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Opinion

Neoscytalidium Dimidiatum: An Emerging Threat in Global Warmth Era

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Abstract

Global warmth as a universal disaster threatens the biodiversity on the earth via its direct devastative impact (fires, floods, and storms) as well as through its stressful impact on the physiology of living organisms. Consequently, some of thermophilic pathogens will get the opportunity to exert their harmful influences on the life of plants, animals and human. The increased incidence of the diseases caused by the thermophilic fungus, *Neoscytalidium dimidiatum* is just one of the biological impacts of global warmth that would annihilate the important woods and affect crop production. The fungus is also pathogenic on humans. The windborne arthrospores of the fungus will be easily disseminated by air currents and the rate of infections will rise. This article considers the real facts and suggests realistic opinions for the management of the disease.

Keywords: Canker; Control; Forest; Tree; Wood

Introduction

Global warmth as a universal disaster affects biosphere in several ways. It has already led to the increased rate of superficial water evaporation, soil drought, the increased salinity of soil water, the unfavorably increased severity of climatic phenomena such as harsh and increased occurrence of floods in the regions of high precipitation rate [1,2] and increased temperature and drought in the already semi-arid and arid areas [3]. Increased temperature leads to decreased cloud formation and increased sunny hours and consequent increase in sun-burned plant tissues. The trend of global warmth is so severe that most continents have experienced extensive fires in their woods in recent years exemplified by widespread annihilation of woods in Algeria [4], Brazil [5], China [6], Greece [7], Iran [8], Italy [4], Portugal [4], Russia [7], Spain [9], Turkey [7], and the United States of America [7]. While these are the events that attract the attention of the most people on the earth, however, soil erosion by repeated floods as well as imbalanced water supplies subject plants to severe environmental stresses may attract less attention. Moreover, floods lead to the prolonged decrease in supply of oxygen available for plant roots in soil, where anaerobic conditions lead to increased population of harmful microbes and root malfunction and even putrescence. Such affected trees are more prone to the attack by opportunistic plant pathogens and pests. Bark and wood beetles are known as important opportunistic pests that attack to the stressed trees.

These pests not only hurt plant health via caving tunnels, but also, they can harbor the infective spores of the pathogenic fungi and directly inoculate them into the wounds. The appearance of the first desert in the green continent [10] is the sound of a bell warning whole world of the increased extension and seriousness of drought stress. Under these stressful conditions, the severe incidence of the diseases caused by the fungus, *Neoscytalidium dimidiatum* (formerly known as *Nattrassia mangiferae*) is potentially high [11]. The fungus belonged to the *Botryosphaeriaceae* family [12] causes a range of disease symptoms including branch wilt, fruit rot, blossom decline, dieback, canker, gummosis, root rot, decline and even the death of whole trees [13-15].

The host range of the fungus is also widespread and includes many trees such as African baobab *(Adansonia digitata*, *Malvaceae, Malvales)* [16], African mahogany *(Khaya senegalensis*, *Meliaceae, Sapindales)* [16], almond (*Prunus dulcis*, *Rosaceae*, Rosales) [17], apple (Malus communis, *Rosaceae*, Rosales) [18], apricot (*Prunus armeniaca*, *Rosaceae,* Rosales) [19], avocado *(Persea americana, Lauraceae, Laurales)* [20], banyan tree (*Ficus beneghalensis*, Moraceae, Rosales) [21], beechwood *(Gemelina arborea*, *Lamiaceae*, *Lamiales)* [22], black locust *(Robinia pseudoacacia, Fabaceae, Fabales)* [18], cassava/ yuca *(Manihot eculenta*, *Euphorbiaceae*, *Malpighiales)* [23], sour orange (*Citrus aurantinum*, *Rutaceae, Sapindales*) [18], date palm *(Phoenix dactylifera*, *Arecaceae*, *Arecales)* [24], elm *(Ulmus procera*, *Ulmaceae)* [18], English walnut *(Juglans regia*, *Juglandaceae*, *Fagales)* [25], eucalyptus (*Eucalyptus camaldulensis*, *Myrtaceae, Myrtales)* [18], fig (*Ficus carica, Moraceae,* Rosales) [15], grapevine (*Vitis vinifera*, *Vitaceae*, Vitales) [26], guava (*Psidium guajava, Myrtaceae, Myrtales*) [27], gum Arabic trees *(Vachellia nilotica,* and *Senegalia senegal, Fabaceae, Fabales)* [16], Indian almond *(Terminalia catapa*, *Combretaceae, Myrtales)* [16], jujube tree (Ziziphus vulgaris, *Fabaceae, Fabales*) [28], lebbek tree (Albizzia lebbek, *Fabaceae*, *Fabales*) [15], lemon (*Citrus limon*, Rutaceae, *Sapindales*) [29], loquat (*Eryobotria japonicae, Rosaceae,* Rosales) [18], magnolia *(Magnolia grandiflora*, *Magnoliaceae, Magnoliales)* [18], mango *(Mangifera indica, Anacardiaceae, Sapindales)* [14], *Mediterranean cypress* (*Cupressus sempervirens var*. fastigiata *Cupressaceae, Pinales,* Gymnosperms) [18], mulberry (Morus sp., Moraceae, Rosales) [18], neem tree (*Azadirachta indica*, Meliaceae, *Sapindales*) [16], old world sycamore *(Platanus orientalis*, *Platanaceae, Proteales)* [18], olive (*Olea europaea*, Oleaceae, *Lamiales*) [30], pacific madrone (*Arbutus menziesii*, Ericaceae, *Ericales*) [31], peach *(Prunus persica)* [32], pear (*Pyrus communis, Rosaceae,* Rosales) [28], pines (*Pinus* spp., *Pinaceae*, *Pinales,* Gymnosperms) [33], pink morning glory (Ipomoea fistulosa, Convolvulaceae, Solanales) [34], pink shower tree (Cassia nodosa, *Fabaceae, Fabales*) [16], pistachio (Pistacia vera, *Anacardiaceae, Sapindales*) [35], pitahaya (*Selenicereus* spp., *Cactaceae*, Caryophyllales) [36], plum (*Prunus domestica, Rosaceae,* Rosales) [28], plumeria *(Plumeria obtusa, Apocyanaceae, Gentianales)* [12], pomegranate (*Punica granatum*, Lythraceae, *Myrtales*) [35], portia tree (*Thespesia populena*, Malvaceae, *Malvales*) [15], Queensland kauri pine (*Agathis robusta*, *Araucariaceae*, *Pinales*, Gymnosperms) [12], royal poinciana *(Delonix regia, Fabaceae, Fabales)* [15], rubber (*Hevea brasiliensis*, Euphorbiaceae, *Malpighiales*) [37], Russian olive (*Elaeagnus angustifolia, Elaeagnaceae,* Rosales) [28], sacred fig (*Ficus religiosa,* Moraceae, *Rosales*) [27], Szechuan pepper (*Zanthoxylum bungeanum,* Rutaceae, *Sapindales*) [38], shittah tree *(Vachellia seyal*, *Fabaceae*, *Fabales)* [16], strawberry tree (*Arbutus unedo*, Ericaceae, *Ericales*) [39], sycamore maple (*Acer pseudoplatanus*, Sapindaceae, *Sapindales)* [18], tibouchina (Tibouchina spp., *Melastomataceae*, *Myrtales*) [40], tomato (Solanum lycopersicum, *Solanaceae*, Solanales) [41], waterberry (*Syzgium cordatum,* Myrtaceae, *Myrtales*) [12], white Guinea yam (*Dioscorea rotundata, Dioscoreaceae, Dioscoreales,* Monocots) [42], yellow poinciana *(Peltophorum pterocarpum, Fabaceae, Fabales*) [15]. The fungus also attacks other species in the *Genera castanea (Fagaceae, Fagales)*, Citrus (Rutaceae, *Sapindales*), Ficus spp., *Musa (Musaceae, Zingiberales)*, *Populus (Salicaceae, Malpighiales)*, *Prunus* (*Rosaceae,* Rosales), *Rhus (Anacardiaceae, Sapindales)*, and Sequoiadendron *(Cupressaceae, Pinales,* Gymnosperms) [43].

The breadth of host range reflects the capability of the fungus to neutralize various defensive chemicals produced in different phytochemical factories. Due to the broad host range of the fungus that spans agricultural crops as well as wild trees, and because of the production of airborne arthroconidia the fungus can easily be distributed by wind. It is expected that these dark windborne conidia will resist the harmful effect of sun ultra-violet rays. The optimal temperature for the fungus growth is 35 °C, while no growth occurs at 40 °C [44]. Therefore, global warmth can support its better growth in the absence of most fungal antagonists. Although no vector has been reported for the pathogen, however, the fungus is known as a soilborne as well as airborne pathogen that can survive in infected debris and diseased trees. The strains are chemically highly variable, however, the production of two naphthoquinone compounds is nearly always species-specific [45]. The existence of such a diversity in the intra-specific level can be the result of yet undiscovered sexual reproduction of the fungus. The ability of the fungus to reproduce sexually can lead to the generation of new strains and subsequent break of resistance in resistant host genotypes. Also, the appearance of new races can lead to fungicide resistance. Additionally, the mycelial matt development of the fungus inside host tissues and out from the access of the fungicides can lead to the fungus colony resistance to the applied fungicides. Thus, considering the increased susceptibility of the stressed trees and the lack of reliable effective measures, global warmth can facilitate the biological disruption of the stressed trees survived from fires. Unfortunately, the disaster is not restricted to phytopathological aspects and there are also reports on its pathogenicity in humans such as keratitis after laser in situ keratomileusis, endophthalmitis, rhinosinusitis, systemic/ invasive disease, fungemia, sub-/cutaneous phaeohyphomycosis [46-48]. Amphotericin B, vericonazole and terbinafine have been known as the antifungal drugs effective against *N. dimidiatum* [49].

Based on what mentioned above, the fungus can cause changes in wood tree diversity and medical problems in some people. Because of environmental as well as economical limits, it is not practically possible to apply chemical fungicides as well as physical measures in vast woods, the protection of woods would need an international cooperation. The simplest way is to reduce the global production greenhouse gases that shall be accompanied by international attempt for extension of forestations. Tolerance to environmental stresses and non-host resistance to such diseases shall be applied in the attempt to keep the required area of woods. Management of superficial running waters and avoidance of water stress via continuous supply of water, if possible, would be helpful. Theoretically, the use of biological agents can partially improve the stress tolerance of the treated trees, however, beside technical, ecological and economic difficulties, it would be practically almost impossible to use a microorganism that can overcome the diverse microbial communities in the complex medium of wood soils. Another choice in the biological management of the disease is the use of endophytic fungi that can colonize whole tree body (i.e. both shoots and roots). Such fungal endophytes shall be able to effectively develop from leaves to tree body and to fast colonize tree shoots and quickly develop to the roots.

The endophytes shall be able to induce systemic resistance pathways of the treated tree and increase its tolerance of abiotic as well as biotic stresses. Such fungal endophytes shall be cultivable, grow well at a broad range of temperatures, and shall be effective antagonists against *N. dimidiatum* and other pathogens and in the meantime safe for plants, humans and livestock. They must be competitive (for food as well as ecological niches), and have potent antibiotic and mycoparasitic activities. The mycoparasitism is necessary in the destruction of formerly developed mycelial mats of the pathogen, where the inner cells can evade from the antibiotic activity of the biological control agent. There are some Trichoderma spp. already known as endophytic symbionts of some tree species [50,51], however, an ideal endophytic fungus for the control of *N. dimidiatum* shall be thermophilic and when applied by aeroplanes/helicopters, it shall effectively use the treated leaves to enter tree branches. Another choice may be the cross protection by the avirulent strains of the pathogen that shall effectively compete for food and the ecological niches, and be able to induce host defensive mechanisms. However, a strain avirulent on a given host tree, may be virulent on other hosts. So, the avirulent strain must get its avirulence due to changes in the most common and fundamental step(s) of pathogenesis. This seems more practical than the use of hypovirulent strains, if any. Due to high genetic diversity among the strains of the pathogen, there must be high number of Vegetative Compatibility Groups (VCGs) that will result in the limited success with hypovirulent strains. In spite of the importance of *N. dimidiatum* and its relative fungi, there is little information on the airborne pathogen that increasingly threatens woods in the era of global warmth. The author hopes that this article will be useful in attraction of younger generations to investigate on this threat.

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