Engineering, 2015, 7, 506-513
Published Online August 2015 in SciRes. http://www.scirp.org/journal/eng
http://dx.doi.org/10.4236/eng.2015.78047

Spread of *Phytophthora capsici* in Black Pepper (*Piper nigrum*) in Vietnam

Van Long Nguyen

Research and Development Pepper Centre, The Western Highland Agricuture and Forestry Science Institute, Pleiku City, Vietnam
Email: wasigl.long@ymail.com

Received 27 July 2015; accepted 23 August 2015; published 26 August 2015

Abstract

Black pepper is the one of most important export products in Vietnam. As the largest exporter, Vietnam's pepper commodities account for 58% of total worldwide exporters. However, Vietnam's pepper production is dealing with disease problems, especially foot rot/quick death infected by *Phytophthora capsici.* The disease results in serious and rapid spread and infection in Vietnam, with yearly reduction of about 2% of total pepper area. Disease management is recently challenging scientists and producers. Investigating characteristics of *Phytophthora capsici* and causes, therefore, play a significant role in treatment. This paper has indicated three main causes, which contribute to serious infection and outbreak of *Phytophthora capsici*; they are biological characteristics, climatic condition and cultivation. To control this disease, early detection and prevention are the best ways to manage disease. Finding new varieties, which are *Phytophthora capsici* tolerance or resistance, is significant in black pepper production worldwide.

Keywords

Black Pepper, *Phytophthora capsici*, Cause, Management, Vietnam

1. Introduction

Black pepper is one of the most important export products in Vietnam, contributing to socioeconomic development. It recently is quickly expanded in both area and yield. According to report of Vietnam Pepper Association—VPA, 2014 [37] the estimation of pepper growing area is about 73,500 ha, in which 53,000 ha are productive. The average pepper yield is about 2.5 tons·ha^{-1}. Pepper products were exported 156,396 tons, accounting for 58% total worldwide export, brought $1.2 billion to Vietnam in 2013. Pepper area increases an average 2800 ha·year^{-1} between 2011 and 2014, and it will continue rising in the future.

How to cite this paper: Nguyen, V.L. (2015) Spread of *Phytophthora capsici* in Black Pepper (*Piper nigrum*) in Vietnam. *Engineering*, **7**, 506-513. http://dx.doi.org/10.4236/eng.2015.78047

In order to get great achievements, pepper producers had applied advanced technologies and cultivations on farms. For instance, increase in organic materials, decrease in chemical fertilizers, use of live supports and drainage systems are applied [37]. However, Vietnam's pepper production is facing extreme problem, relatived to threat of diseases. Statistics of VPA [37] indicated from 2012 to 2014, pepper area was decreased about 2% year^{-1} (1200 ha) resulted from aging and diseases. In Gia Lai province specifically, pepper yield was dropped up to 30% in 2014 compared with 2013 [7]. The main and most serious disease on Vietnam's pepper areas is foot rot/quick death/*phytophthora* rot, which is caused by *Phytophthora capsici* [33].

Phytophthora capsici (*P. capsici*) is one of the most important vegetable pathogens worldwide, which was introduced by [6]. It is an oomycete soil-borne plant pathogen that causes root, fruit and foliar disease on a variety of vegetables. Plants that are infected by this pathogen will die within 2 - 3 weeks in rain and adjacent plants will be infected within one or two months [13]. Quick death of *Piper nigrum* can be presented that *phytophthora* spores develop into the roots and stems, especially collar causing foot rot (**Figure 1**). Rotting of collar destroys phloem and xylem, preventing transfer of water and nutrient from the roots to aerial parts of plant [21]. Therefore, plant died intermediately with symptoms of sudden leaf wilting and dropping. Importantly, the first symptoms of disease are very hard and often undetected by farmers and technicians. They detected disease when the upper part of pepper vine shows a performance as leaf yellowing, wilting and dropping [33]. Once these symptoms are observed, the infection is already at its severe stage with most of the root rotted and the underground stem showing a brownish-black lesion.

P. capsici causes significant decline in pepper yields in all pepper producing countries and it is very hard to control. For example, foot rot in Indonesia resulted in degradation of pepper production from 5% - 0%, yield decline is up to 30% - 40% in some gardens and others can devastate 100% [15]. Malaysia, a similar, more than 95% of pepper farms were infected *P. capsici*, causing 5% - 10% of productivity decrease [11]. And in India, foot root causes up to 30% yield loss [2].

In Vietnam, the first disease recording was in the half of 20th century, in Ba Ria-Vung Tau province with devastating 390 ha of *Piper nigrum* [33]. Several gardens have over 80% in death rate in North Central Coast [28], in some cases 100% pepper vines died off [33]. In the Western Highlands, similarly, average 50% of pepper farms were infected by *P. capsici*. The infection level depends on investigated locations, ranging from 24.6 to 83.3% [12]. Management of *P. capsici* on *Piper nigrum* is enormously complex and a big challenge. Meanwhile, study on this pathogen in Vietnam was limited, which leads to lack of knowledge and information [28]. Therefore, this review aims to investigate the causes including biological characteristic of pathogen, climate and cultivations that contribute to serious infection and quick outbreak of *P. capsici* in Vietnam's black pepper production.

Figure 1. Symptoms of *Phytopthora capsici* infection on black pepper: (A) A wilting pepper vine result in collar rot; (B) collar infection; (C) leaf infection.

2. Key Elements Affecting Outbreak of Disease

2.1. Biological Characteristics of *P. capsici*

2.1.1. Morphological Details

The understanding in biology of *P. capsici* is still shortcoming, leading to unsuccessful treatment. According to many scientists, two mating types of pathogen are A1 and A2 [8] [22] [32]. They also were detected in four provinces In Vietnam, co-existing in the same farm, even though in the same poles [29]. Moreover, the number of isolates of *P. capsici* is still undetected, because individual studies and different locations have found different number of *P. capsici* isolates. For instance, In Vietnam, reference [29] investigated genetically 118 isolate of *P. capsici* from *Piper nigrum*, whereas, 113 isolates were isolated in India [2]. In contrast, reference [18] investigated 255 isolates from 21 countries of six continents; most of them have genetic structure was n = 10.

2.1.2. Reproduction

In addition, the reproduction process of pathogen causes challenges to scientists and producers. *P. capsici*produces several types, both sexual and asexual means. Meanwhile, mycelia produced three asexual spores including sporangia, zoospore and chlamydospore. Zoospores are the major propagules of infection [17]. Each oospore that produces a male and female gametangium, so called antheridium and oogonium respectively [8], serve as the overwintering inoculum of pathogen (**Figure 2**). Moreover, under good condition of free moisture on plant surface or saturated soil, sporangia release motile and biflagellate zoospores. Each sporangium produces 20 to 40 motile zoosposes under free water conditions [14]. Additionally, sporangia and zoospores are secondary inocula and they can be reproduced repeatedly during the growing season, causing rapid escalation of disease [5].

2.1.3. Life Cycle

Life cycle of pathogen is a one of elements contribute to maintaining and developing pathogen. Temperature (20˚C - 28˚C) and moisture (>80%) are optimal for both chlamydospores and oospores live over 6 years in soil; 2 - 3 rainy seasons in dead plant materials [16]. More importantly, inoculum can survive in the soil up to 19 months without host plants [11].

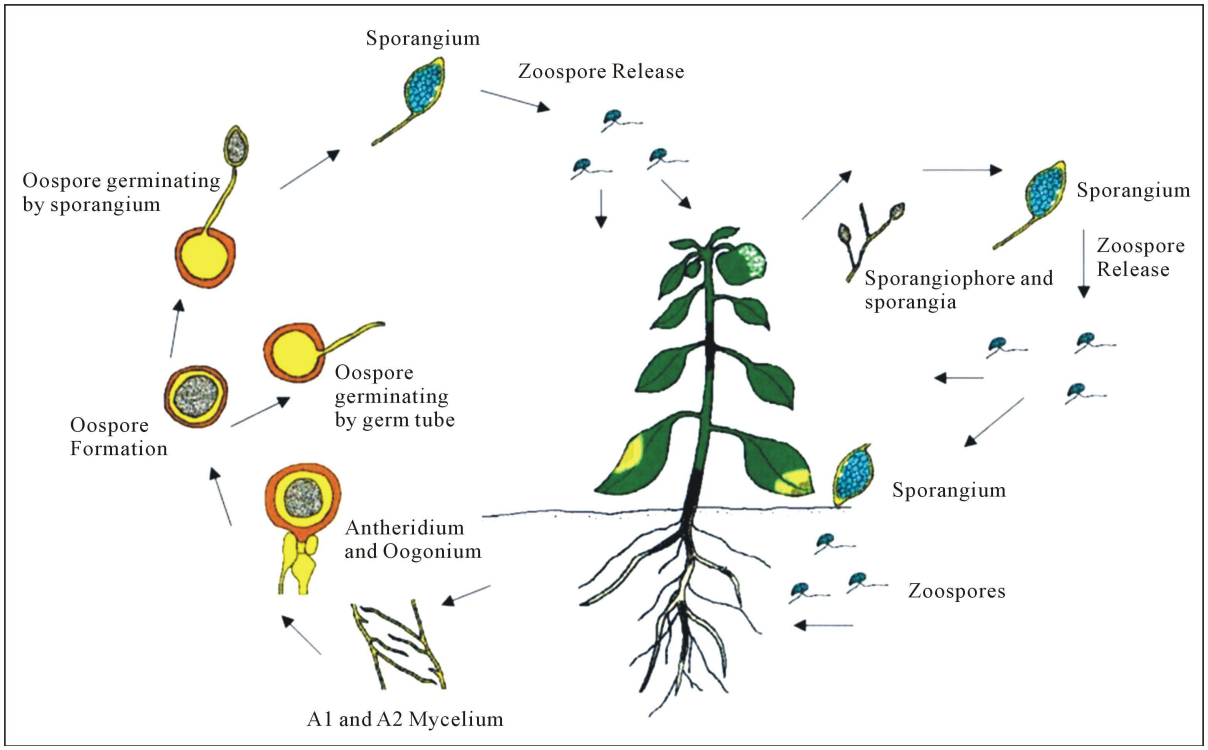

Figure 2. Life cycle of *P. capsici*, causal agent of *Phytophthora* blight [22].

2.1.4. Outbreak

In terms of the spread of *P. capsici*, there are many ways to transport zoospores. The main source of inoculum is in contaminated soil (0 - 30 cm); Chlamydospores and thickened mycelium are the main survival structure of *P. capsici* in soil [3]. Oospores can directly geminate and damage plants. Sporangia, in contrast, are easily to dislodge from sporangiophore and disseminate within fields by wind, rain, wounds and irrigation water [22] [32]. These are causal agents that through saturated conditions, they can move and infect both of roots and aerial parts of plant.

The production of large numbers of asexual and the movement of spores through water and soil are the keys for successful propagation and dissemination of *P. capsici*. It can be explained that zoospores have two differently morphological flagella, thus they can swim in the soil and surface water from plants toward plants, even though towards other pepper gardens over long distance [23] [36]. This was investigated by [4], inoculum moved over 70 m from point sources of inoculum with furrow irrigation. Besides that, within a bush, the foliar infection outbreaks via rain splashes from lower portions to upper portions, while the adjacent plants, spreads through both rain splashes and windblown water droplets [19]. Several studies reported spores transported by insects, snails and feral pigs [1]; live plants, organic matter, soils and irrigation water [25]. Therefore, it is often impractical to screen live plants, organic matter, and soil and irrigation water for *Phythopthora* species.

2.1.5. Susceptible Hosts

Other challenge in disease management is the diversity of susceptible hosts. Scientists found that the pathogen not only hosts on solanaceous and cucurbitaceous species (watermelon, squash, pumpkin, tomato, cucumber), but also perennial tropical crops namely black pepper, macadamia, vanilla and cacao [5] [10] [22] [26] [30] [32]. Therefore, disease always present and remain on farms, so it will be outbreak when getting optimal conditions.

P. capsici, additionally, has relationships with microorganisms, as an insurmountable constraint in *P. capsici* management. It is coexisting with several pathogens on infected plants; they accelerate quickly death. In Mexico, *P. capsici* found from roots of wilted plants along with many microorganisms such as *Verticilliumdahliae Kleb* [24]. In Vietnam, *P. capsici* not only collaborate with three P. species namely *P. capsici*, *P. nicotianae* and *P. cinnamomi*, but also has strong relationship with parasitic nematodes such as *Meloidogyne incognita*, *Radopholus similis* [30] [32] [33].

2.2. Climatic Conditions

Vietnam's growing pepper areas has optimal climatic conditions for *P. capsici* development. The growth and reproduction are occurring in soil moisture conditions and warm temperature. Combination factors including daily rainfall range of 15.8 - 23.0 mm, temperature of 22.7˚C - 29.6˚C, sunshine 2.8 - 3.5 h/day and humidity of 81% - 90% are favorite conditions for outbreak and dissemination of aerial infection [20].

Similarly, Vietnam, average temperature at pepper areas ranges from 21˚C to 24˚C, and average of annual rainfall is over 2000 mm, average of air moisture is over 80%. Rainy season starts from April to onward until October (**Figure 3**). In this period, the average rainfall is expected 90% in total yearly rainfall. Thus, the soils are high moisture capacity, leading to enhancement of spread and dissemination of soil-borne fungi, especially *P. capsici*. This is investigated by references [31] [32], the highest level of disease is in during the rainy season from May to November.

2.3. Inappropriate for Cultivated Methods

There are many technologies that were applied by pepper farmers, could be inappropriate in Vietnam. They acerbate infection and spread of disease.

Firstly, black pepper live originally under forest and live supports such as *Cassia siamea*, *Wrightiaannamensis*, *Leucaenaleucocephala*, *Adenantherapavonina*, *Glyricidiasepium* and *Gmelinaarborea*. These supportsplay important roles in yield, disease management, also improving quality. However, because of popular and available death supports and rapid growth of pepper areas, pepper growers tend to replace of live supports with dead standards (**Figure 4**). In Western Highlands, the investigation's [9] showed, more than 95% of black pepper areas applied dead wood support.

Likewise, The Western Highlands Agriculture & Forestry Science Institute—WASI [35] has documented that using dead support in this area was about 82%. Many scientists have emphasized that disease index and percentage

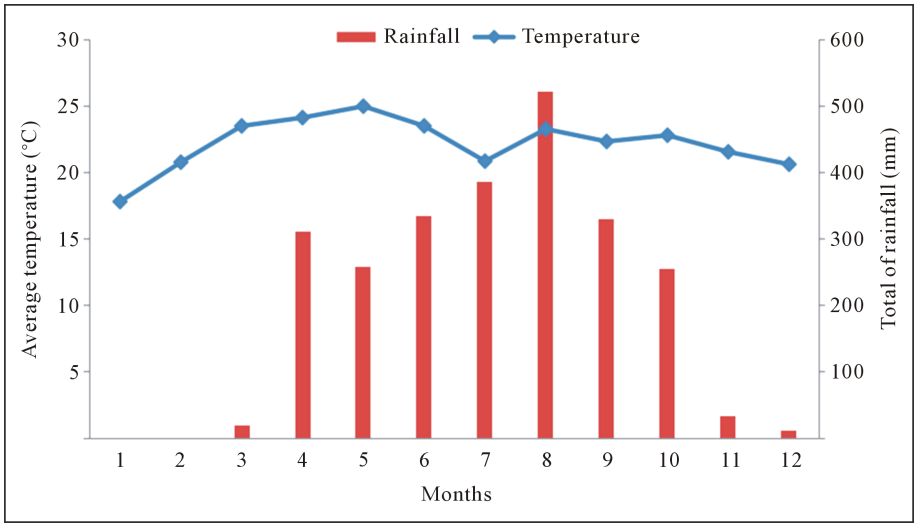

Figure 3. The average temperature (˚C) and total rainfall per month in 2004 at Pleiku, Gia Lai, Vietnam [27].

Figure 4. Influence of dead support on disease infection: concrete support (A) and timber support (B).

of dead plant from foot rot were lower in the pepper fields with live support than use of dead wood standard, concrete and brick tower [15] [33] [35].

In cultivation, deep planting means that plant cuttings 30 - 50 cm under topsoil layer and basin making with dimensions of 1.2 × 1.2 × 0.2 m were technical advances, being applied for both coffee and pepper by grower. Reference [15] has highlighted that majority of pepper farm, 91% of farmes in Gialai provinces have applied these techniques (**Figure 5**). However, they could be inappropriate. It can be explained, in rainy seasons, vines with basin making become waterlogged. Waterlogged condition is negative effect on growth of root systems, but is optimal condition for growth and outbreak of spore of *P. capsici*. Reference [2] found that temporary anaerobic conditions that cause increased root exudation and low oxygen, stimulate germination and growth of pathogen propagules. In fact, percentage of disease and disease index in farms with basin making were 16.5% and 60.3% respectively higher than in the normal farms [15]. Furthermore, the investigation of [15] indicated that, most of black pepper farms did not have drainage system; only less than 50% pepper farm had good drainge system in total of growing pepper areas in Vietnam [31]. This is a important cause, resulting in infection and spread of *P. capsici* in rainy season. Reference [34] has demonstrated that the spread of wilting disease

Figure 5. Effect of basinmaking on infection: deep basin maling (A) and waterlogged in rainyseason (B).

happens more frequent in the region with flat lands and pepper orchards without drainage systems. Additionally, in dry seasons, pepper is watered following 10 - 15 days intervals [32], leading to soil moisture increase, as a result, increase in survial of pathogen.

The next cause leading to promoting *P. capsici* infection is without soil treatment. Studies stated that most of growing pepper areas in Vietnam is formed by replacement of vegatative and coffee areas [15] [32] [35]. Because of high values of black pepper, farmers grow directly pepper after removing previous crops without soil treatment such as rotation, soil-drying for several seasons. This leads to remaining population of soil borne pathogen. Population is not decreased under ecomonic thereshod level, therefore, pathogen has chance to survive and inject. This also proved by [33], if the soils in pits is dried by sunlight for two months or three seasonal rotations to nonsusceptible host of *P. capsici*, disease indicence declined up to 22.8%. reference [8] emphasized that rotation to nonsusceptible host plays an important role in both reducing the build up *P. capsici* population and increasing avaibility of noninfected lands.

Lastly, as many worldwide black pepper producers, lack of *P. capsici* tolerant cultivars is large barrier in disease management. Reference [31] emphasized, Lada Belantoeng, An Do, Vinh Linh and Loc Ninh are popular cultivars in Vietnam, but there were not *Phythopthora* tolerant cultivars. Consequently, the most of cultivars are highly likely to be infected *P. capsici.* This is a serious problem, contributing to fast spread of *P. capsici*, because the main propagation of black pepper is cutting. Cuttings are disease-free and taken from free disease gardens, plays vital role in pepper production. However, technicians and farmers are very difficult to detect free disease cuttings. Therefore, growers tend to use their own cuttings or cuttings from neighbor's farms for planting materials without disease detection [32].

3. Conslusion

The paper has highlighted evidence to support the significant demage of *P. capsici* in Vietnam's pepper production. Disease is still being the big challenge for both producers and scientists related to long term survival of oospores in the soil, an increasing list of susceptible hosts, spread of pathogen via water, fungicide-resistant pathogen and lack of commercially acceptable resistant cultivars. Therefore, eradication of *P. capsici* on infected farms is impossible. Therefore, we must accept the disease presence on farms. Importantly, early detection and prevention are the best ways to manage disease. To do this, producers should not only provide optimal conditions to pepper growth, but also prevent increase in pathogen population. The combination of cultural, biological and chemical methods is necessary. Using live supports for vines, making drainage system, phytosanitation; planting legume and grass cover on pepper farms and rotation of unsusceptible hosts are suggested due to coping with the damage of *P. capsici* and protecting environment. *Trichoderma* as antagonistic microorganisms is also supported to manage outbreak of Phythopththora. Further study on management of *P. capsici* in black pepper should be continued. Finding new varieties, which are *P. capsici* tolerance or resistance, is significantly important in black pepper production worldwide.

References

[1] Alvarez, L.A., Gramaje, D., Abad-Campos, P. and García-Jiménez, J. (2009) Role of the *Helix aspersa* Snail as a Vector of *Phytophthora citrophthora* Causing Branch Cankers on Clementine Trees in Spain. *Plant Pathology*, **58**, 956-963. http://dx.doi.org/10.1111/j.1365-3059.2009.02088.x

[2] Anandaraj, M. (2000) Disease of Black Pepper. In: Ravindran, P.N., Ed., *BLACK PEPPER* (*Piper nigrum*), Indian Institute of Spices Research, Kozhikode, Overseas Publishers Association, 239-268.

[3] Anandaraj, M. (1997) Ecology of *Phytophthora capsici*, Causal Organism of Foot Rot Disease of Black Pepper (*Piper nigrum* L.). Ph.D. Thesis, University of Calicut, Calicut.

[4] Café-Filho, A.C. and Duniway, J.M. (1995) Dispersal of *Phytophthora capsici* and *P. parasitica* in Furrow-Irrigated Rows of Bell Pepper, Tomato and Squash. *Plant Pathology*, **44**, 1025-1032. http://dx.doi.org/10.1111/j.1365-3059.1995.tb02661.x

[5] Erwin, D.C. and Ribeiro, O.K. (1996) Phytophthora Diseases Worldwide. American Phytopathological Society Press, St. Paul, MN.

[6] Fernandez-Pavia, S.P., Biles, C.L. and Liddell, C.M. (2004) Characterization of Southern New Mexico Phytophthora-capsici Leonian Isolates from Pepper (*Capsicum annuum* L.). *Revista Mexicana de Fitopatología*, **22**, 82-89.

[7] Gia Lai Statistical Office (2014) Gia Lai Statistical Year Book 2014.

[8] Hausbeck, M.K. and Lamour, K.H. (2004) *Phytophthora capsici* on Vegetable Crops: Research Progress and Management Challenges. *Plant Disease*, **88**, 1292-1301. http://dx.doi.org/10.1094/PDIS.2004.88.12.1292

[9] Huong, H.T.T. (2003) Investigating and Studying the Use of Live Supports Replaces Wood Standard on Pepper Production in Western Highland and North Central Coast. Master Thesis, Hanoi University of Agriculture, Hanoi.

[10] Kueh, T.K., Fatimah, O. and Lim, J.L. (1993) Management of Black Berry Disease of Black Pepper. In: Ibrahim, M.Y., Bong, C.F.J. and Ipor, I.B., Eds., *The Pepper Industry*: *Problems and Prospects*, Universiti Pertanian Malaysia, Sarawak, 162-168.

[11] Kueh, T.K. (1990) Major Diseases of Black Pepper and Their Management. *The Planter Malaysia*, **66**, 59-69.

[12] Loang, T.K., Hoa, D.T.L., Khoa, L.D. and Nam, T.T. (2006) Research on Diseasencaused by Phytophthora on Industrial and Fruit Trees in Western Highland. Final Project Report, 2003-2005. The Western Highlands Agriculture & Forestry Science Institute.

[13] Manohara, D. and Rizal, M. (2002) Pests and Diseases on Pepper in Indonesia and Their Management. Paper Presented at the Symposium on Pests and Diseases on Pepper. Sarawak, Malaysia.

[14] Mchau, G.R.A. and Coffey, M.D. (1995) Evidence for the Existence of Two Distinct Subpopulations in *Phytophthora capsici* and a Redescription of the Species. *Mycological Research*, **99**, 89-102. http://dx.doi.org/10.1016/S0953-7562(09)80321-3

[15] Nam, T.N.T. (2012) Final Report of Project: Research, Supplement of Technical Standar for Black Pepper Production Following GAP in GiaLai.The Western Highlands Agriculture & Forestry Science Institute.

[16] Nambiar, K.K.N. and Sarma,Y.R. (1982) Some Aspects of Epidemiology of Foot Rot of Black Pepper. In: Nambiar, K.K.N., Eds., *Phytophthora Diseases of Tropical Cultivated Plants*, Central Plantation Crops Research Institute, Kasragod, 225-231.

[17] O'Gara, E., Howard, K., Wilson, B. and Hardy, G.E.S.J. (2005) Management of *Phytophthora cinnamomi* for Biodiversity Conservation in Australia: Part 2—National Best Practice Guidelines. A Report Funded by the Commonwealth Government Department of Environment and Heritage and the Centre for Phytophthora Science and Management, Murdoch University, Western Australia.

[18] Quesada-Ocampo, L.M., Granke, L.L., Mercier, M.R., Olsen, J. and Hausbeck, M.K. (2011) Investigating the Genetic Structure of *Phytophthora capsici* Population. *Plant Disease*, **101**, 1061-1073.

[19] Ramachandran, N., Sarma, Y.R., Anandaraj, M. and Abraham, J. (1988) Effect of Climatic Factors on *Phytophthora* Leaf Infection in Black Pepper Grown in Arecanut-Black Pepper Mixed Cropping System. *Journal Plantation Crops*, **16**, 110-118.

[20] Ramachandran N., Sarma, Y.R. and Anandaraj, M. (1990) Vertical Progression and Spread of *Phytophthora* Leaf Infection in Black Pepper in Arecanut-Black Pepper Mixed Cropping System. *Indian Phytopathology*, **43**, 414-419.

[21] Ravindran, P.N., Babu, K.N., Sasikumar, B. and Krishnamurthy, K.S. (2000) Botany and Crop Improvement of Black Pepper. In: Ravindran, P.N., Eds., *Black Pepper* (*Piper nigrum*), Indian Institute of Spices Research Kozhikode, Overseas Publishers Association, Kerala, 23-142.

[22] Ristaino, J.B. and Johnston, S.A. (1999) Ecologically Based Approaches to Management of Phytophthora Blight on Bell Pepper. *Plant Disease*, **82**, 1080-1089. http://dx.doi.org/10.1094/pdis.1999.83.12.1080

[23] Ristaino, J.B. and Gumpertz, M.L. (2000) New Frontiers in the Study of Dispersal and Spatial Analysis of Epidemics Caused by Species of the Genus *Phytophthora*. *Annual Review of Phytopathology*, **38**, 541-576. http://dx.doi.org/10.1146/annurev.phyto.38.1.541

[24] Sanogo, S. (2006) Predispositional Effect of Soil Water Saturation on Infection of Chile Pepper by *Phytophthora capsici*. *Horticultural Science*, **41**, 172-175.

[25] Scott, P., Burgess, T. and Hardy, G. (2013) Globalization and *Phytophthora*. In: Lamour, K., Eds., *Phytophthora*: *A Global Perspective*, CABI, Wallingford, 226. http://dx.doi.org/10.1079/9781780640938.0226

[26] Tian, D. and Babadoost, M. (2004) Host Range of *Phytophthora capsici* from Pumpkin and Pathogenicity of Isolates. *Plant Disease*, **88**, 485-489. http://dx.doi.org/10.1094/PDIS.2004.88.5.485

[27] The Highland Centre for Hydro-Meteorological Forecasting (2015) Data of Temperature and Rainfall 2014.

[28] Truong, N.V., Burgess, L.W. and Liew, E.C.Y. (2008) Prevalence and Aetiology of Phytophthora Foot Rot of Black Pepper in Vietnam. *Australasian Plant Pathology*, **37**, 431-442. http://dx.doi.org/10.1071/AP08034

[29] Truong, N.V., Liew, E.C.Y. and Burgess, L.W. (2010) Characterisation of *Phytophthora capsici* Isolates from Black Pepper in Vietnam. *Fungal Biology*, **114**, 160-170. http://dx.doi.org/10.1016/j.funbio.2009.11.005

[30] Truong, N.V., Burgess, L.W. and Liew, E.C.Y. (2012) Cross-Infectivity and Genetic Variation of *Phytophthora capsici* Isolates from Chilli and Black Pepper in Vietnam. *Australasian Plant Pathology*, **41**, 439-447. http://dx.doi.org/10.1007/s13313-012-0136-4

[31] Ton, N.T., Huong, N.T., Loang, T.K. and Ha, T.T.T. (2011) Study on the Integated Management of Soil-Borne Diseases of Black Pepper. Final Report of Ministerial Research Project 2006-2010. Institute of Agricultural Science for Southern Vietnam.

[32] Ton, N.T. (2010) Research on Varietal Selection and Advanced Cultivation Practices for a Sustainable Development of Pepper Industry. Final Report of Ministerial Research Project.

[33] Ton, N.T., Nam, T.N.T., Don, L.D., Tri, M.V., Hieu, N.M. and Phuong, N.B. (2005) Study on the Scientific, Technogogical and Marketing Measures for the Development of Black Pepper Production Serving to Processing and Export. Final Report of National Research Project. Institute of Agricultural Science for Southern Vietnam.

[34] Vien, N.V. (2007) Report on Diseases and Pests on Black Pepper and the Control Measures. Paper Presented at Workshop on the Current Production and the Effect of Diseases and Pests Problems to the Pepper Development in Vietnam. Daknong Province.

[35] The Western Highlands Agriculture & Forestry Science Institute (2008) Final Report of Science and Technology 2004-2006: Study on Scientific and Socioeconomic Strategies in Order to Sustainable Perennial Plantations in Western Highlands.

[36] Wei, Y.H., Pernelyn, S.T., Leila, M.B. and Adrienne, R.H. (2013) Phytophthora Cinnamomi in Australia. In: Lamour, K., Ed., *Phytophthora*: *A Global Perspective*. CABI, Wallingford, 124.

[37] Vietnam Pepper Association (2014) Report: Pepper Sector in 2014 and Prediction in 2015. http://www.peppervietnam.com