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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	-	-

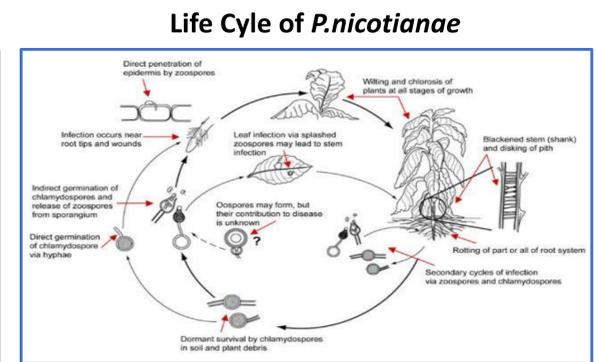
## Durable R-gene Management

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	<b>F-Box-Nictaba protein</b> from <i>N. plumbaginifolia</i> involved in <b>Salicylic acid pathway</b>	<a href="https://doi.org/10.3390/ijms24087353">10.3390/ijms24087353</a>
<i>Nta-miR6155</i>	Overexpression	Enhanced resistance	Inhibited growth, reduced nitrogen	<b>Small non-coding RNA's</b> . Overexpression results in <b>strong antioxidant activity and higher SA signalling response</b>	<a href="https://doi.org/10.3389/fpls.2023.1281373">10.3389/fpls.2023.1281373</a>
<i>Glutathione S-transferase</i>	RNAi silencing	Increased Resistance	N/A	<b>Potential negative regulator of defence</b>	<a href="https://doi.org/10.1016/j.bbrc.2009.07.003">10.1016/j.bbrc.2009.07.003</a>
<i>NtbHLH49</i>	Knockdown/Silencing	Increased Resistance	N/A	<b>Transcription factor in hormone signalling pathway</b>	<a href="https://doi.org/10.3389/fpls.2022.1073856">10.3389/fpls.2022.1073856</a>
<i>DMR6</i>	Gene KO	High Resistance	Slightly lower yield	<b>DMR6 is a susceptibility factor that is essential for P. nicotianae to infect</b>	<a href="https://doi.org/10.1002/csc2.70150">10.1002/csc2.70150</a>

## 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*

