Fusarium oxysporum: Life cycle, symptoms and control measures

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Fusarium sp.

- *Fusarium* is a complex genus and the most diverged species in the Eumycota for its worldwide distribution, causing diseases in plants, animals, and humans as well as the profuse presence of non-pathogenic Fusarium in the natural ecosystem.
- *Fusarium oxysporum* species complex (Fosc) is an economically devastating species of Fusarium and is globally-dispersed in various habitats, along with indoors, soil, and marine environments.
- *Fusarium oxysporum* has many different *formae speciales* which are each selectively pathogenic on a limited number of crops.
- Even within one crop, different *formae speciales* may occur and cause different symptoms.
- It is a crucial ubiquitous soil-borne phylogenetic diversified fungus with a vast host range including horticultural and grain crops that cause diseases like wilt, rot, and damping-off.
- Members of this species complex are not the only source of uncontrollable vascular wilt diseases in various plants, but also the source of contagious diseases in humans and create a serious challenge to food security and public health.
- In terms of the economic importance of the fungus, the pathogen was ranked fifth among the top 10 plant pathogenic fungi.

Source: https://doi.org/10.3390/agronomy11071310

...*Fusarium*

- *Fusarium oxysporum* is the only *Fusarium* that actually grows inside the vessel system of the host plant and spreads upwards inside the plants.
- The other species are dispersed upwards on the outside of the plant.
- Most *Fusarium* species only make asexual spores. Some also produce ascospores.
- *Fusarium* overwinters for many years in the soil and on crop residues of infected plants as chlamydospores (thick walled mycelium cells) or mycelium.
- Survival is also possible on seed, greenhouse structures, tools and machinery.
- Primary infection is either seed-borne or takes place as infection of the roots at the root tip or in small wounds, for example where lateral roots branch off from the tap root.
- This seed and soil-borne plant pathogen causes serious detrimental effects on contaminated transplants showing symptoms like chlorosis, necrosis, immature leaf fall, vascular system browning, and finally wilting, which causes tremendous yield reduction.
- Additionally, if infection occurs earlier or during the harvesting period, some of them can produce mycotoxins (such as trichothecenes and fumonisins) in agricultural products.
- Cereals and other food grains can be contaminated by Fusarium toxins and causes many diseases like feed refusal syndromes in mammals, moldy sweet potato toxicity, and poisoning in bean hulls and different other living organisms

https://www.koppert.in/challenges/disease-control/fusarium-wilt/

Fusarium oxysporum

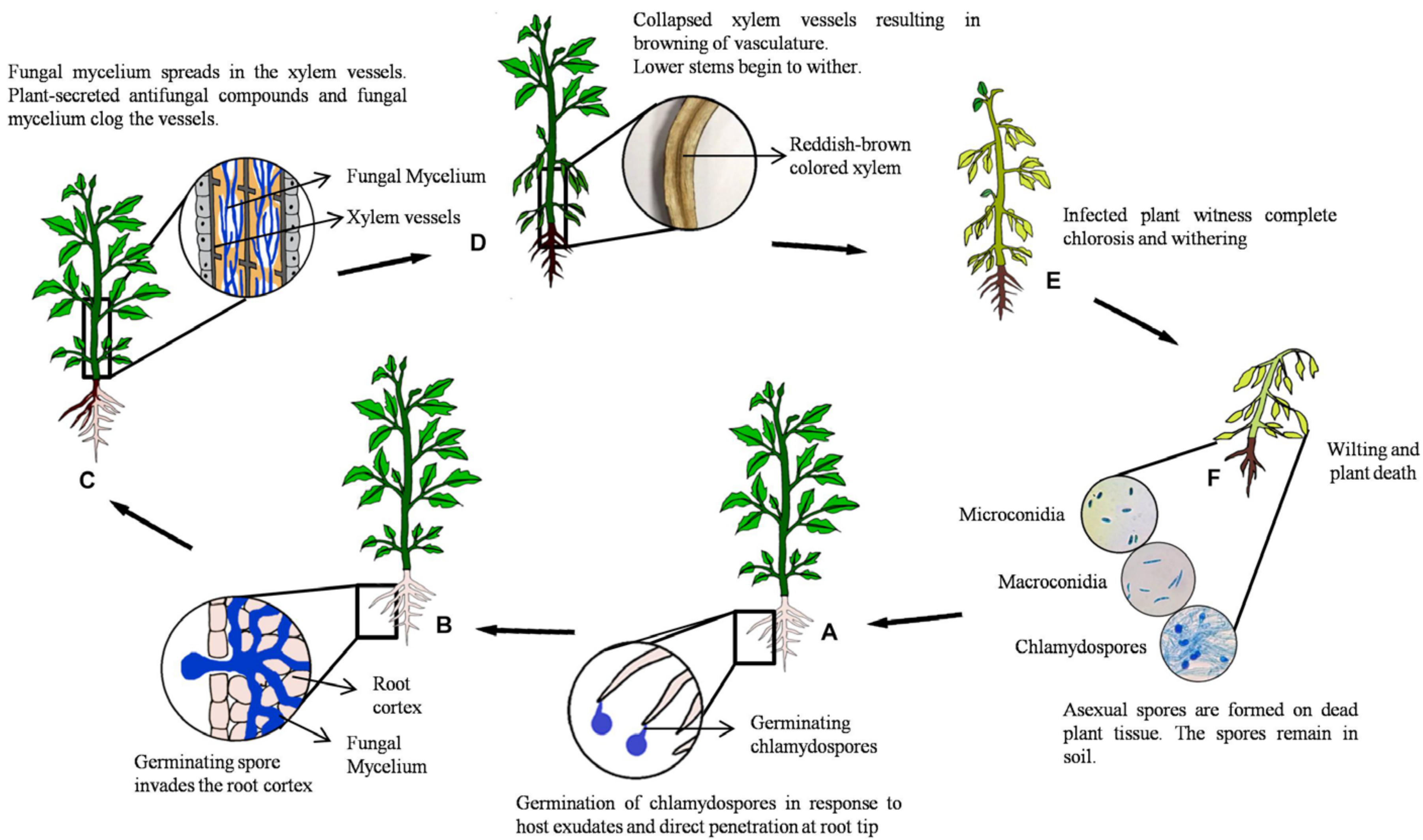
- *Fusarium oxysporum* emended by Snyder and Hansen (1940) is an anamorphic species within the genus Fusarium.
- It is genetically heterogenous, polytypic morphospecies which represents most abundant and ubiquitous soil-borne fungus; few strains have been reported from tundra soils as well which exist as saprophytes and pervasive plant root endophytes.
- During saprophytism mode, Fusarium species degrade lignin and complex carbohydrates associated with soil debris.
- Fungal pathogens after adhesion gain access into plant interior through stomata and wounds in leaf and stem tissue.
- However, in several cases, cell wall degrading enzymes (CWDEs) and secondary metabolites secreted by fungus facilitate penetration.
- Once pathogen penetrates host, it secretes protein effectors that suppress plant defence responses and promotes invasion (Lo Presti et al. 2015).
- Pathogenic fusarium employ various infection strategies like biotropic (pathogen that colonizes living plant tissue and obtains nutrient from them), necrotrophic (pathogen that kills host cell and obtains nutrient from dead cells) and hemibiotrophic (pathogens that are initially biotrophic and subsequently necrotrophic) varying in mode of interaction.

Disease cycle

- Fusarium oxysporum reproduces asexually, it produces chlamydospores, microconidia and macroconidia (Nelson et al. 1983).
- **Microconidia** are uninucleate which germinate poorly with germination efficiency ranging from 1 to 20% (Ebbole and Sachs 1990).
- The microconidia are the most abundantly produced spores.
- They are oval, elliptical or kidney shaped and produced on aerial mycelia.
- **Macroconidia** are multinucleate and germinate rapidly.
- Macroconidia, which have three to five cells and have gradually pointed or curved edges, are found on sporodochia on the surface of diseased plant (in culture the sporodochia may be sparse or nonexistent).
- **Chlamydospores** are resulting from the structural modification of vegetative hyphae or a thick-walled conidial cell and accessory spores (Schippers and van Eck 1981).
- Chlamydospores are usually formed singly or in pairs, but can sometimes be found in clusters or in short chains.
- They are round thick walled spores produced within or terminally on an older mycelium or in macroconidia.
- Chlamydospores unlike the other spores can survive in the soil for a long period of time.
- F. oxysporum is diversified on shape of macroconidia, structure of micro-conidiophores, formation of chlamydospores

… Disease cycle

- *F. oxysporum* is a common soil pathogen and saprophyte that feeds on dead and decaying organic matter. It survives in the soil debris as a mycelium and all spore types, but is most commonly recovered from the soil as chlamydospores.
- This pathogen spreads in two basic ways: it spreads short distances by water splash, and by planting equipment, and long distances by infected transplants and seeds.
- *F. oxysporum* infects a healthy plant by means of mycelia or by germinating spores penetrating the plant's root tips, root wounds, or lateral roots.
- The mycelium advances intracellularly through the root cortex and into the xylem.
- Once in the xylem, the mycelium remains exclusively in the xylem vessels and produces microconidia (asexual spores).
- The microconidia are able to enter into the sap stream and are transported upward.
- Where the flow of the sap stops the microconidia germinate.
- Eventually the spores and the mycelia clog the vascular vessels, which prevents the plant from up-taking and translocating nutrients.
- In the end the plant transpires more than it can transport, the stomata close, the leaves wilt, and the plant dies.
- After the plant dies the fungus invades all tissues, sporulates, and continues to infect neighboring plants.



Collapsed xylem vessels resulting in browning of vasculature.
Lower stems begin to wither.
Fungal mycelium spreads in the xylem vessels. Plant-secreted antifungal compounds and fungal mycelium clog the vessels.
Reddish-brown colored xylem
Fungal Mycelium
Xylem vessels
D
Infected plant witness complete chlorosis and withering
E
C
Wilting and plant death
F
Microconidia
Macroconidia
Chlamydospores
B
A
Root cortex
Fungal Mycelium
Germinating spore invades the root cortex
Germinating chlamydospores
Asexual spores are formed on dead plant tissue. The spores remain in soil.
Germination of chlamydospores in response to host exudates and direct penetration at root tip

Pathogenicity Factors

- Xylem-colonizing *Fusarium* pathogens employ both general and specific pathogenicity mechanisms to invade the host.
- While components of cell signaling pathways encompass the general factors regulating pathogenicity, such as:
  – cyclic adenosine monophosphate (cAMP),
  – mitogen-activated protein kinase (MAPK),
  – Ras (retrovirus-associated DNA sequences) proteins, G (guanine nucleotide-binding) protein, and
  – cell wall-degrading enzymes,
- Effectors and host-specific toxins attribute specificity to pathogens.
- Effectors secreted by the pathogen facilitate its colonization by modulating immune response in the host plant.

Environment

- As previously stated *F. oxysporum* is a common soil saprophyte that infects a wide host range of plant species around the world.
- It has the ability to survive in most soil—arctic, tropical, desert, cultivated and non-cultivated.
- Though *Fusarium oxysporum* may be found in many places and environments, development of the disease is favored by high temperatures and warm moist soils.
- The optimum temperature for growth on artificial media is between 25-30 °C, and the optimum soil temperature for root infection is 30 °C or above.
- However, infection through the seed can occur at temperatures as low as 14 °C.
- *F. oxysporum* thrives at soil temperatures above 24 °C (75 °F) and can live indefinitely in soil without access to living host plants.

How to prevent Fusarium wilt

- Remove or destroy crop residues
- Choose resistant cultivars
- Use clean propagation materials (seed can be treated effectively with hot water)
- Use clean substrate in greenhouse crops
- Disinfect tools, machinery and irrigation water in greenhouses
- Prevent stress for the plants
- Ensure there is adequate soil drainage
- Apply nitrogen in the form of nitrate instead of ammonium
- Prevent damage during harvest and during post-harvest storage and enhance wound healing after harvest, depending on the crop
- Prevent plant diseases by optimizing plant potential and crop resilience.