KSPP Award Lectures

AL-1
Contribution Award

Internship of Plant Pathologist

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Introduction

The study of plant pathology ultimately aims at controlling disease that can be met by various methods. These controlling methods should not be harmful not only to plants but also to animals (including humans) which consume plant products. Thus, it should be studied thoroughly how controlling methods may affect on plant growth as well as on physiology and ecology of animal.

Plant diseases are caused by biological interaction between parasites and hosts, and this interaction can be affected by environmental condition. Therefore, it is necessary for rational studies of plant diseases to gain fundamental knowledge of parasites, hosts, and environmental condition. Otherwise, the studies may lead to fragmental outcome and their value cannot be assessed from academic and practical aspects.

Science is developing and differentiating at the same time. The studies of plant pathology are also differentiated and pioneering research is carried out in every aspect these days. However, the essential studies of plant pathology should be marching on the basis of the established fundamental knowledge and performed in a highly organized manner. The pioneering research is elucidation of the cases, which was not understood by the existing methods but can be solved by the cutting-edge techniques.

Here I would like to describe concerns that many scientists only try to pursue high-tech research but they are forgetful of the scientific hierarchy and self-satisfied with the meaningless outcome.

In a medical society, a doctor is able to become a specialist after 1 to 2 year internship training, in which he or she learns treatment of human diseases in every aspect, and then residentship training, in which he or she concentrates on specialized field. I consider that specialized outline should be followed by general introduction not only in a medical field, but also in all other academic area.

Research interests of plant pathology

1. Observation and description

Diagnosis of plant diseases

Diagnosis of plant diseases is the top priority for plant pathology. Wrong diagnosis would mislead the continued processes or results. Thus, it is indispensable for disease diagnosis to observe and describe the plants in an abnormal condition.

The training is emphasized on differentiating parasitism and non-parasitism when plants are in an abnormal condition. A misjudgement of parasite-causing disease, which is actually caused by environmental or genetic changes, would lead to a wasted study. Generally the nonparasitic disease spreads even distribution of abnormal plants in a certain area or field. Meanwhile, the parasitic disease gives rise to individual hosts with a different strength of symptom and the disease propagation can be traced.

Diagnosis of parasitic disease is not simple because disease symptom can be different depending on the host age, parasite-binding region, or environmental condition. The parasites attacking a wide range of hosts could cause a different symptom on a different host, whereas different parasites could show a similar symptom in the same host, referred as "variation of plant disease symptom". Therefore, we cannot jump to a conclusion before clarifying identification of the parasite.

Identification of pathogens

Most pathogens except obligate parasites are possible for *in vitro* cultivation. However, pathogen should be isolated cautiously from the infected plants because the infected area contains many dead cells where saprophytes can exist.

The isolated pathogens need to be tested for their pathogenicity. A particular microorganism can be accepted as a pathogen when it satisfies the Koch's postulates, proposed early in 1876, that are 1) the pathogen must be found associated with the disease in all the diseased plants examined, 2) the pathogen must be isolated and grown in pure culture on nutrient media, and its characteristics described, 3) the pathogen from pure culture must be inoculated on healthy plants of the same species or variety on which the disease appears, and it must produce the same disease on the inoculated plants, and 4) the pathogen must be isolated in pure culture again, and its characteristics must be exactly like those observed in step 2.

2. Pathway of inoculum

Investigation of inoculum

All plant diseases are occurred by an inoculum, therefore identification of inoculom could be a big help to prevent the disease. An inoculum can survive on the intermediate hosts, seeds, or soil, as a reproductive body such as a spore or as a vegetative body such as a mycelium. When the plants start to grow, the inoculum begins to activate, transfer to the hosts, and cause disease.

Dispersal of inoculum

No inoculum has been reported that it reaches the host by itself. The inoculum of most pathogens is carried to its host plants by wind, water, or insects, and some inocula are transferred by farm appliances, seeds, seedlings, animals, or humans.

Generally the diseases, caused by eucaryotes that attaches aerial parts of plant, are dispered by wind, whereas those below the earth level are by farm appliances or seedlings. In the case of diseases occurred by bacteria, water is highly influential, and insects or farm appliances also spread the disease. Virus is spread through direct contact or by farm appliances, but insects are the major carriers.

Understanding of inoculum and propagation methods plays an important role of controlling diseases and it is the first step for disease prevention.

Penetration of pathogens

How do the arrived pathogens penetrate the host? Are the pathogens able to cause disease? Which route do the pathogens go along with inside the host? How do the pathogens lead to a local lesion or a systemic disease? Anatomy of plant disease may be a big help to understand disease nature and to build controlling plans.

Although some eucaryote pathogens were reported that they were capable of direct infection or cuticular infection, most pathogens penetrate the host through natural opening, such as stomata, hydathode, lenticel, nectary gland or flower organ, or wounds.

The pathogens penetrating successfully establish nutrient transfer from host, referred as the stage of infection. As the pathogens are growing in a way of intercellular parasite or intracellular parasite, disease is developing in the infected plants. The growth of pathogens can be limited by the host plant, causing a local lesion, whereas the pathogen growth can be continuing concurrently with the growth of the host plant, inducing a systemic disease.

3. Plant disease and environment (Ecology of plant disease)

Environment is one factor to cause plant disease and it effects on both hosts and pathogens. Therefore, it is important for disease precaution and prevention to understand the environmental effect on plant disease. Environment can be classified into atmospheric environment and soil environment.

Atmospheric or above-ground environment

Plant diseases occurred above ground are affected by atmospheric condition. Amount of daylight has an influence on plant growth as well as pathogen proliferation and invasion. Wind assists in arrival of pathogens as well as wound generation of host plants, therefore it eases inoculation of pathogens. Moisture (water) is important for pathogen germination, especially for bacteria. Atmospheric environment is also involved in propagation of insects, which participate in pathogen transfer. Polluted air creates obstacle for the plant growth, causing physiological disease.

Soil environment

Soil is the place where plants root down and grow. The physical condition of soil (temperature, humidity, constitution, etc.) is directly related to plant growth as well as affects activation of chemical condition (nutrients, acidity, chemical elements, noxious compounds, etc.), that can change the growth condition of plants.

In the case of some pathogens which are sensitive to physical or chemical soil environment, modulation of soil condition can prevent pathogen growth.

4. Mechanisms of disease development

Pathogens can damage the host plants if they have the abilities, that are 1) aggressiveness and colonization, and 2) toxin production. The pathogens, which invade plant vascular bundles, can cause disease only by blocking the bundles where the pathogens colonize, howeve,r some pathogens need to produce enzymes which injure the plant structure, or toxins which break down host cells.

Biochemistry of plant diseases is the studies for the enzymes and toxins produced by the pathogens, and it is indispensable for studying plant disease development.

5. Host resistance

Host structure and resistance

Outer structure of plant has a direct connection with pathogen penetration, whereas inner structure affects disease development. For example, fine hairs on plant surface can affect attachment of the pathogens, meanwhile structure, number, or location of stomata may change the landing of pathogen. The wax layer on the leaf surface excludes humidity, therefore preventing pathogen germination. Additionally it thickens cuticle layer, that protects pathogen penetration.

As the epidermal layer of inner structure is thick, it is able to prevent direct penetration of pathogen and to tolerate wounds. The structure of cambium (vascular bundles, sieve tubes, and parenchyma,) is involved in development of vascular bundle diseases.

Host body fluid and resistance

In many cases, the same genus of plants contains different body fluid compounds depending on cultivars or lineages. Some cultivars contain more favorable or unfavorable components for pathogens than other cultivars, thus accelerate or delay the disease.

The difference of structure and compounds is related to the age of plants, however, it is mainly originated from genetic inheritance of individual plants and can be supplemented by careful fertilization and management.

6. Modification of pathogens

Pathogens are exposed to high chances of modification because of a short generation time and simple chromosome structure. Modification is random, but in some cases, the modulated pathogens are capable of attacking the resistance host or vice versa. The concept of "race (physiological cultivars)" comes from the same context.

Adaptation is a temporary change, and the adapted plants are supposed to be restored to the former condition when the environment changes.

7. Plant-microbe interactions

Disease resistance and susceptibility are considered to be under the control of strength of pathogen pathogenicity and host resistance until Flor proposed "gene-for gene theory" in 1956. Flor's theory clarified the concept of race and reformed the research direction of plant disease resistance.

Development of genetic and molecular technology has been placed on confirming the hypothesis that the virulence (Vir) genes (pathogen) and the resistance (R) genes (host) are dominant or recessive, and pairing of Vir and R genes determines disease resistance. These days genetic approaches become the major stream of plant disease research, to which MPI scientists and young researchers devote themselves.

8. Control of plant diseases

Since plant disease is a biological phenomenon caused by pathogen, plant, and environment as a complex, overall understanding of each factor is necessary to protect plants from diseases. Additionally, it is important to consider "group" of plants when controlling plant disease.

Development of control substances

We should aim at generating an effective and safe disease control substance under the preferential consideration of human environment. Recently researchers conduct active studies on the biological control, which bases its principle on the competition for survival between living creatures, and they take an interest in antagonistic microorganisms.

Many chemicals, used for plant disease control, have shown to be toxic to pathogens and may be toxic to other organisms including human. Although application of chemicals is often necessary for food production, we cannot neglect to find other environmentally friendly means of controlling plant diseases.

Selection and breeding of resistance plants

Plant breeding usually intends to increase yield or produce high quality product, but generation of disease resistance plants can be the most important purpose for plant breeders. Despite production of many superior cultivars, conventional breeding costs much time but ends up with low successful rate. Therefore genetic engineering technology is applied for production of disease resistance plants, which is called as "Genetically Modified Organism (GMO)".

Integrated pest management

Integrated pest management (IPM) is the application of not only the means to inhibit pathogen activity but also fertilization and management to raise disease tolerance as follows, cultivation of resistant cultivars, maintaining of fertile soil using organic fertilizers, the fewest application of pesticides, and elimination of inoculum.

Conclusion

All the scholars, who study plant pathology, are familiar with the content described above. Therefore, they should be fully aware of this knowledge and not hesitate to answer the questions involved.

Additionally I would like to point that plant disease research has to be carried out in a successive and organized manner, beginning from the fundamental knowledge. For example, even the research using high-tech technology will become meaningless without fundamental understanding of disease symptom or pathogen ecology.

The importance cannot be weighed on a specific research fields. For example, as imports and exports of agricultural products increase and crops become diversified, new plant diseases are occurred, thus disease diagnosis itself is very important but it also creates new subjects for disease studies. The research has to initiate from the first step, and then proceed to the conclusion in a rational way.

As the concerns of a plant pathologist, the curriculum of undergraduate can be regarded as a fundamental course of agricultural biology and that of graduate as an internship to become a plant pathologist. In some cases, a graduate student jumps to a highly specified area too early, loses the chance of internship training, therefore becomes a defective scientist. I would like to ask the students to undergo internship course to become a genuine plant pathologist.

AL-2
Academic Award

Disease Problem and Its Solutions in Apple Industry of Korea

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1. Disease problems in apple industry in Korea

As apples have long been bred only for good taste and high yield, while disease resistance has been almost completely neglected, much more diseases occur on apple than other major crops. Moreover, due to the nature of perennial crops, eradication of diseases from the orchard is very difficult once they had