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Plant disease pathogens may cross the ecological border and cause diseases to humans

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Plants, like animals and humans, are known to suffer from a huge number of diseases caused by various pathogens including, viroids, virusoids, viruses, mycoplasma and spiroplasma, rickettsia, bacteria, protoctista, fungi and nematodes. Due to biological differences in the anatomy, histology, cytology, physiology, biochemistry and genetic makeup, usually pathogens of each category of hosts (plants, animals and humans) are confined to only one type of hosts with many known to infect both animals and humans and are thus termed zoonosis. Although the general notion that plant pathogens are restricted to plants and cannot infect neither animals nor humans is commonly adopted, it is shown here not to be true. However, research has shown that patients with their immune systems being compromised (like those having acquired immunodifficiency syndrome, organ or bone marrow transplantations, AIDS, hepatitis B, steroid treatment, uncontrolled diabetes, cancer or undergoing chemotherapy etc.), many plant pathogens, known as opportunistic organisms, can infect them with sometimes fatal consequences.

Pseudomonas aeruginosa, the causal agent of bacterial blight on lettuce is an opportunistic, nosocomial pathogen of immunocompromised individuals. It can invade nearly any tissue in the human body, provided they are already weakened. The bacterium typically infects the airway, urinary tract, burns, and wounds, and also causes other blood infections. Symptoms vary widely from dermatitis, urinary tract infections to gastrointestinal infections, endocarditis and even systemic illness (Todar, 2006). To make matters worse, this bacterium is becoming increasingly antibiotic resistant in institutional settings.

Human health can also be affected by bacterial species used as biocontrol agents for plant diseases. *Pantoea agglomerans (formerly called Erwinia herbicola or Enterobacter agglomerans)*, which is known as a plant pathogen and some strains are used for biological control of fire blight disease of pear and apple has been recognised as an opportunistic organism in immunocompromised patients causing serious medical conditions in man including septicaemia, septic arthritis, endophthalmitis, periostitis, endocarditis, osteomyelitis and urinary-tract infections. (Paula *et al.,* 2006; Dutkiewicz, 2016). The bacterium may enter human bodies through accidental punctures by contaminated plant thorns or with contaminated intravenously-administered solutions (Dennis *et al.,* 1973).

Similarly, Mucor is a common indoor mold that is implicated in many crop storage diseases of which Mucor rot in apple is merely an example. Mucor is among the fungi that cause the group of infections in man known as zygomycosis or more precisely mucormycosis. This type of infection is caused by a number of fungi belonging to the order Mucorales (Hibbett *et al.,* 2007) with *Rhizopus oryzae* being the most common organism isolated from patients with mucormycosis and is responsible for about 70% of all cases of mucormycosis (Ribes *et al.,* 2000, Roden *et al.,* 2005). *Rhizopus oryzae* is a fungus that lives worldwide on dead organic matter. It also infects carrots, pineapples and mangoes.The fungus is an opportunistic human pathogen causaing zygomycosis (or more properly mucormycosis) to human.The infection typically involves the rhino-facial-cranial area, lungs, gastrointestinal (GI) tract, skin, or less commonly other organ systems. Black nasal ulceration and periorbital fungal infection known as Mucormycosis, or Phycomycosis is a dangerous fungal infection usually occurring in the immunocompromised patient, affecting the skin (Cutaneous Zygomycosis), mouth cavity (Mucormycosis palate) and the regions of the eye, nose, and through its growth and destruction of the periorbital tissues, it will eventually invade the brain cavity resulting in a rhinocerebral abscess. External symptoms involve necrotic lesions and presence of cotton-like growth on its surface (James *et al.,* 2016).

Aspergillus niger the causal agent of black mold disease in onion and several other crops, its spores if inhaled can infect the respiratory system causing a disease called allergic bronchopulmonary aspergillosis or pseudotuberculosis (Vlahakis and Aksamit, 2001; Greenberger, 2002; Moss, 2002) which involves breathing problems in both immuno-compromised and healthy people. In immuno-compromised patients, infection with *A. niger* or the common relative, *A. fumigatus* or *A. flavus* can be a life-threatening one. Although *A. flavus* is a rare species, it can similarly cause nasal and sinus infections in such patients *A. niger* was also found to cause fungal endophthalmitis with its two types, namely endogenous endophthalmitis, which arises from haematogenous spread from a focus of infection elsewhere in the body and exogenous endophthalmitis, resulting from primary inoculation of the eye following surgery or penetrating trauma (Kermani and Aggarwal, 2000; Machado Od Ode *et al.,* 2003; Hashemi *et al.,* 2009; Hosseini *et al.,* 2009). *Aspergillus infection can* cause general ill-health and bleeding in the lung and can worsen asthma and cause allergic sinusitis in patients

with allergic tendencies. What makes the problem even worse is that the fungus was shown to have developed signs of drug resistance (Tamgadge *et al.,* 2012).

Additionally, it was reported that most infections of otomycosis which is a chronic condition endemic in tropical and subtropical regions and is rarely reported in infants and children are due to *A. niger* or, less commonly, *A. fumigatus*. Most cases are unilateral, and patients complain of ear pain, itching of the auditory canal, and a sense of fullness. Otorrhea (decreased hearing) and tinnitus (ringing or buzzing in the ears) are less common. Examination of the auditory canal typically shows conidial "forests" or mycelial mats (Paulose *et al.,* 1989; Rutt, and Sataloff, 2008; Jia *et al.,* 2012).

Botrytis cinerea is another plant pathogen known to infect large number of fruits and vegetables causing the grey mold disease. The fungus infecting grapes may also infect man causing "winegrower's lung" among farmers (Popp *et al.,* 1987). The disease is a rare form of hypersensitivity pneumonitis (a respiratory allergic reaction in predisposed individuals). Symptoms include fever, chills, malaise, cough, chest tightness, dyspnea, rash, swelling and headache. Symptoms resolve within 12 hours to several days upon cessation of exposure (Sharma, 2006).

Despite the question about the possible direct effect of plant pathogens on humans, Plant pathogens may negatively affect human health indirectly by reducing crop quantity and quality including nutritional value. Several plant pathogens (*Aspergillus* spp., *Penicillium* spp., *Fusarium* spp., *Claviceps* spp.) can affect humans by reducing the available food or by contaminating human food with toxic compounds (Baranyi, 2013; Cary *et al.,* 2017

One of the most common ways through which plant diseases can indirectly affect human health is through excreting toxic metabolites 'mycotoxins' by fungi infecting plant products. Although the fungi producing these mycotoxins are plant pathogens and do not infect humans, they can do that indirectly through the mycotoxins they excrete causing harm to human and animal health resulting in diseases and death. Examples of fungal species producing mycotoxins include *A. flavus*, *A. parasiticus*, *Fusarium* spp. and *Penicillium* spp. Several groups of mycotoxins have been recognized, of which Aflatoxins (types = B_1, B_2, G_1 and G_2) are one of the most dangerous ones. Although Aflatoxins have long been known to be produced mainly by two main Aspergilli (*A. flavus* and *A. parasiticus*), but recently 20 different species of Aspergillus (e.g. *Aspergillus ochraceoroseus*) and other genera have been reported to produce Aflatoxins (Baranyi, 2013).

Feeding on plant parts contaminated with aflatoxins causes a syndrome known as aflatoxicosis which is characterised by vomiting, abdominal pain, pulmonary edema, convulsions, coma, and death with cerebral edema and fatty involvment of the liver, kidneys, and heart. Aflatoxins are highly carcinogenic metabolites of which Aflatoxin B_1 is frequently referred to as the most potent naturally occurring carcinogen. It is considered to be 1000 times more potent as a carcinogen than benzopyrene. The toxin is lethal at high doses and is carcinogenic to humans at low doses and can result in reduced liver function, vomiting and abdominal pain. Annual deaths in some parts of Africa due to the effect of aflatoxin have been reported to reach 250,000 annually (Wild *et al.,* 1992). Mycotoxins can be consumed indirectly by humans through the consumption of meat from animals fed on feed contaminated with mycotoxin excreting *Aspergilli*. Evidence of acute aflatoxicosis in humans has been reported from many parts of the world, namely the Third World Countries, like Taiwan, Ouganda, India, and many others.

The fungus *Claviceps purpurea*, beside some other species of the same genus, is another plant pathogen that infects cereals including wheat causing a disease called ergot (Kien and Cvak. 1999). The fungus is characterised by the production of hard fungal mycelial structures termed sclerotia that replace grains in the spikes of their hosts (Miedaner and Geiger, 2015). Sclerotia contains over 40 different toxic alkaloids. of which some may have psychedelic (e.g. Lysergic acid and Lysergic acid amide), vasoconstriction (e.g. Ergotamine, Ergochristine and Ergocryptine), smooth muscle contracting (e.g. ergometrine) and hallucinating (e.g. lysergic acid diethylamide) effects. The hallusinating compound "lysergic acid diethylamide" (known as LSD) is produced during the baking of bread made with ergot-contaminated wheat. Consumption of bread produced from contaminated flour can thus result in ergotism disease in humans. Ergotism has been reported to result in Dry gangrene of hand, foot and leg from poor circulation (Balique, 1968), loss of peripheral sensation, hallucinations or even death (Křen and Cvak, 1999; White *et al.,* 2003).

Although LSD is relatively non-toxic and non-addictive, various governments around the world outlawed it after a number of fatal accidents were reported. Such accidents involved, for example, people under the influence of LSD jumping to their deaths off high

buildings thinking they could fly.

Plant viruses and subviral pathogens (e.g. viroids and virusoids) could highly likely represent potential pathogens to animals and humans (Gibbs and Weiller, 1999), particularly those suffering from immunodeficiency (Balique *et al.,* 2015). In a recent study (Colson *et al.,* 2010) it was reported that *Pepper mild mottle virus* reacted with the immune system of humans and induced clinical symptoms including fever, abdominal pains, and pruritus. But one has to admit that no clear evidence on the pathogenic role of this plant virus in humans was provided.

The discovery of drug-resistant aspergillosis in patients who have never before taken antifungal medications suggests that drug resistance in some cases could be coming from the environment and not from previous use of antifungals. we should limit use of agricultural fungicides that are structurally similar to medically important antifungal medications. More research is needed too, she says, on the basic life cycle of fungal plant pathogens. Such knowledge could lead to more judicious use by helping farmers to better plan when in the growth cycle to apply fungicides to their crops. Indeed, fungal diseases have become a "silent" epidemic among immunocompromised individuals and the problem seems to only be exacerbating with time: Over the past year, reports have emerged of yet another frequently drug resistant hospital-associated fungal threat, *Candida auris*, in at least 16 countries around the world. As the environment around us changes and our natural defenses become more tenuous, it is warned that we need to take steps to protect ourselves, especially the most vulnerable among us (Konkel, 2017).

Although most plant pathogens do not naturally infect humans, it is a good practice to avoid eating rotted vegetables and fruits or plant produce contaminated by toxin-producing bacteria and fungi. Removing diseased parts of leaves and fruits with some apparently healthy tissues surrounding them may help reduce pathogen inoculum and amount of toxins ingested. However, this may not ensure that all toxic substances has been excluded as some may have diffused into apparently healthy parts of fruits. While cooking may result in the destruction of some mycotoxins, some are not destroyed by high heating. The effects of some mycotoxins can be minimised or eliminated by adding some mycotoxin-binding agents or through deactivation.

More research is needed on the direct effects of plant pathogens and diseases on humans. Special attention should be given to mycotoxin-producing fungi and their presence in human food and animal feed. Efforts should be directed towards avoiding plant disease epidemics similar to the late blight disease of potatoes in Ireland through food diversification and the development of effective plant disease management strategies. Awareness of community about the ways by which plant diseases can affect human health is also important.

Biography

Elasayed Elsayed Wagih (Ph.D, DIC, CIDTT) is an Egyptian Professor of Virology and Biotechnology and Acting President of the Arab Society for Biotechnology. He received a B.Sc. in Plant Pathology from University of Alexandria and in 1970. He obtained an M.Sc. degree in Plant Bacterial Diseases from the same university. In 1981, he gained a PhD degree in Virology from the Imperial College of Science (Technology and Medicine), University of London and was awarded in the same year a DIC from the Royal College of Science. In March 2008, he earned The Cambridge International Diploma for Teaching and Training (CIDTT) from University of Cambridge, United Kingdom. Since June 26, 1992, Prof. Wagih has been working as Professor of Plant Pathology and Biotechnology in the Department of Plant Pathology, College of Agriculture, University of Alexandria, Egypt. He is the former Head of the Department and former Vice Director of research of the Biotechnology Centre of the College. He harvested a number of local and international awards, prizes and certificates of appreciation, the last most important of which was the "Highest National Award for Scientific Research Achievement" awarded by The Egyptian Academy of Science and Technology in 1998. Prof. Wagih has served as a member of the National Committee for Promoting University Faculty, a position granted through a national merit-based competitive procedure conducted by the Supreme Council of Egyptian Universities for more than five years. He is also the former Representative of North Africa and a Board Member of the Governing Council of the African Crop Science Society (ACSS) for three successive election periods. He was invited as a visiting scientist to carry out collaborative research at several world famous institutes including: Imperial College of Science, Technology and Medicine, University of London, Oklahoma State University, USA, John Innes Centre, Norwich, UK and PNG-Unitech., North of Australia. His research involved different aspects of molecular plant pathology with particular emphasis on viral replication, sub-genomic messages in protoplasts, gene expression, protein synthesis, probing and cDNA technology for pathological studies, gene silencing and genetic engineering to generate virus-resistant transgenic plants. He discovered two plant viruses, "Peanut Chlorotic Ringspot Virus" and "Peanut Top Paralysis" and invented two new techniques, "Zymoblot" and "Mirror Image *in vivo* electroblotting technique" for the detection of gene expression in terms of enzyme activity and self/non-self proteins.Prof. Wagih has over 40 years of teaching experience and is the author of a series of the first and most popular and comprehensive books on Biotechnology in Egypt and the rest of the Arabic–speaking countries. He established the field of Modern Biotechnology at the College of Agriculture, University of Alexandria and was the first to design the syllabi and teach the relevant courses for both under and postgraduate students. His web page entitled "Biotech. Knowledge Capsules" has been designed to serve an educational purpose and for this it included a series of recorded episodes on the YouTube explaining different topics and concepts of biotechnology.

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