Unraveling the Virulence Mechanism of *Fusarium oxysporum* Tropical Race 4 in Banana Wilt

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http://thunderhouse4-yuri.blogspot.com/2012/06/fusarium-oxysporum.htm

Outline

- Introduction and Background
- Infection and Colonisation
- Virulence Factors
- Conclusion

Banana

- Main dietary sources of carbohydrates in Africa, Southeast Asia, and tropical America
- Most important fruit in terms of production volume and trade
- Most traded variety currently: Cavendish banana

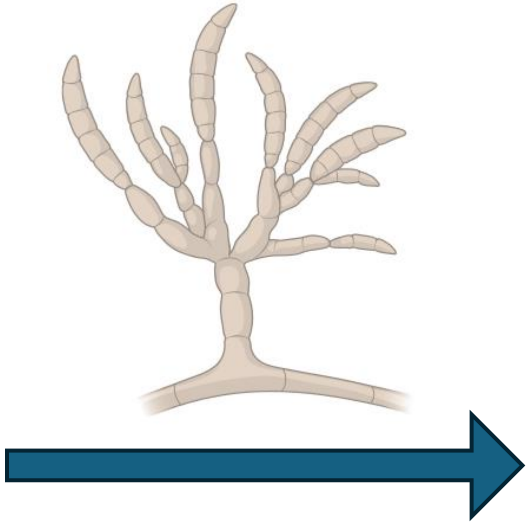
  -> ~99% of banana export

  -> ~50M tonnes production volume

(Food and Agriculture Organizations of United Nations , 2024a)

Fusarium wilt of banana (Panama disease)

Healthy banana plant



Fungal-infected banana plant

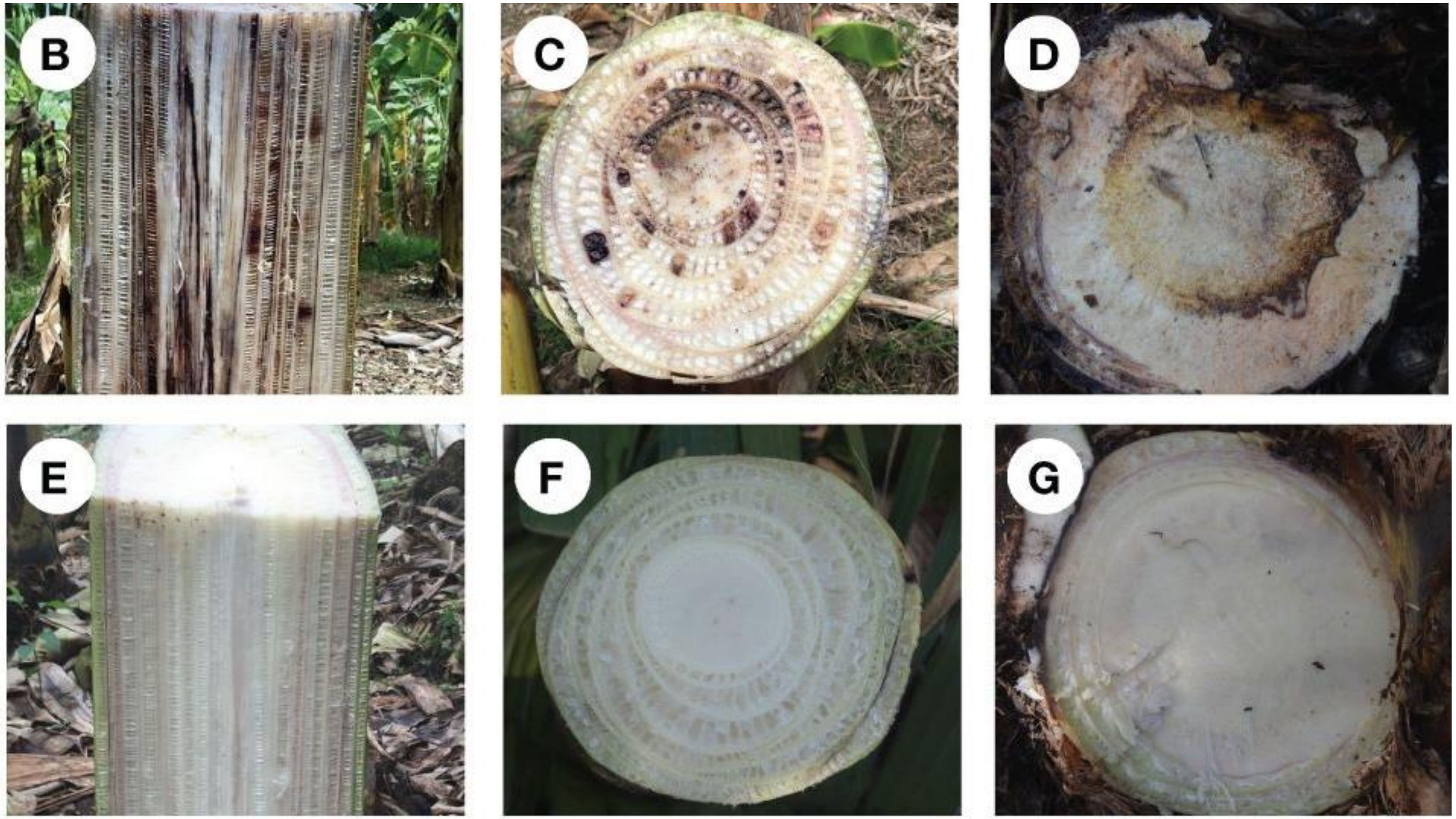
External symptom:
Yellowing and wilting of leaves

(Munhoz *et al.*, 2024; The Editors of Encyclopaedia Britannica, 2024)

Banana wilt (Panama disease)

Fungal-infected banana plant

Healthy banana plant



Internal symptoms:
Vascular necrosis & discolouration

(Munhoz *et al.*, 2024)

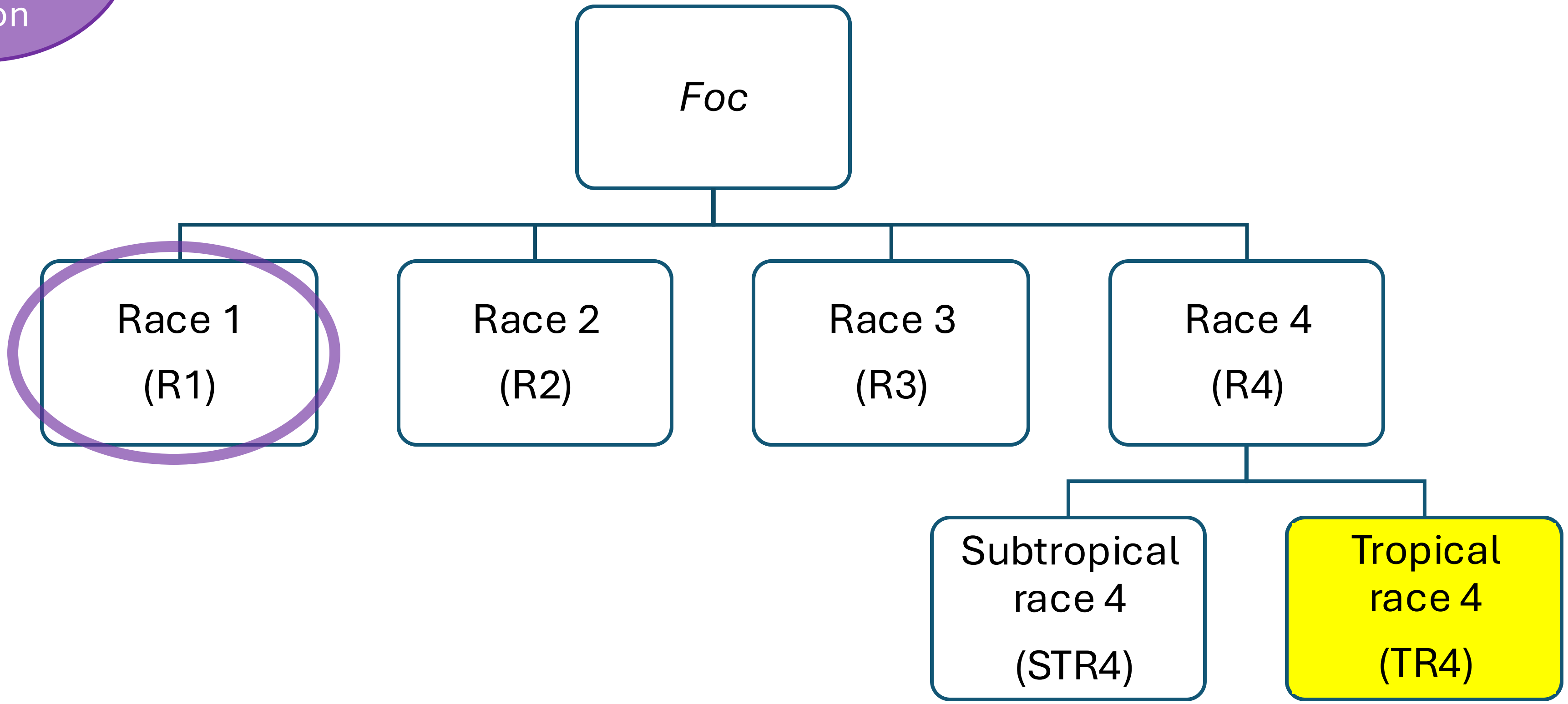
Fusarium oxysporum f. sp. *cubense (Foc)*

wiped out almost all banana plantations

Total trade losses: USD 2.3 billion

Caused epidemic of banana wilt in mid-twentieth

Resolved by substitution of race 1 resistant cultivars – Cavendish banana

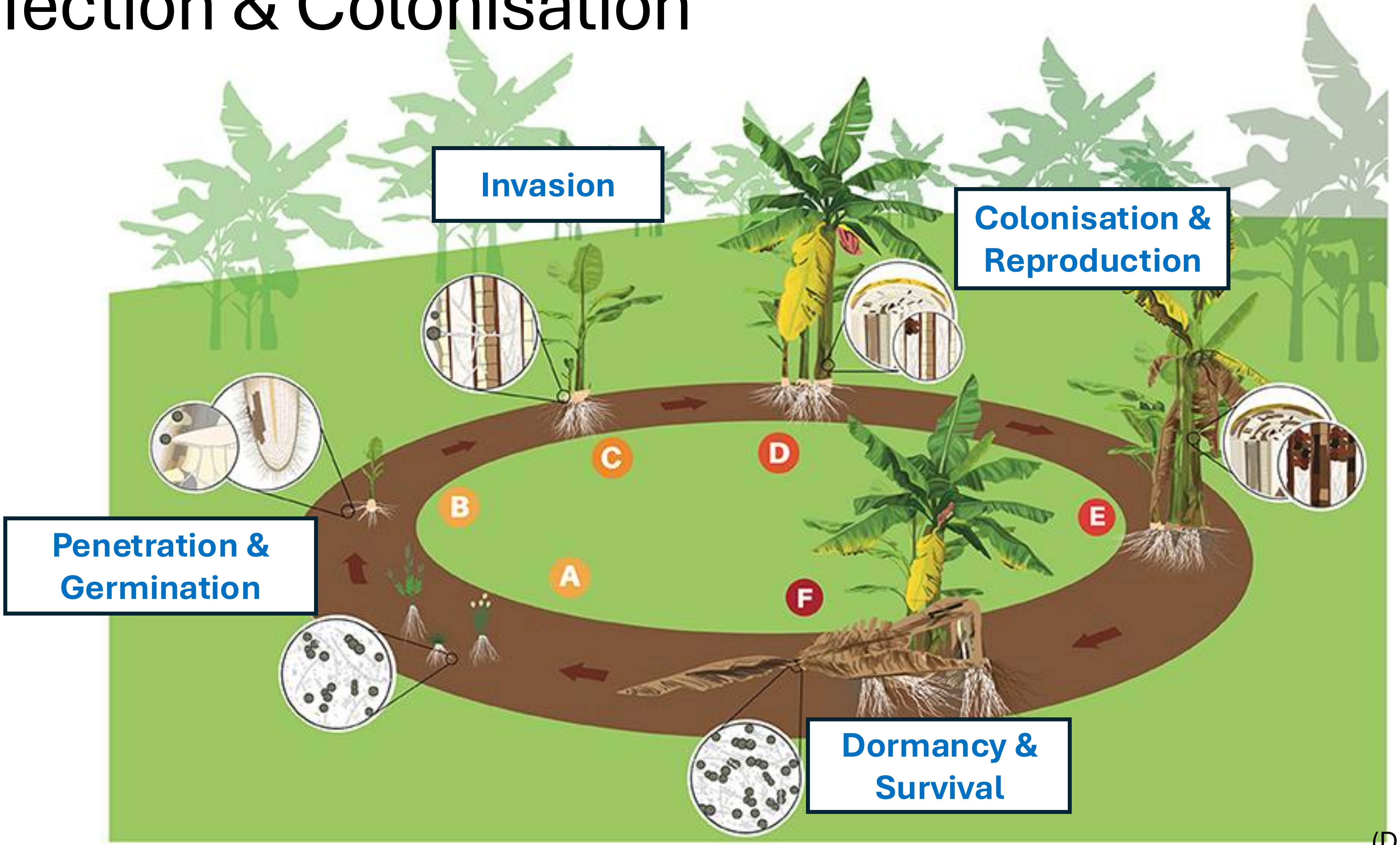


Foc Tropical race 4 (TR4)

- Initial report: 1989
- Currently affecting 23 countries, including largest banana exporters
- Estimated that 80% of global production is under the threat of TR4
- No cure

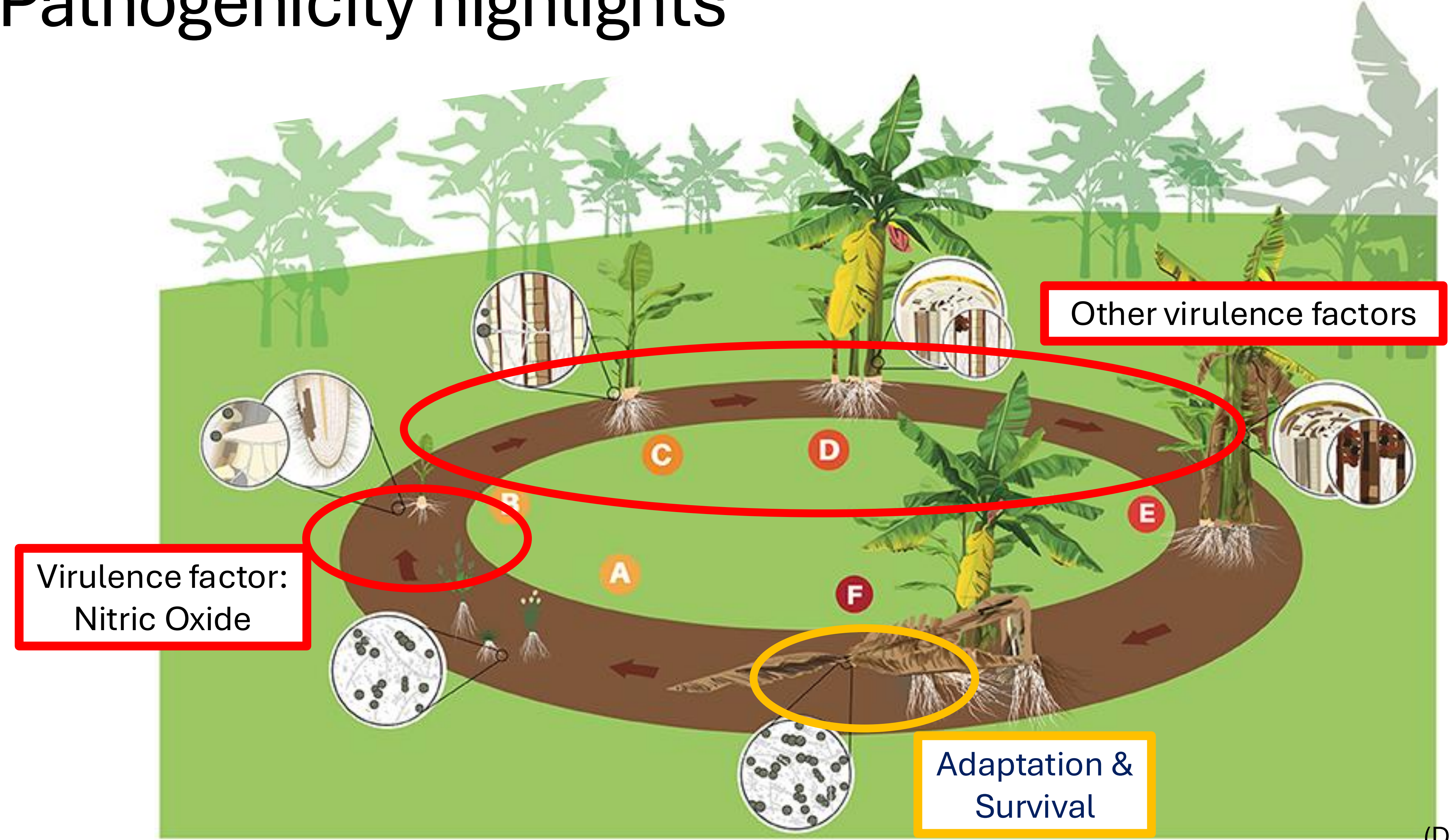
(Department of Agriculture, Fisheries and Forestry, 2024; Food and Agriculture Organizations of United Nations , 2024b)

Infection & Colonisation



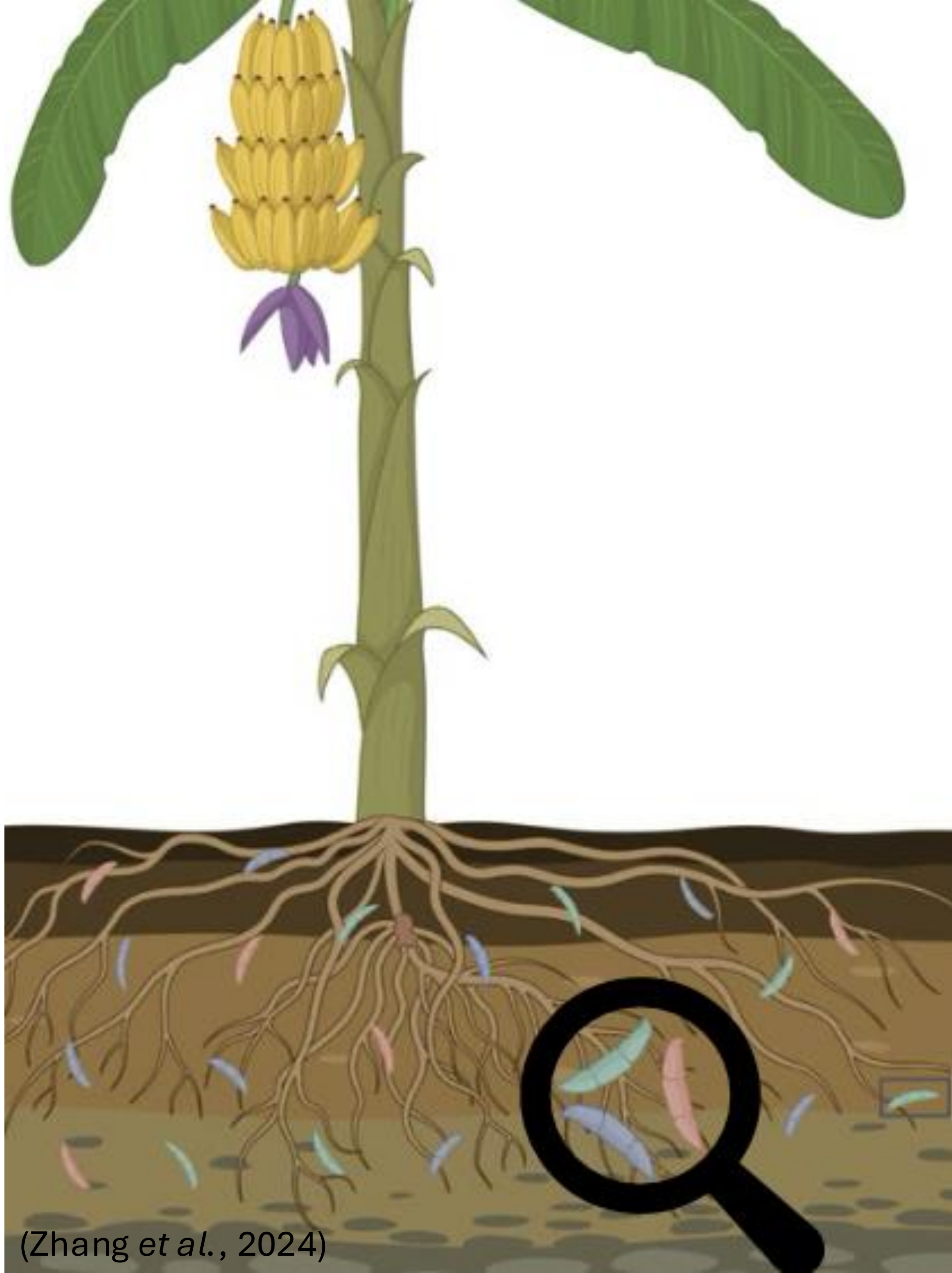
(Dita *et al.*, 2018)

Pathogenicity highlights



(Dita *et al.*, 2018)

Nitric Oxide (NO) burst – Nitrosative stress



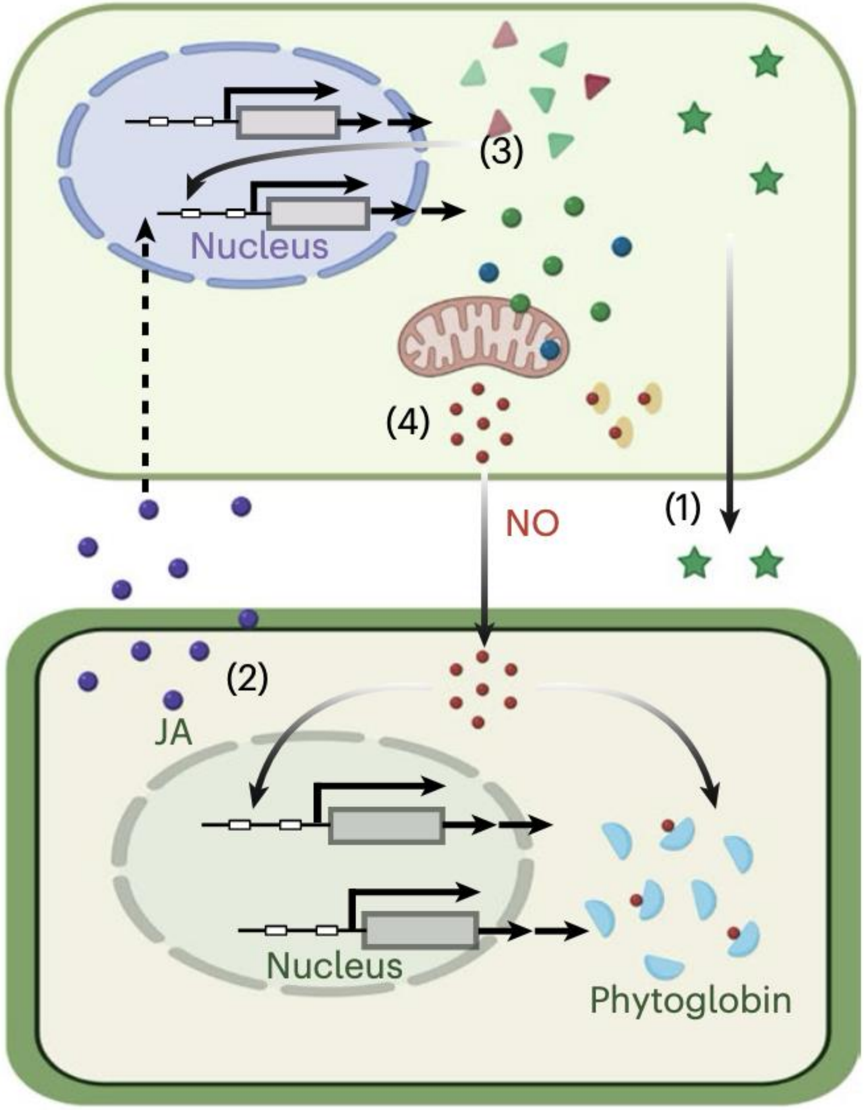
(Zhang *et al.*, 2024)

Nitric Oxide (NO) burst

- Fungal-host interaction
- Impose nitrosative stress within the root

- Process:

(1) Plant-fungal recognition
(2) Induction of JA signalling pathway
(3) Transcription reprogramming, upregulating a transcription factor required for host-mediated fungal NO production
(4) Fungus-derived NO burst in plant



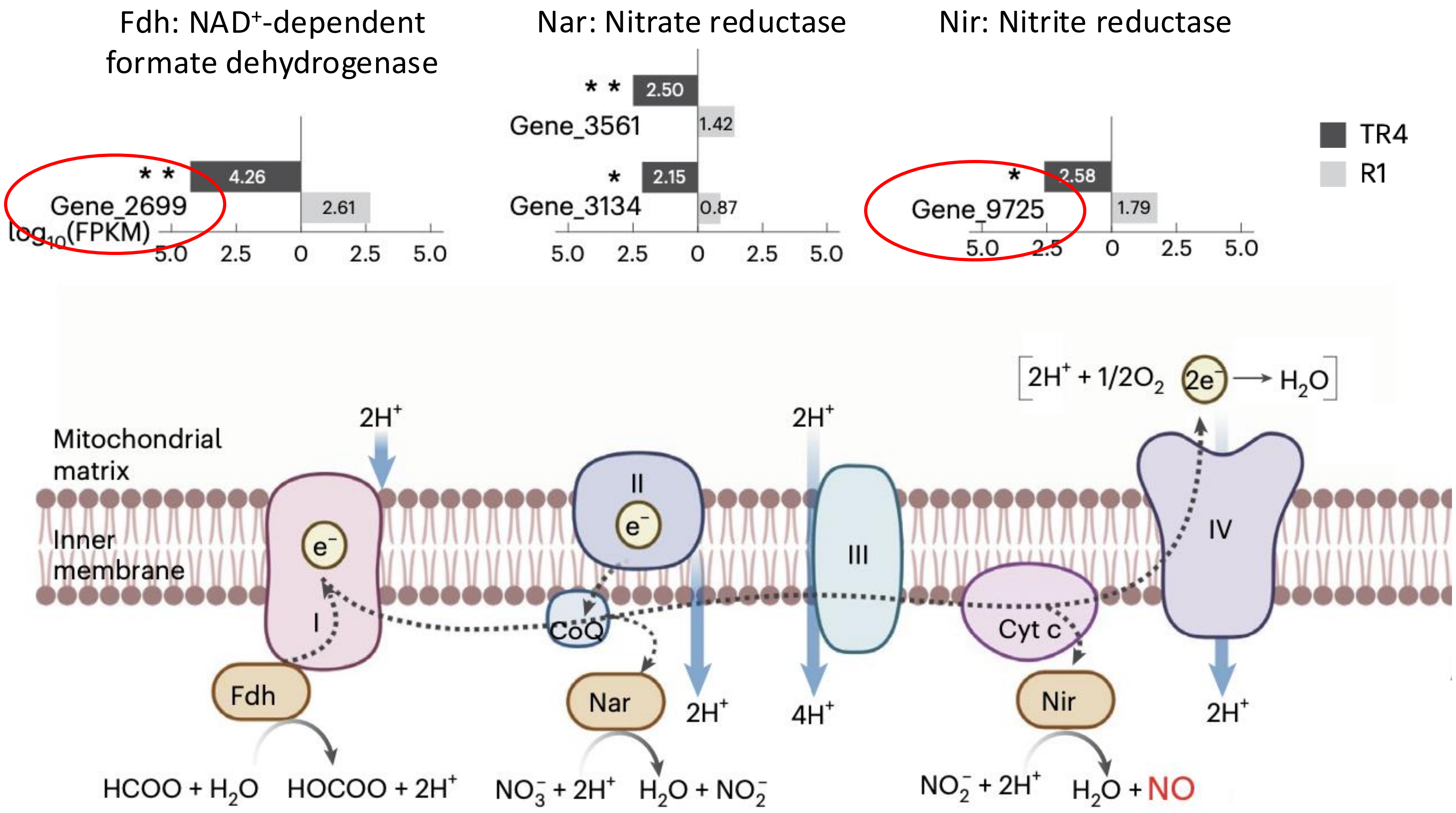
Foc TR4 cell

Plant cell

(Zhang *et al.*, 2024)

Nitric Oxide (NO) burst

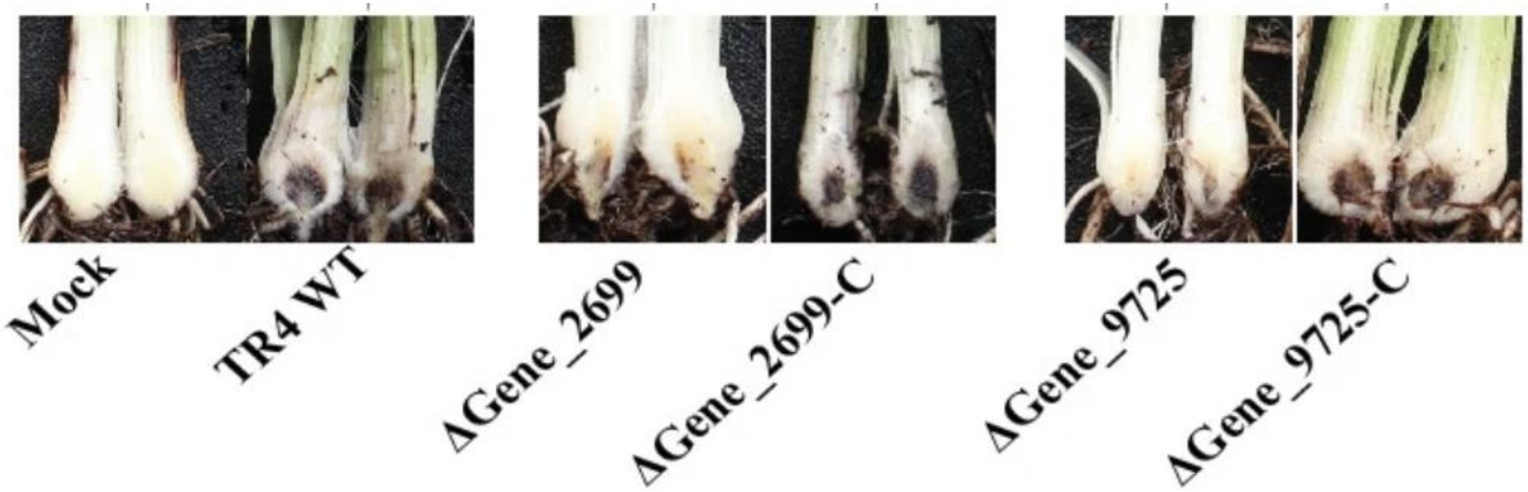
- Upregulation of genes in the NO biosynthesis pathway in TR4



(Zhang *et al.*, 2024)

Nitric Oxide (NO) burst

- Gene knockout and complementation of Gene_2699 & Gene_9725

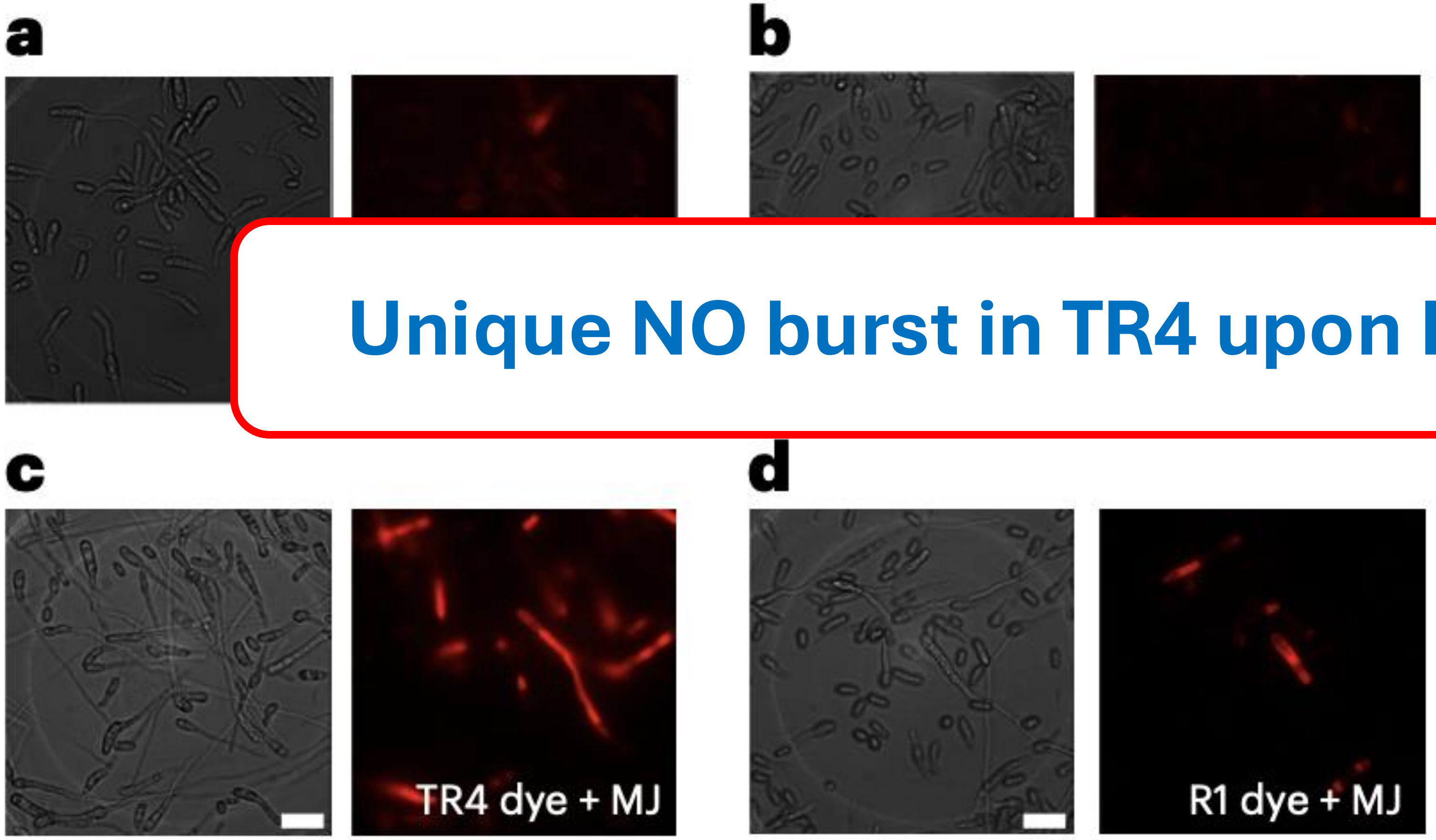


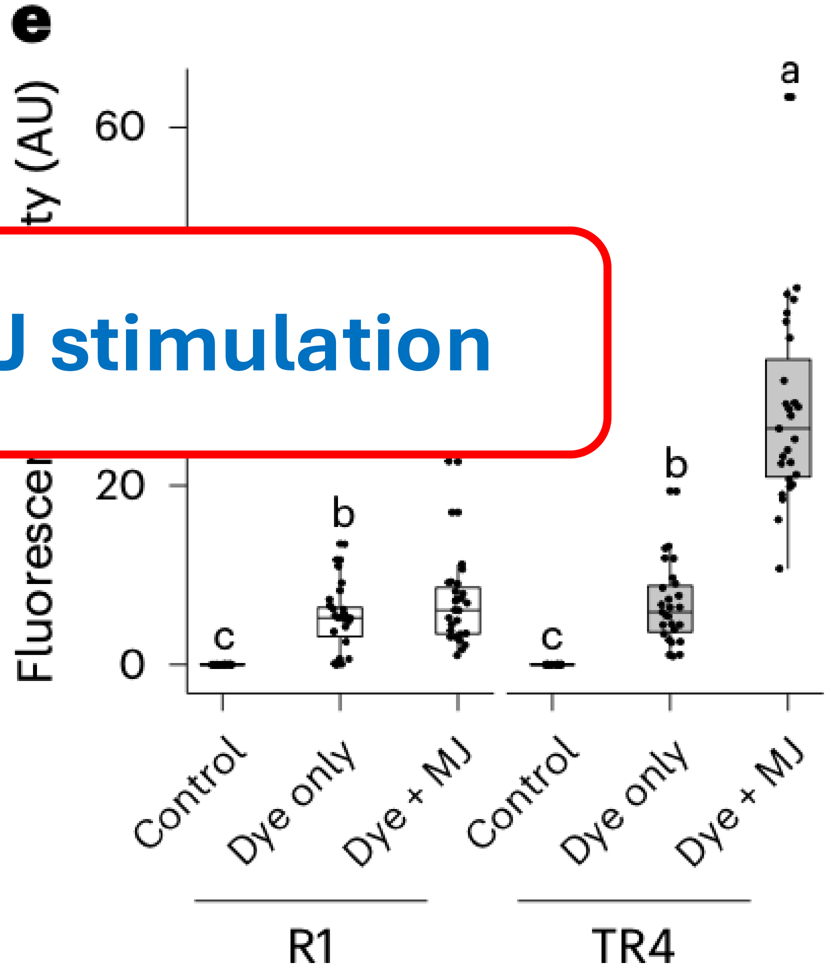
NO production facilitates TR4 invasion to the banana root

(Zhang *et al.*, 2024)

Nitric Oxide (NO) burst

- Alternative source of NO burst in TR4 - Methyl jasmonate (MJ) stimulation
  (Active form of JA)





Unique NO burst in TR4 upon MJ stimulation

Red fluorescence signal: Indicate NO production

(Zhang *et al.*, 2024)

Other identified virulence factors

(Zhang *et al.*, 2024)

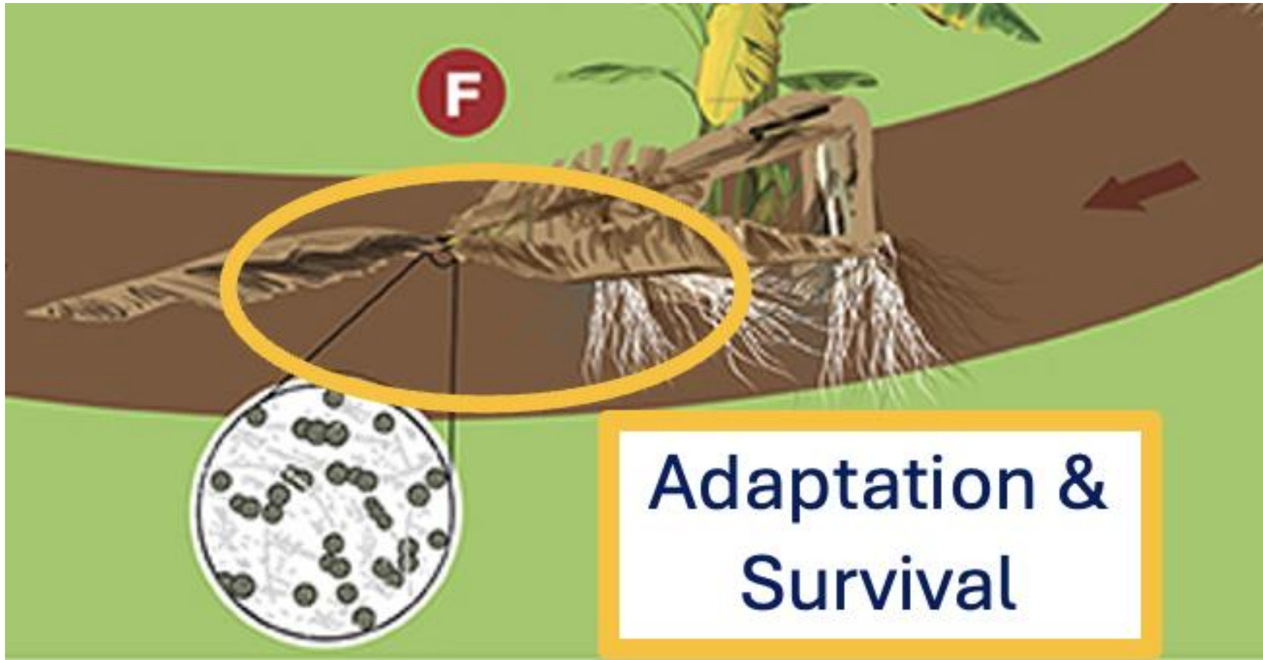
Other identified virulence factors

Virulence confirmed by gene knockouts, while the underlying pathogenetic mechanisms awaits elucidation-

Gene Name	Annotation	Biological Functions	References
SIX1a	Secreted in xylem protein 1a	Virulence	Widinugraheni et al. 2018
SIX8	Secreted in xylem protein 8	Virulence	An et al. 2019
CP1	Cerato-Platanin Family Protein	Virulence	Liu et al. 2019
FSE1	*Fusarium* special effector 1	Virulence elicitor	Yang et al. 2023
SP9	Secreted protein 9	Virulence	Guo et al. 2022
CUPIN1	cupin_1 domain containing protein	Virulence	Yan et al. 2022
SSP1	Small Secreted Protein 1	Conidiation, Virulence elicitor	Wang et al. 2022b
SSP17	Small Secreted Protein 17	Virulence	Wang et al. 2023b
M35_1	Metalloprotease Effector	Virulence	Zhang et al. 2021
OASTL	O-acetylhomoserine(thiol)-lyase	Virulence	Wang et al. 2020
ECM33	GPI-linked cell wall protein	Growth, Virulence	Huang et al. 2022
PGC4	Exo-polygalacturonase 4	Growth, Virulence	Dong et al. 2020
GCN5	General Control Non-derepressible 5	Growth, Conidiation, Virulence	Liu et al. 2022
PMI1	phosphomannose isomerase	Growth, Virulence	Usman et al. 2023
OCH1	α-1,6-mannosyl transferase	Growth, Conidiation, Virulence	Li et al. 2014
GCS	Glucosylceramide synthase	Growth, Conidiation, Virulence	Wang et al. 2022a
SLT2	MAP kinase	Growth, Virulence, BEA synthesis	Ding et al. 2015
MKK2	MAP kinase	Growth, Virulence, BEA synthesis	Ding et al. 2015
BCK1	MAP kinase	Growth, Virulence, BEA synthesis	Ding et al. 2015
FGA2	Gα subunit	Growth, Virulence	Guo et al. 2016
FGB1	Gβ subunit	Growth, Conidiation, Virulence	Guo et al. 2016
SGE1	SIX gene expression 1	Growth, Conidiation, Virulence	Gurdaswani et al. 2020
RLM1	MADS-box TF	Virulence, FSA/BEA synthesis	Ding et al. 2020
ATF1	bZIP transcription factor	Virulence	Qi et al. 2013
PP1	Pheromone precursor 1	Growth, Virulence	Liu et al. 2023
QDE2	AGO protein	Growth, Conidiation, Virulence	Li et al. 2022
DCL1	Dicer protein	Conidiation	Li et al. 2022

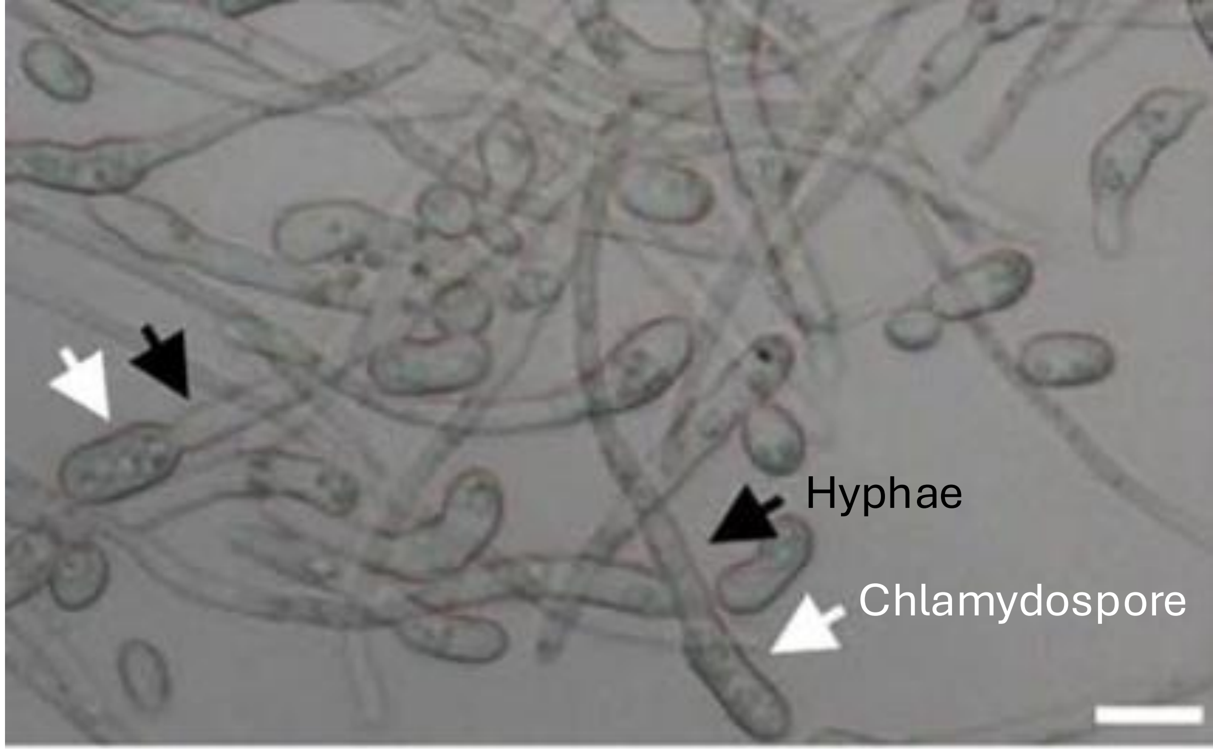
(Chen *et al.*, 2024)

Adaptation and Survival Mechanisms



Adaptation and Survival

- Production of chlamydospore
  - Resilient in unfavourable environmental conditions
  - Persistence in soil (may survive in the soil >20 years)



- Facilitate dissemination: plant-to-plant movement / soil dispersal

- Infect new host efficiently when bananas are planted/replanted

***Foc* TR4 can survive, disperse, and infect the hosts effectively**

(Chen *et al.*, 2024)

Control Strategies

New resistant banana

Cultural practices

Integrated management

Conclusion

- *Foc* is again posing imminent risk to food security and global banana trade
- Nitrosative stress contributes to the virulence of *Foc* TR4
- Research, agricultural and industrial sectors should work together to avoid another banana crisis

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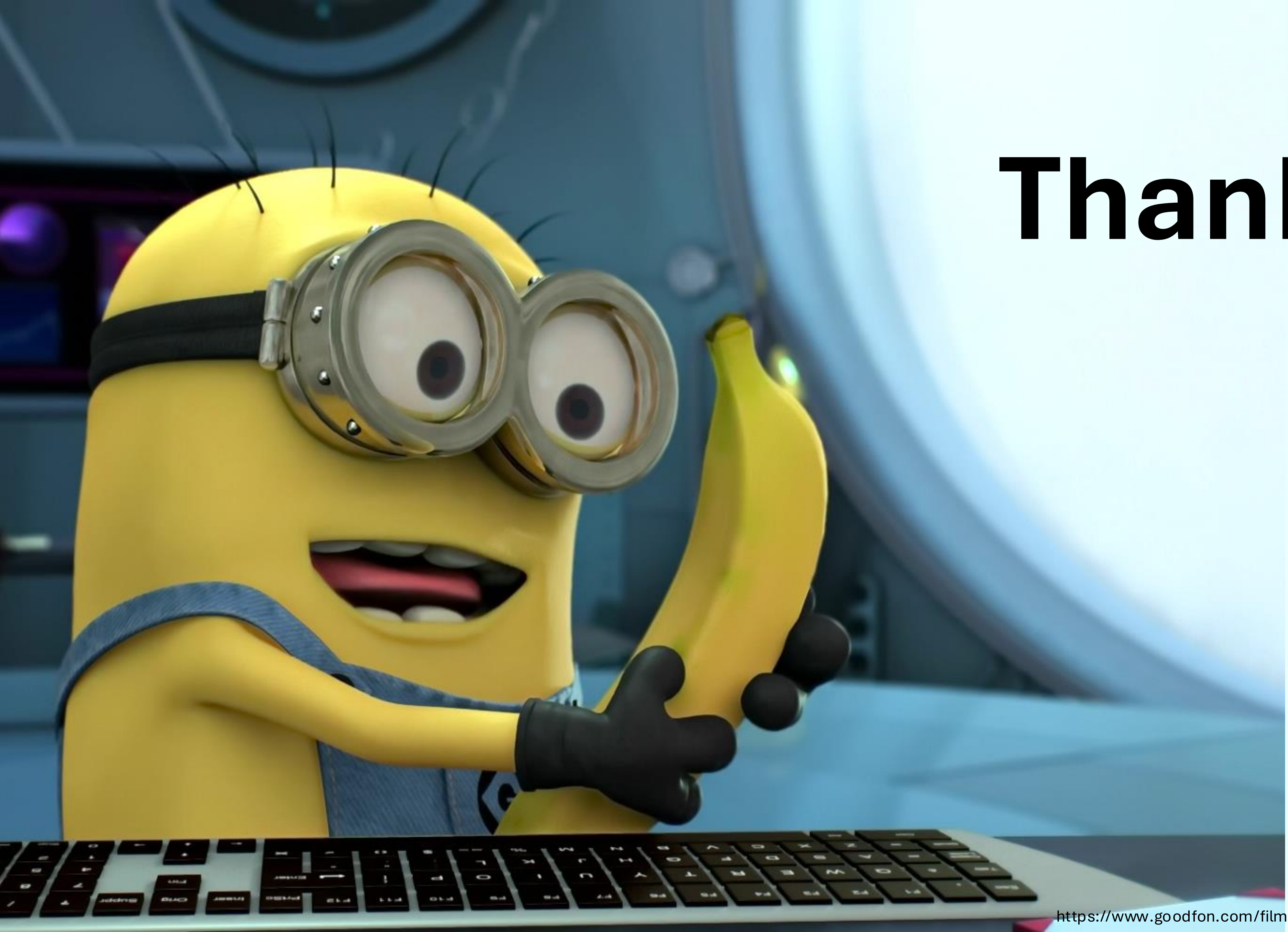

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