-value	0.001	0.068	0.056	0.006

Values with different superscripts in each column are significantly different ($p<0.05$)

Table 2. Comparison of incidence of fungal diseases and frequency of occurrence of isolates associated with aerial stems and leaves of irrigated potato field in Kaduna and Katsina State

	Disease Incidence (%)		
Fungal Disease	**Kaduna**	**Katsina**	**P-value**
Early blight	0.67±0.67	4.67±2.40	0.225
Leaf blight	7.67±1.45	7.00±2.08	0.423
Fusarium wilt	2.00±1.16	4.33±0.88	0.02
Sclerotinia wilt	0.33±0.33	3.33±0.67	0.095
	Frequency of Isolation (%)		
Alternaria sp	0.67±0.17	4.00±2.08	0.242
Botrytis sp	2.67±0.88	1.67±0.33	0.225
Fusarium sp	1.33±0.88	3.33±0.33	0.074
Helminthosporium sp	2.67±0.33	2.00±0.58	0.184
Stemphylium sp	2.00±0.58	1.67±0.67	0.423
Sclerotinia sp	0.33±0.33	2.67±1.20	0.250

DISCUSSION

The survey showed that early blight disease was found to be high in Gwamusawa and Bakori fields in Katsina State. This agreed with findings of Abbas (2017), who reported that early blight disease tends to be more severe in humid regions because the dew or free moisture on the foliage of potato plants can cause conidia of *Alternaria* to germinate within 30-40 minutes and the germ tubes arising from conidia penetrate the leaf epidermis directly through micro pores.

The results showed that Hunkuyi had a high incidence of leaf-blight caused by *Botrytis* sp. This could be associated with the irrigation schedules (time, amount and frequency of water). Irrigation remains a common problem in developing countries due to lack of technology. Layronas *et al*. (2013) reported that excessive irrigation and high fertilizer input lead to dense canopy making the leaves to remain wet for a long period, which is conducive for the development of botrytis disease.

The results indicated that Hunkuyi had the highest incidence of leaf blight caused by *Helminthos*p*orium* sp. This may likely be due to the maize cultivation during the rainy season farming before the cultivation of potato in the dry season. Shatty and Franyer (2015) noted that the maize residue harboured *Helmiothos*p*orium* blight pathogens. With the maize residues in contact with the soil surface the conidia and chalamidiospores were formed and the spread of *Helminthos*p*orium* pathogens on the soil surface penetrates the leaf tissues.

The study revealed that leaf blight caued by *Stemphylium* sp was observed in most of the areas surveyed. Suheri and Prince (2000) reported *Stemphylium* blight in the 1930s in Florida, USA. Since then, the *Stemphylium* leaf blight disease has spread to Asia, Europe and Africa. Zhang *et al*. (2010) reported that between 2004-2008 *Stemphylium* blight also attacked the fields in China, resulting in 30-70% yield loss. The results showed that Dan-Danga had the highest incidence of *Stemphylium* blight. This might be due to the fact that the *Stemphylium* sp could have overwintered in the fields. Since the farmers in Dan- Danga normally rotate onion with potato and other crops, it may probably be the carryover of pathogens from onion to potato plants. Mehta (2013) reported that in India the incidence of *Stemphylium* blight was high in the fields where onion was rotated with potato.

Karfe area had the highest incidence of *Fusarium* wilt disease, due, perhaps, to acute shortage of irrigation water in the area which makes potato plants to be under water stress. According to Kora *et al*. (2005), *Fusarium* wilt is severe at high temperature and dry soil condition.

Sclerotinia wilt disease was observed in nearly all the surveyed areas. The soil could have been infested with *Scleretium* which has overwintered in the soil due to rotation of carrot with potato in the fields. Akinlabi *et al*. (2015) reported that *Sclerotium* is capable of invading the crop from infested soil.

CONCLUSION

Results of this study showed that the *Fusarium* and *Slerotinia* wilt diseases were associated with aerial stems. Early blight was observed in the leaves. *Alternaria* sp, *Helminthosporium* sp, *Sclerotinia* sp. and *Fusarium* sp. Were the other pathogens isolated from the diseased plants. The results showed that rotation of potato with other crops like carrot, onions maize as well as irrigation schedules could have predisposed the crops to infections.

AKNOWLEGEMENT

The authors thank the farmers in the study areas as well as the technical staff of the Department of Microbiology, Ahmadu Bello University, Zaria and Tanimu Tela of the Division of Agricultural Colleges, A.B.U., Zaria for their assistance.

REFERENCES

Abbas, A. (2017). First Report of *Alternaria* Blight of Potato in Normal Valley Glight Bastitan, Pakistan. *Journal of Applied Microbiology*, 3(3):137-138.

Akinlabi, A. A., Kehinde, I. and Afolabi, C. J. (2015). Report of *Sclerotian sclerotian* as Causal Organism of the Leaf Spot and Stem Blight Disease of African Yam Bean. *Applied Bioscience*, 90 (4): 8408-8412.

Bannet, H. L. and Hunter, B. B. (1978). *Illustrated Genera of Imperfect Fungi*. 4th Edition. Mineapolis Burgress Publishing Company, Minneapolis, MN, 241p.

CABI. Crop Protection Compodium (2013). *Solanum tuberosum*. Datasheet. Available at http://www.cabi.org/cpc/datasheet/50561.Accessed 31 March 2015

CIP (2009). Select the Best: Positive selection to Improve Farm Saved-Seed. *Training Manual*. Internation Potato Centre, Lima, Peru. 108p.

CIP (2011). Road Map for investment in the seed value chain in Africa. International Potato Centre (CIP), Lima, Peru.

Cochran, W. G. (1977). Sampling Techniques.Wiley, New York NY. 428p.

Food and Agriculture Organisation of the United Nations (2012). Substainable Potato Production. Guideline for Developing Countries. Food and Agriculture Organisation of the United Nations, Rome. ISBN. 978-92-5-106409-2.

Food and Agriculture Organisation of the United Nations (2008). International Year of the Potato. Potato Diffusion (Hidden Treasure). http://www.potato2008. Retrieved 30th December, 2017.

Forster, P.M., and Taylor, K. (2006). Climate Forcing and Climate Sensitivities Diagnosed from Coupled Climate Model Integration. *Journal of Climatology*, **7**(6) 6181-6194.

Guchi, E. (2015). Disease Management Practic on Potato (Solanum tuberosum L.) in Ethiopia. *World Journal of Agricultural Research*, 3(1):34-42.

Jha, D. K. (1995). Laboratory Manual on Seed Pathology. Vikas Publishing House Ltd. pp13-30.

Leyronas, C., Duffaceid, M. and Nicot, P. C. (2013). Comparative Efficiency of the isolation Methods for *Botrytis cineara*. *Mycology*, 3 (4): 227-232.

Kora, C., Modonald, M.R. and Boland, G.I. (2005). *Plants Pathology* 54:256-279.

Muhammad, A. (2009). Plateau and Irish Potato Agriculture. Daily Trust Online. Tuesday 16th July, 2009. Retrieved From www.dailytrust. com/index.php. on 10th September 2017.

Mehta, V. R. (2013). Genetic Diversity among Isolates of *Stemphylium solani* from Cotton in India. *Plant Pathology*, 57(4): 380-385.

Nelson, G.C. and Nabulie, S. (2000). Microbiology. A *Laboratory Manual* (3rd edition).ULP, Newyork pp. 211-223.

NRCRI (2012). *The Annual Potato Programme* Report of the National Root Crops Reserch Institute, Umudike 2012. 108p.

Pitt, J. and Hocking, A.(1997). *Fungi and Spoilage* (2nd ed.). Blackie Academy of Professionals, London, N.Y..280p.

Suheri, H. and Prince, T. V. (2000). Infection of Onion Leaves by *Alternaria porri* and *Stemphylium vasiccalum* and Disease Development in Controlled Enviroment in Homebok Indonesia. *Phytophathology,* 4(3): 375-382.

Shatty, K. and Franyer, M. (2015). *Silver Scurf of Potatoes*. Kimbely Research and Extension Centre, University of Idaho. U.S.A. 138p.

Were, H.K., Kabira J.N., Kinyua, Z.M., Olubayo, F.M., Karinga, J.K. and Aura, J.L (2013) Occurannce and distribution of Potato Pests and Diseases in Kenya. *Potato Research,* 56 (4): 325-342.

Visser, R., Bachem, C., Boer, J. and Melo, P. (2009). Sequencing the Potato Genome: Outline of the Results to Come from the Elucidation of the Sequence of World's third Most Important Food Crop. *American Journal of Potato Research*, 86 (6): 203-209.

Zhang, L., Huag, J. and Hsiang, T. (2010). Integrated control of Garlic Leaf Blight caused by Stemphylium solani in China. *Canadian Journal of Plant Pathology*, 32 (5): 135-138.