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Seed Security Breach: Modes of Pathogen Invasion

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SUMMARY

In agricultural crops, how seed-borne pathogens spread and infect is crucial. Seeds and plant parts store vital nutrients like carbohydrates and proteins. Fungi and bacteria on these parts grow, using these nutrients. Eventually, they turn harmful to seedlings and plants. Seeds, starting from their formation during parent plant flowering, remain susceptible to microbial attacks until germination and seedling growth. Seeds store food and energy, and some microorganisms have developed ways to invade and utilize them. Infections often harm seeds, offering a path for pathogens to persist between generations and spread across regions. Numerous reviews cover microorganisms that target seeds. Neergaard's book is rich in details about pathogens and storage diseases in seeds. Richardson has assembled a catalog of seed-borne pathogens.

INTRODUCTION

Infection directly from the infected mother parts, often referred to as "vertical transmission," occurs when pathogens are passed from a parent plant's infected tissues to its offspring, typically through seeds, spores, or other reproductive structures. This mode of transmission can lead to the inheritance of the pathogen by the next generation of plants. Vertical transmission is a crucial aspect of plant disease epidemiology and can significantly impact the health and genetic diversity of plant populations.

Flower stalk/Fruit stalk:

Infection originating directly from infected maternal parts, such as flower stalks or fruit stalks, entails the transfer of pathogens from these diseased plant structures to the offspring. This transmission mode can occur through infected seeds, contaminated reproductive structures, or pathogens residing within the maternal tissues. It represents a significant pathway for the vertical transmission of pathogens from parent plants to their progeny.

Fungus

Infection through direct transmission from infected maternal parts like flower stalks or fruit stalks, mediated by fungi, and involves the transfer of fungal pathogens from these diseased plant structures to the offspring. This mode of transmission can occur through infected seeds, contaminated reproductive components, or the presence of fungal pathogens within the maternal tissues. Here are a few examples of such infections:

Powdery Mildew: Powdery mildew fungi can infect flower stalks and fruit stalks, leading to the transmission of the pathogen to the seeds produced. The fungus can grow on the surface of these structures and produce spores that can infect the developing seeds.

***Fusarium*:** *Fusarium* species are known to infect flower stalks and fruit stalks of various plants. These fungi can cause diseases like *Fusarium* wilt, and the pathogens can be present in the maternal tissues, leading to their transmission to the seeds.

Anthracnose: Anthracnose fungi can infect flower stalks and fruit stalks, causing lesions and cankers. The pathogens can spread to the seeds produced by the infected plant, facilitating vertical transmission.

Rust: Rust fungi can infect flower stalks and fruit stalks, producing spores that can be carried to the seeds. These spores can germinate on the developing seeds, leading to fungal growth.

Verticillium: Verticillium wilt-causing fungi can infect the vascular tissues of flower stalks and fruit stalks. These fungi can lead to the colonization of seeds produced by the infected plant, resulting in transmission to the next generation.

These examples illustrate how fungal pathogens can infect maternal plant parts and subsequently be transmitted to the offspring through seeds or other reproductive structures. Vertical transmission via infected maternal parts plays a role in the perpetuation of fungal diseases within plant populations.

Bacteria

Infections that occur directly from infected mother parts to flower or fruit stalks are often caused by bacterial pathogens. Bacteria can be transmitted through various means, such as contaminated tools, rain splashes, wind, insects, or even during cultural practices like pruning. Here are a few examples of bacterial infections that can lead to flower or fruit stalk infections:

Fire Blight (*Erwinia amylovora*): Fire blight is a bacterial disease that affects a wide range of plants, primarily members of the Rosaceae family, including apple and pear trees. The bacteria can move from infected branches or shoots to flower clusters through rain splashes or insect vectors. Infected flower stalks show wilting, browning, and a burnt appearance, resembling the disease's name.

Bacterial Canker (*Pseudomonas syringae*): Bacterial canker affects various fruit trees like cherries, peaches, and plums. The bacteria can move from infected twigs to flower buds and subsequently infect the flower stalks. Symptoms include sunken lesions on stems, black discoloration, and dieback.

Bacterial Wilt (*Ralstonia solanacearum*): Bacterial wilt is a widespread disease affecting a variety of plants, including tomatoes, peppers, and eggplants. The bacteria infect the vascular system, leading to wilting and death of the plant. Infected mother parts can introduce the bacteria to the plant's vascular system, affecting flower stalks and causing flower drop.

Bacterial Soft Rot (*Erwinia carotovora*): This bacterial pathogen can cause soft rot in many plants, including various vegetables. Infected mother parts, such as tubers or rhizomes, can transmit the bacteria to developing flower stalks. The flower stalks may become water-soaked, turn brown, and exhibit a foul odor due to the breakdown of tissues.

Bacterial Spot (*Xanthomonas* spp.): Bacterial spot is a common disease affecting plants like tomatoes, peppers, and other related crops. The bacteria can be introduced from infected leaves or stems to flower stalks through splashing water or contaminated tools. Infected flower stalks may show dark spots, lesions, or browning.

It's important to note that bacterial infections can spread rapidly, so early detection and proper management practices are essential to prevent further spread and damage. Implementing proper sanitation measures, using disease-resistant plant varieties, practicing good pruning techniques, and applying appropriate bactericides are some strategies that can help manage bacterial infections and reduce the risk of flower or fruit stalk infections.

Nematode

Nematodes are microscopic roundworms that can cause plant diseases by infecting various parts of the plant, including flower and fruit stalks. Nematodes can spread from infected mother parts to these stalks through soil contact, water movement, and other vectors. Here are a few examples of nematode infections that can lead to flower or fruit stalk infections:

Root-Knot Nematodes (*Meloidogyne spp*.): Root-knot nematodes are common and widely distributed plant parasites. These nematodes infect plant roots, causing the development of characteristic galls or knots on the roots. The nematodes can move from infected roots to flower or fruit stalks through the vascular system. As a result, the flower stalks may become distorted, weakened, or galled, leading to reduced flower production and fruit quality.

Cyst Nematodes (*Heterodera and Globodera spp*.): Cyst nematodes are another group of plant-parasitic nematodes that can cause damage to flower and fruit stalks. These nematodes create cysts on the roots, which protect and house the nematode stages. The nematodes can spread from infected roots to other parts of the plant, including stalks. This can result in weakened stalks, stunted growth, and reduced flower or fruit development.

Lesion Nematodes (*Pratylenchus spp*.): Lesion nematodes are soil borne nematodes that feed on plant roots and can also move to aboveground parts of the plant, including flower and fruit stalks. These nematodes create lesions or cavities in the roots, which can lead to decreased water and nutrient uptake. The damage to the root system can indirectly affect the health and development of flower and fruit stalks.

Stubby-Root Nematodes (*Trichodorus and Paratrichodorus spp*.): Stubby-root nematodes can cause stubby and distorted root systems in plants. These nematodes can also transmit certain plant viruses. When infected plants produce flowers and fruits, the nematodes can potentially move from the roots to the stalks, affecting flower and fruit development.

Reniform Nematodes (*Rotylenchulus spp*.): Reniform nematodes are known for their kidney-shaped appearance. They feed on plant roots and can cause damage to various crops. As they damage the roots, the nematodes can weaken the plant's overall structure, including flower and fruit stalks.

Managing nematode infections involves practicing proper crop rotation, using nematode-resistant plant varieties, improving soil health, and implementing cultural practices that reduce nematode populations. Nematicides, which are chemical compounds designed to control nematodes, can also be used, but their use should be approached with caution due to potential environmental and health impacts. Early detection and integrated management strategies are crucial to minimizing the impact of nematode infections on flower and fruit stalks.

Seed stalk (Funicules):

Fungus

Xylem infecting *F. oxysporum f.sp lycopersici* – v.b – funiculus – internal tissues of the seed Xylem infecting *Verticillium* dahlia causing wilt of beet and spinach – v.b – funiculus – internal tissues of the seed.

Bacteria

Pseudomonas syringae pv. lachrymans causing angular leaf spot of cucurbits - Enter through funiculus and micropyle into seed coat, endosperm and embryo *Xanthomonas campestris pv. phaseoli* causing bacterial blight of bean - funiculus – ovule - seed

Xanthomonas campestris pv. campestris causing black vein of cabbage – funiculus – seed coat

Virus

All the embryo infecting viruses infect ovule through funiculus

Bean mosaic virus – infect ovule and young seed through funiculus

Micropyle:

Bacteria

Xanthomonas campestris pv.phaseoli - Enter through micropyle - seed.

Pseudomonas syringae pv. lachrymans causing angular leaf spot of cucurbits- enter through micropyle - seed coat- endosperm-embryo

Pseudomonas syringae pv. pisi, halo blight of pea, enters through micropyle – seed

External Pathogen Intrusion: Plant Vulnerability to Outside Infections

Matured seeds can indeed become infected by pathogens introduced from outside sources. These pathogens can include bacteria, fungi, viruses, and even nematodes. Infection can occur during the seed's development on the plant, during harvesting, or during storage. Here are some examples of how matured seeds can be infected by pathogens from external sources:

Seed-Borne Fungi:

Fungi can infect matured seeds and remain dormant until conditions are favorable for germination. They can be introduced externally during various stages, including flowering, fruiting, harvesting, and storage. For instance:

***Fusarium* species:** These fungi can infect a wide range of crops, causing diseases like *Fusarium* wilt. Infected seeds can transmit the pathogens to the next generation.

***Alternaria* species:** These fungi cause diseases like *alternaria* leaf spot. They can infect mature seeds and remain dormant until germination.

Seed-Borne Bacteria:

Bacteria can also infect seeds from the external environment. Pathogenic bacteria can be introduced during various stages and persist in or on the seed coat. Examples include:

***Xanthomonas campestris*:** This bacterium causes black rot in cruciferous plants. Infected seeds can carry the bacteria to new plants.

Pseudomonas syringae: Some strains of this bacterium can cause bacterial speck in tomatoes and other plants. The bacteria can be transmitted via infected seeds.

Seed-Borne Viruses:

Some viruses can be transmitted through infected seeds. While less common, this can still be a source of infection:

Cucumber Mosaic Virus (CMV): CMV can infect a wide range of plants, and infected seeds can carry the virus, leading to infected seedlings.

External Contaminants:

Pathogens can be introduced through contact with contaminated soil, tools, water, or even by insects or other vectors:

Soil-Borne Pathogens: Soil can contain a variety of pathogens. Seeds that come into contact with contaminated soil during harvesting or storage can carry these pathogens.

Tools and Equipment: Contaminated tools used during harvesting or processing can introduce pathogens to the seeds.

Insects and Vectors: Insects that feed on plant tissues can transmit pathogens to seeds. For example, aphids can transmit certain viruses to seeds during feeding.

To reduce the risk of seed infection, proper crop management practices are essential. This includes planting disease-resistant varieties, using certified disease-free seeds, practicing good sanitation in the field and during harvesting, and ensuring proper seed storage conditions to prevent moisture and mold growth. Seed treatment with fungicides or other protective agents can also be considered to minimize the risk of external contamination leading to seedborne infections.

CONCLUSION

"Highlighting 'Seed Security Breach: Modes of Pathogen Invasion,' we've seen how external factors introduce harmful pathogens during growth, harvest, and storage. Safeguarding seeds through vigilance, resistance, and proper practices is imperative for sustaining plant health."

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