

## Phytopathogens and stress tolerance in Greek apple and pear selected cultivars under the frame of InnOBreed Project

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### Abstract

*Pathogenic microorganisms or the non-parasitic disorders, such as environmental and nutritional stresses, are responsible for disease expression and development in fruit trees. On the other hand, well-formed and healthy propagative material is essential for economic success in fruit growing. BioFru organic farm, located in Kastoria, NW of Greece, as part of AEGILOPS network, holds a heritage fruit nursery preserving, currently, 130 apple and 65 pear old cultivars. The scope of BioFru Organic Farm under the frame of InnOBreed project and the Greek case study, is to advance breeding activities and selection (transition from pre-breeding to breeding protocol validation). Main activities involve final selection of candidate apple and pear cultivars (screening phases of material) and development of a participative breeding program. Eleven (11) samples of twigs with leaves from three (3) pear and eight (8) apple cultivars were examined in the laboratories of Benaki Phytopathological Institute (Athens, Greece), in early autumn 2025, to detect certain important phytopathogenic fungi, bacteria, phytoplasmas, viruses and viroids. The laboratory testing indicated that four (4) apple and one (1) pear samples were free from the phytopathogenic organisms tested. These results, accompanied with useful agronomical and fruit quality traits and, also, tolerances to other biotic or abiotic stresses detected, will be used for the final selection of the most promising cultivars.*

**Keywords:** pathogenes, stress, tolerance

### Introduction

Apple scab fungus is one of the most important diseases for pome fruits in Greece while codling moth and pear psyllid, are the most serious pest problems that require many applications per year (H.C.P.A., 2022). For both conventional and organic pome crops well-formed and healthy propagative material is essential for economic success in fruit growing. Local fruit varieties may be resistant to biotic and abiotic stresses and adapt to the conditions of each location (Drogoudi, 2022). BioFru organic farm (Kastoria, Greece) holds AEGILOPS's heritage fruit nursery preserving, currently, 130 old apple and 65 pear cultivars collected mainly from the region of Western Macedonia (Northern Greece), as well as the region of Epirus (Western Greece). The scope of BioFru Organic Farm is to advance breeding activities and selection (transition from pre-breeding to breeding protocol validation). Main activities involve final selection of candidate apple and pear cultivars (screening phases of material) and development of a participative breeding program. For the purpose of identifying healthy mother trees for further propagation and useful traits for organic farming adaptation, description study was carried out in 2004 and 2025 and also samples of selected apple and pear material at pre-breeding stage were examined for phytopathogenic agents in 2025.

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## Material and Methods

In **Table 1** are presented all apple and pear accessions used for testing:

Table 1: Apple and pear accessions tested

Accession	AEG_BIO_A0035	AEG_BIO_A0089	AEG_BIO_A0002	AEG_BIO_A0061	AEG_BIO_A0007	AEG_BIO_A0029	AEG_BIO_A0021	AEG_BIO_A0008	AEG_BIO_P0044	AEG_BIO_P0016	AEG_BIO_P0034
Pome species	Apple								Pear		

For Laboratory Phytopathological Analysis the following testing methods were used:

1. Mycological examination: (a) Macroscopic, stereoscopic-microscopic examination, isolation-cultivation on nutrient growth medium (PDA) and microscopic examination of the developed fungal colonies for *Verticillium dahliae* and *V. albo-atrum*, *Neofabraea alba* and *N. malicortis*, *Glomerella cingulata* and *Neonectria ditissima*.
2. Bacteriological examination: Phytoplasmas: real-time PCR [EPPO PM7/133 (1)] (a) *Erwinia amylovora*: immunofluorescence [EPPO PM 7/97 (1)] and real-time PCR [EPPO PM 7/20 (3)] (b) *Pseudomonas syringae* *pv.* *syringae*: immunofluorescence [EPPO PM 7/97 (1)]
3. Virus testing: RT-qPCR and RT-PCR molecular tests for the detection of ACLSV, ASSVd, ARWV1, ARWV2, ASPV, ASGV,

For biotic and abiotic stress factor assessment on the field a macroscopic (visual) assessment using ECPGR- EUROFRIN Descriptors for *Malus* and *Pyrus* developed under InnOBreed project based on ECPGR Characterization and Evaluation Descriptors for Apple and Pear Genetic Resources (Lateur *et al.*, 2022) was implemented. The assessment of at least 5 trees per accession was implemented in two continuous growing periods (2024 - 2025).

## Results

From the results of Laboratory testing presented in **Table 2** it is indicated that four (4) apple (A0061, A0029, A0021, A0008) and one (1) pear (P0016) samples were free from all the phytopathogenic organisms tested (pathogens Not Detected, ND). Also, all samples were free from mycological and bacteriological diseases tested. As regards viruses all samples were free from ASSVd, ARWV1, ARWV2, ASGV, ApMV, ADFVd viruses, apple samples A0035, A0089, A0002 and A0007 were detected with virus ACLSV, apple samples A0035, A0089, A0002 A0007 and pear samples P0044, P0045 were detected with virus ASPV and, finally, pear samples P0044, P0045 were detected with virus PBCVd.

Table 2: Pathogenic laboratory analysis results (ND = Not Detected, DT = Detected)

Accession sample	AEG_BIO_A0035	AEG_BIO_A0089	AEG_BIO_A0002	AEG_BIO_A0061	AEG_BIO_A0007	AEG_BIO_A0029	AEG_BIO_A0021	AEG_BIO_A0008	AEG_BIO_P0044	AEG_BIO_P0016	AEG_BIO_P0034
Pathogen											
<i>Verticillium dahliae</i> , <i>V. albo-atrum</i> , <i>Neofabraea alba</i> , <i>N. Malicortis</i> , <i>Glomerella cingulata</i> , <i>Neonectria ditissima</i> , <i>Erwinia amylovora</i> , <i>Pseudomonas syringae</i> pv. <i>syringae</i>	ND										
ACLSV	DT	DT	DT	ND	DT	ND	ND	ND	ND	ND	ND
ASSVd, ARWV1, ARWV2, ASGV, ApMV, ADFVd	ND										
ASPV	DT	DT	DT	ND	DT	ND	ND	ND	DT	ND	DT
PBCVd	ND	DT	ND	DT							

Apple accession A0021 is among most tolerant for flower frost and A0035 for drought. Pear P0016 found to be tolerant to frost and all pear accessions tolerant to drought. For sunburn susceptibility all apple and pear accessions were tolerant. As regards to global tree & foliage health Apple A0007 and Pear P0016 were the most healthy accessions. All apple accessions found to have medium to good tolerance to apple scab, good tolerance to Powdery mildew (*Podosphaera leucotricha*), European canker (*Neonectria ditissima*), Anthracnose (*Elsinoe piri*), Apple blotch (*Diplocarpon coronariae*), Brown rot (*Monilinia fructigena*) on fruits diseases and Codling moth (*Cydia pomonella*) and medium to good tolerance to Rosy Apple aphid (*Dysaphis plantaginea*). Finally, all pear accessions were tolerant to Pear scab (*Venturia pirina*), Brown spot (*Stemphyllium vesicarium*), Fire blight (*Erwinia amylovora*), Pear rust (*Gymnosporangium sabinae*), Brown rot (*Monilinia fructigena*) and Pseudomonas, post harvest diseases & disorders, pear aphids (*Dysaphis pyri*), Psylla (*Cacopsylla pyri*), pear Leaf Blister (*Eriophyes pyri*, *Phytoptus*), Sinuate pear Borer (*Agilus sinuatus*) and pear Midge (*Contarinia pyrivora*).

Table 3: Biotic and abiotic stress factor assessment on the field (heavy dark green colour stands for the most resistant or healthy accession performance per factor)

Biotic and abiotic stress factor	Accession										
	ATEG_BIO_A003	ATEG_BIO_A008	ATEG_BIO_A000	ATEG_BIO_A006	ATEG_BIO_A000	ATEG_BIO_A002	ATEG_BIO_A002	ATEG_BIO_A000	ATEG_BIO_P004	ATEG_BIO_P001	ATEG_BIO_P003
Flower frost tolerance (scale 1-9, 9=tolerant)	4	5	5	5	5	5	7	5	6	7	6
Drought susceptibility/tolerance - symptoms on leaves (scale 1-9, 9 = tolerant)	7	5	5	5	5	5	5	5	7	7	7
Sunburn susceptibility/ on Fruits (scale 1-9, 9= susceptible)	2	2	2	3	1	2	1	1	2	1	1
Global tree & foliage health (scale 1-9, 9= healthy)	3	5	5	3	7	5	5	5	5	9	5
Apple scab ( <i>Venturia inaequalis</i> ) on Leaves and Fruits (scale 1-9, 1= no symptoms)	3	6	4	6	3	4	4	4			
Powdery mildew ( <i>Podosphaera leucotricha</i> ) (scale 1-9, 1= no symptoms)	1	1	1	3	1	1	1	1			
European canker ( <i>Neonectria ditissima</i> ), Anthracnose ( <i>Elsinoe piri</i> ), Brown rot on fruits ( <i>Monilinia fructigena</i> ) (scale 1-9, 1= no symptoms)	1	1	1	1	1	1	1	1			
Apple blotch ( <i>Diplocarpon coronariae</i> ) (scale 1-9, 1= no symptoms)	1	1	1	2	1	1	1	1			
Rosy Apple aphid – ( <i>Dysaphis plantaginea</i> ) (scale 1-9, 1= no symptoms)	1	3	5	3	3	3	3	5			
Codling Moth – ( <i>Cydia pomonella</i> ) (scale 1-9, 1= no symptoms)	1	3	3	3	3	1	1	3			
Pear scab – ( <i>Venturia pirina</i> )/ Leaves and Fruits (scale 1-9, 1= no symptoms)									4	3	2
Pear scab – ( <i>Venturia pirina</i> )/ on twigs & branches (scale 1-9, 1= no symptoms)									3	3	1
Brown Spot on Pear ( <i>Stemphyllium vesicarium</i> ), Fire Blight ( <i>Erwinia amylovora</i> ), Brown rot on fruits ( <i>Monilinia fructigena</i> ), <i>Pseudomonas syringuae</i> (scale 1-9, 1= no symptoms)									1	1	1
Pear rust ( <i>Gymnosporangium sabinae</i> ) (scale 1-9, 1= no symptoms)									2	2	1
Post harvest diseases & disorders (Grey & Blue Mould Rot, Brown Rot, internal core breakdown,) (scale 1-9, 1= no symptoms)									1	1	1
Pear aphids ( <i>Dysaphis pyri</i> ) (scale 1-9, 1= no symptoms)									5	5	3
Psylla ( <i>Cacopsylla pyri</i> ), Pear Leaf Blister mite ( <i>Eriophyes pyri</i> , <i>Phytoptus</i> ), Sinuate Pear Borer ( <i>Agrilus sinuatus</i> ), Pear Midge ( <i>Contarinia pyrivora</i> ) (scale 1-9, 1= no symptoms)									1	1	1

## Discussion

The study indicated that some accessions samples preserved in heritage nursery are free from pathogenetic agents or resistant. Also, it confirms that local varieties may be resistant to biotic and abiotic stresses and adapt to the conditions of each location. The Institute of Plant Breeding & Genetic Resources - Department of Deciduous Fruit Trees in Naoussa (Greece) collects fruit plant genetic resources from all species and maintains in a network greenhouse, also pure genetic material, from few local apple and pear varieties, free from significant viruses and viroids. This material has been studied and often has important commercial characteristics or may be the necessary primary material for the creation of new varieties resistant to climate change. Drogoudi (2022) has shown that local Greek apple and pear varieties bear fruit consistently in arid and dry island areas, without cultivation, while foreign varieties often fail and are uprooted. Also, old apple varieties in Lesvos Island were found to have high productivity, long postharvest shelf life and being the most resistant to diseases, in comparison with improved apple varieties cultivated in the area (Douma *et al.*, 2016). Old cultivars and landraces were bred in times of low-input agriculture and, therefore, the relevance of many of them to organic systems might be much better than modern materials (Koutis *et al.*, 2018). Participatory plant breeding methods with organic principles could exploit this invaluable plant material, developing new cultivars, particularly for marginal environments (Newton *et al.*, 2010), enhancing in this way the sustainability of agricultural systems.

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## References

- Douma. C., Koutis, K., Thanopoulos, R., Tsigou, R., Galanidis, A., & Bebeli, P. (2016). Diversity of agricultural plants on Lesvos Island (Northeast Aegean, Greece) with emphasis on fruit trees, *Scientia Horticulturae*, Volume 210, Pages 65-84, ISSN 0304-4238, <https://doi.org/10.1016/j.scienta.2016.07.009>.
- Drogoudi.P. (2022). Fruit tree local cultivars: Phenotypic characterization of prunus, pear and almond from mainland and islands of Greece. Edition: ELGO DIMITRA-IPBGR-DDFT. Pages 128. ISBN: 978-618-80367-6-5
- Hellenic Crop Protection Association (2022). Green Deal, The impact on Greek agriculture. [https://esyf.gr/wp-content/uploads/2022/02/ESYF\\_PRASINH-SYMFONIA-ENG.pdf](https://esyf.gr/wp-content/uploads/2022/02/ESYF_PRASINH-SYMFONIA-ENG.pdf) (assessed 23.11.2025)
- Koutis, K., Warlop, F., Bollinger, N, Steinemann, B, Buruezzo, A. R., Mendes Moreira, P., Messmer, M. (2018) Perspectives on European organic apple breeding and propagation under the frame of LIVESEED Project. *Proceedings of 18th International Conference on Organic Fruit -Growing*, Hohenheim, 2018.02.19-21. Ed. FOEKO e.V. pp. 104-107.
- Lateur, M., Dapena, E., Szalatnay, D., Gantar, M. E., Guyader, A., Hjalmarsson, I., Höfer, M., Ikase, L., Kellerhals, M., Lacis, G., Militaru, M., Miranda Jiménez, C., Osterc, G. Rey, J.B. Rondia, A., Volens, K., Zeljković, M.K., Ordidge M. (2022) ECPGR Characterization and Evaluation Descriptors for Apple Genetic Resources
- Newton, A.C., Akar, T., Baresel, J.P., Bebeli, P.J., Bettencourt, E., Bladenopoulos, K.V., Czembor, J.H., Fasoula, D.A., Katsiotis, A., Koutis, K., Koutsika-Sotiriou, M., Kovacs, G., Larsson, H., Pinheiro de Carvalho, M.A.A., Rubiales, D., Russell, J., Dos Santos, T.M.M., & Vaz Patto, M.C., (2010). Cereal landraces for sustainable agriculture. A review. *Agron. Sustain. Dev.* 30, 237–269, <http://dx.doi.org/10.1051/agro/2009032>.