Interaction of carbon nanotubes with *Fusarium* spp.

Sunčana Včelik[1], Ivana Borišev[2], Aleksandar Đorđević[2], Danica Jović[2], Biljana Crevar[1], Marina Barišić[1], Tihomir Kovač[1]*

[1] Josip Juraj Strossmayer, University of Osijek, Faculty of Food Technology, Department of Applied Chemistry and Ecology, Franje Kuhača 20, 31000 Osijek, Croatia
[2] University of Novi sad, Faculty of Sciences, Department of Chemistry, Biochemistry and Environmental protection, Trg Dositeja Obradovića 3, 21000, Novi Sad, Serbia

*Corresponding author: tkovac@ptfos.hr

1 Background & aim

Carbon nanotubes (CNTs) are increasingly used, raising questions about their effects on plant-pathogenic fungi.

Fusarium oxysporum and *Fusarium graminearum* cause important diseases and mycotoxin contamination.

AIM: To summarise the effects of CNTs on *Fusarium* growth, cell integrity and metabolism.

2 Mechanisms of antifungal action

1 Contact & adsorption
CNTs bind to spores and hyphae; adsorbed tubes may block water channels.

2 Envelope damage
Membrane disruption, cell-wall deformation, impaired nutrient transport.

3 Oxidative stress
Higher intracellular ROS damages lipids, proteins and nucleic acids.

4 Metabolic shift
Antioxidant defence and secondary metabolism are altered.

3 Evidence at a glance

93.2% mycelial growth suppression of *F. oxysporum* f. sp. tuberosi at 550 µg/mL functionalised MWCNTs (Manzoor et al., 2026)

18.2% spore germination of *F. graminearum* with surface-modified MWCNTs, about 3× lower than pristine (Wang et al., 2017)

607% peak ROS generation (DCFH-DA assay) at the highest CNT dose (Manzoor et al., 2026)

4 What governs the effect

Surface functionalisation
–OH, –COOH and $–NH_2$ groups → **better dispersion + spore contact**

Dispersion stability
Well-dispersed tubes → **better access to fungal cells**

Concentration
150–550 µg/mL → **dose-dependent inhibition**

5 Fungal transformation of CNTs

Extracellular oxidative enzymes (laccase, lignin and Mn-peroxidase) can modify CNT surfaces, adding –COOH/–CO groups and stripping graphene layers (Juárez-Cisneros et al., 2021).

Complete biodegradation has not been demonstrated.

6 Mycotoxins & open questions

MYCOTOXINS

CNTs may modulate mycotoxin biosynthesis in *Fusarium*.

Species- and condition-dependent

OPEN QUESTIONS

→ Standardised CNT characterisation
→ Realistic doses
→ In planta trials

7 Conclusions

- CNTs inhibit Fusarium growth and spore germination, depending on functionalisation, dispersion and dose.
- Direct contact and ROS-driven oxidative stress are the main modes of action.
- Understanding these interactions is essential for CNT risk assessment and for their use as antifungal agents in agriculture and biotechnology.

References

1. Wang et al. (2017) Surface modification of carbon nanotubes with an enhanced antifungal activity for the control of plant fungal pathogen. Materials 10(12): 1375.
2. Manzoor et al. (2026) Elucidating the mechanisms of Fusarium oxysporum f. sp. tuberosi inhibition using functionalized multi-walled carbon nanotubes. J. Integr. Agric. 25(4): 1544–1555.
3. Juárez-Cisneros et al. (2021) Ligninolytic activity of Penicillium chrysogenum and Pleurotus ostreatus involved in the biotransformation of synthetic multi-walled carbon nanotubes modify its toxicity. PeerJ 9: e11127.

Acknowledgement: This study was supported by the project "Studies of Bioactive Food Components with New Possibilities of Use for Healthy Nutrition and Nutritional Supplements" (BioActFood, NPOO 581-UNIOS-93), funded by the European Union – NextGenerationEU through the Recovery and Resilience Mechanism.