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ORIGINAL ARTICLE

Report on emerging foliar soft rot disease on ginseng *Panax vietnamensis* and the identification of *Neocosmospora ipomoeae* and *Fusarium miscanthi* as the causal pathogens

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SUPPLEMENTARY MATERIAL

The authors are fully responsible for both the content and the formal aspects of the supplementary material. No editorial adjustments were made.

Table S1. Summary of the survey on foliar diseases associated with *Panax vietnamensis* in Vietnam

Survey area	Survey farm	Ginseng variety	Coordinates	Farming conditions	Plant age [year]	Disease incidence [%]	
						foliar soft rot disease	anthracnose disease
Quang Nam and Kon Tum provinces	QN1	Ngoc Linh	15°1′36″N 107°58′53″E	net house	1–3	10	2
	QN2	Ngoc Linh	15°00′607″N 108°01′660″E	natural forest canopy	1–3	2	16
	KT1	Ngoc Linh	14°59′30″N 108°1′16″E	net house and natural forest canopy	1–3	17	4
	KT2	Ngoc Linh	14°59′38″N 108°1′10″E	natural forest canopy	1–3	19	0
Lai Chau and Lao Cai provinces	MT	Lai Chau	22°33′42″N 102°49′49″E	natural forest canopy	1–3	12	30
	SH	Lai Chau	22°18′48″N 103°14′4″E	net house	1–3	22	2
	SP1	Lai Chau	22°21′225″N 103°51′476″E	net house	1–7	16	10
	SP2	Ngoc Linh	22°21′225″N 103°51′476″E	net house	1–7	26	1

Table S2. The disease index of foliar soft rot disease caused by the fungal pathogens *Neocosmospora ipomoeae* LN5 and *Fusarium miscanthi* KT2.1.2 on *Panax vietnamensis* in the pathogenicity test

Fungal pathogen	After 3 days		After 12 days	
	infection rate* [%]	disease index* [%]	infection rate* [%]	disease index* [%]
Neocosmospora ipomoeae LN5	44.44	1.01	44.44	12.46
*Fusarium miscanth*i KT2.1.2	55.56	0.67	55.56	12.44

*the infection rate and disease index were calculated according to TCVN 13268-5:2022: Plant protection – Pest surveillance method – Part 5: Medicinal plants

The formulas for calculation were:

$$\text{Infection rate [\%]} = \frac{\text{The total number of diseased plants}}{\text{The total number of researched plants}} \times 100,$$

$$\text{Disease Index [\%]} = \frac{[(N_1 \times 1) + (N_3 \times 3) + (N_5 \times 5) + (N_7 \times 7) + (N_9 \times 9)]}{N \times K} \times 100,$$

where: N_1: The number of infected leaves at level 1 with a total lesion <1% of the leaf area;
N_3: The number of infected leaves at level 3 with a total lesion >1–5% of the leaf area;
N_5: The number of infected leaves at level 5 with a total lesion >5–25% of the leaf area;
N_7: The number of infected leaves at level 7 with a total lesion >25–50% of the leaf area;
N_9: The number of infected leaves at level 9 with a total lesion >50% of the leaf area;
N: The total number of leaves investigated;
K: The highest infection level in the hierarchy.

The most severe lesions caused by strains *N. ipomoeae* LN5 and *F. miscanthi* KT212 were estimated for 25% of the leaf surface (equivalent to infection level 5). At this stage, whole leaves wilted and fell out.

Table S3. Leaf-associated diseases on Panax ginseng and the causal pathogens

Disease	Symptoms	Panax ginseng variety	Reported planting area	The causal pathogen	Reference
Alternaria blight	necrotic lesions of 2 to 20 mm in diameter with a dark brown margin and a yellow-green halo	*Panax quinquefolium* L.	America Canada	*Alternaria panax*	Putnam and Toit 2003; Hill and Hausbeck 2009
Leaf spot	brown oval/round spots of 3 to 9 mm in diameter with white/yellow halos in the center, leading to leaf withering and falling, and plant wilting.	*Panax ginseng* Meyer	China	*Alternaria alternata* *Boeremia exigua*	Lee *et al*. 2019; Wang *et al*. 2024
		Panax japonicus	China	*Boeremia exigua*	You *et al*. 2015
		Panax quinquefolius	America	*Pestalotiopsis nanjingensis*	Liyanapathiranage *et al*. 2023
Anthracnose	dark spot lesions (might be with a hole in the center) that can be enlarged and fused to make blight areas, leading to defoliation	*Panax ginseng* Meyer	Korea	*Colletotrichum panacicola*	Nakata, Takimoto, 1922
		Panax ginseng Meyer	Korea	*Colletotrichum dematium*	Han *et al*. 2004
		Panax quinquefolium L.	America Canada China	*Colletotrichum dematium* *Colletotrichum coccodes* *Colletotrichum sojae*	Mc. Partland, Hosoya 1998; Guan *et al*. 2021b
Grey mold	water-soaked, concentric lesions start at the leaf tips and proceed back along the leaf mid-rib, resulting in enlarged blight zones	*Panax quinquefolium* L.	America	*Botrytis cinerea*	Punja 1997
		Panax ginseng Meyer	China	*Botrytis cinerea*	Wang *et al*. 2022
Foliar soft rot	irregular water-soaked rotten lesions of 5 to 10 mm in diameter. As the disease progressed, the lesions enlarged (up to 25% leaf surface), and the infected leaves turned wilting black, easily falling out	*Panax vietnamensis*	Vietnam	*Neocosmospora ipomoeae* *Fusarium miscanthi*	this study

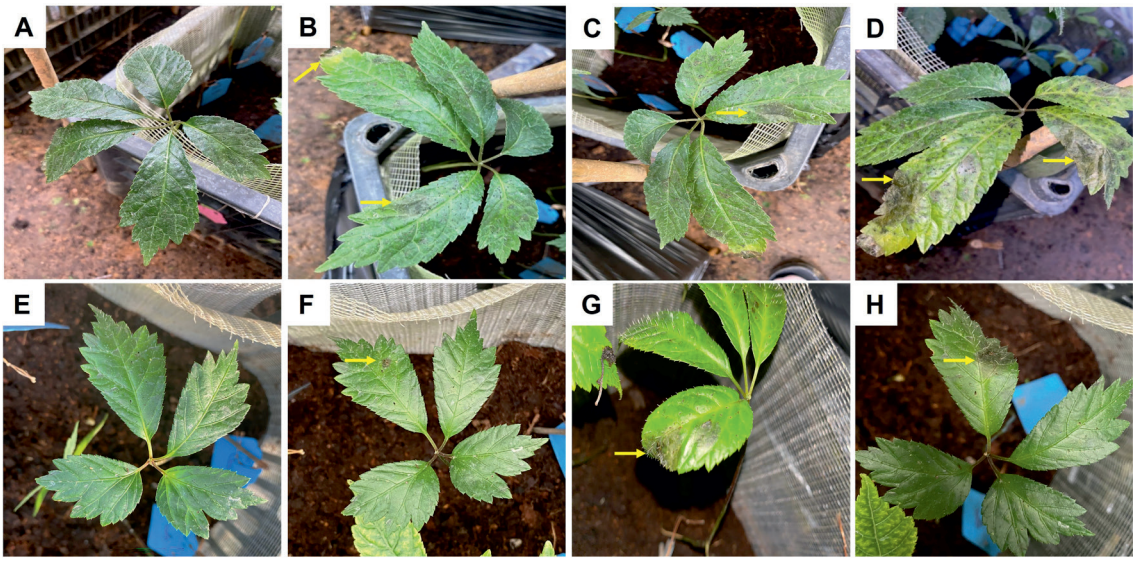

Fig. S1. Disease index shown by the fungal pathogens *Neocosmospora ipomoeae* LN5 (A–D) and *Fusarium miscanthi* KT212 (E–H) on 2-year-old ginseng plants under net house conditions. A, E – beginning of the infection; B, F – disease level 1; C, G – disease level 3; D, H – disease level 5