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A review of Genetic approaches to control black shank in tobacco

BACKGROUND

Phytophthora nicotianae, a soil-borne oomycete also known as *Phytophthora parasitica* var. *nicotianae*, is a globally destructive plant pathogen. This pathogen can survive in the soil as oospores and chlamydospores for 4 to 6 years, and spreads via motile zoospores that are chemotactically attracted to exudates from the host roots. *P. nicotianae* has a broad host range, infecting over 255 plant genera across 90 families.

Tobacco farmers incur significant losses due to this single pathogen

Published sources of genetic resistance against *P. Nicotianae* Races

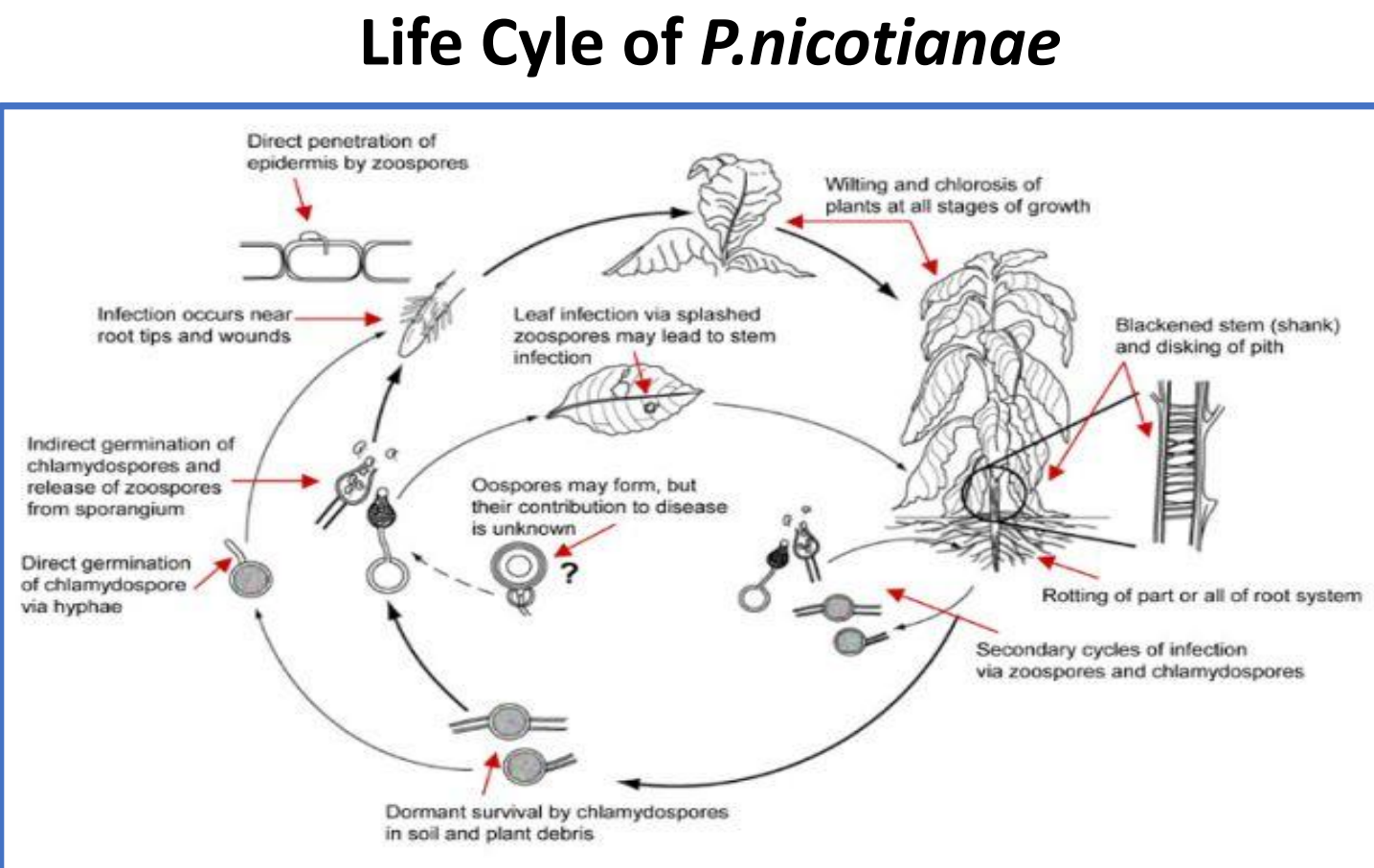
Locus	Type	Species of origin	Race 0	Race1	Race2	Race3	Race4	Durability
<i>Php</i>	Monogenic R gene	<i>N. plumbaginifolia</i>	R	S	S	R	R	Low
<i>Phl</i>	Monogenic R Gene	<i>N. Longiflora</i>	R	S	S	S	S	Low
<i>Phn7.1</i>	Polygenic	<i>Nt</i> ‘Florida 301’	PR	PR	-	PR	PR	Moderate
<i>Phn15.1</i>	Polygenic	<i>Nt</i> . ‘Beinhart 1000’	HPR	HPR	-	HPR	HPR	Moderate
<i>Wz</i>	Introgressed genomic region	<i>N. rustica</i>	HPR	HPR		HPR	HPR	Moderate
<i>LG 6</i>	Polygenic	<i>Nt</i> ‘K346’	S	R	-	R	-	-

Durable R-gene Management

Breeding programs must deploy a multi-layered approach to enhance durability of resistance genes:

- 1. **Pyramiding/stacking of Resistance Genes** -> Difficult for *P. nicotianae* to overcome multiple R genes.
 - 2. **Combining complete and partial resistance** -> Partial resistance acts as a second line of defence.
 - 3. **Rotating cultivars with different R genes** -> To reduce the selection pressure on the pathogen.
- These strategies can increase the longevity of resistance genes.

There is a shortage of R genes to effectively apply this multi-layered defence strategy



Gallup, C.A., M.J. Sullivan, and H.D. Shew. 2006. Black Shank of Tobacco. The Plant Health Instructor. DOI: 10.1094/PHI-I-2006-0717-01

Published Biotech methods to enhance resistance

Target gene	Molecular Strategy	Effect on Resistance	Agronomic effects	Functionality description	Key ref. DOI
<i>NpPP2-B10</i>	Overexpression	Enhanced resistance	Accelerated growth	F-Box-Nictaba protein from <i>N. plumbaginifolia</i> involved in Salicylic acid pathway	10.3390/ijms24087353
<i>Nta-miR6155</i>	Overexpression	Enhanced resistance	Inhibited growth, reduced nitrogen	Small non-coding RNA's . Overexpression results in strong antioxidant activity and higher SA signalling response	10.3389/fpls.2023.1281373
<i>Glutathione S-transferase</i>	RNAi silencing	Increased Resistance	N/A	Potential negative regulator of defence	10.1016/j.bbrc.2009.07.003
<i>NtbHLH49</i>	Knockdown/ Silencing	Increased Resistance	N/A	Transcription factor in hormone signalling pathway	10.3389/fpls.2022.1073856
<i>DMR6</i>	Gene KO	High Resistance	Slightly lower yield	DMR6 is a susceptibility factor that is essential for <i>P. nicotianae</i> to infect	10.1002/csc2.70150

SUMMARY AND PROSPECTS

- It is important for breeders **not to release single resistance genes** in new varieties to avoid *P. nicotianae* rapidly adapting and rendering those R-genes no longer effective.
- **Polygenic resistance sources** are moderately durable and **also need to be combined with other R genes to avoid pathogen adaptation**.
- It is essential to **identify novel resistance genes/loci** from the wider *Nicotiana* germplasm pool **to broaden available R-genes/loci**.
- **Biotechnology approaches** can deliver solutions to improve black shank resistance, for example knocking out the *DMR6* susceptibility factor.

Complete crop loss by *P. nicotianae*



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