Urban Trees' Terpenoids: plant-host interactions in a challenging and changing environment

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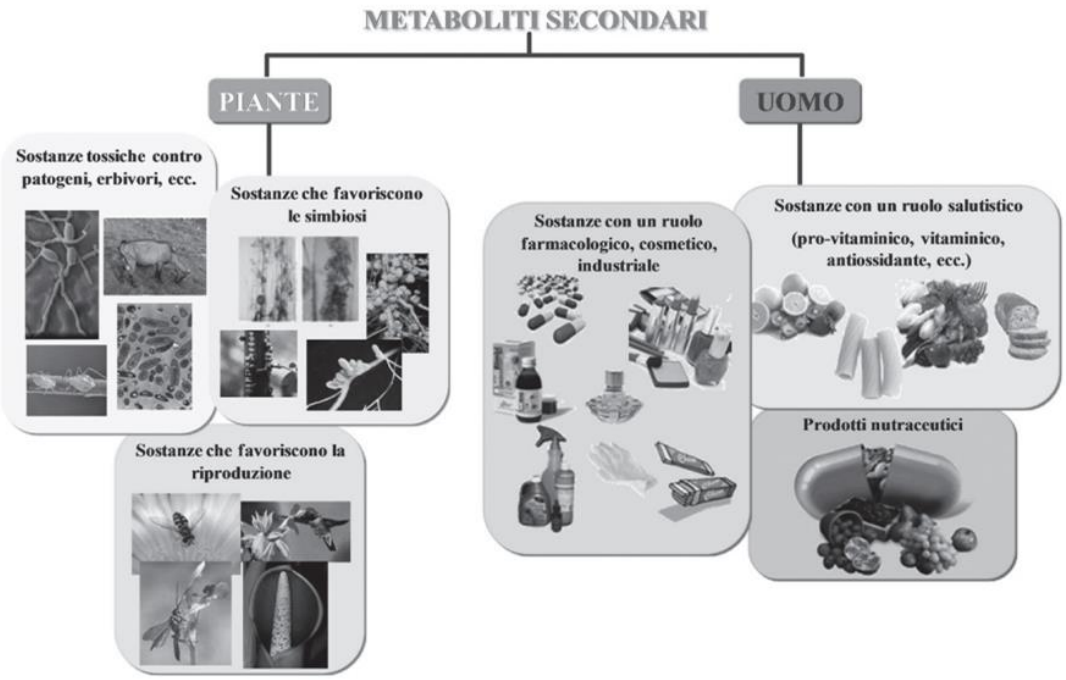
«Secondary» plant metabolites belong to three main groups:

- Phenols
- Alkaloids
- **Terpenoids**



About terpenoids…..

…..also called **isoprenoids**, because they contain repetitions of the 5-C isoprene unit.

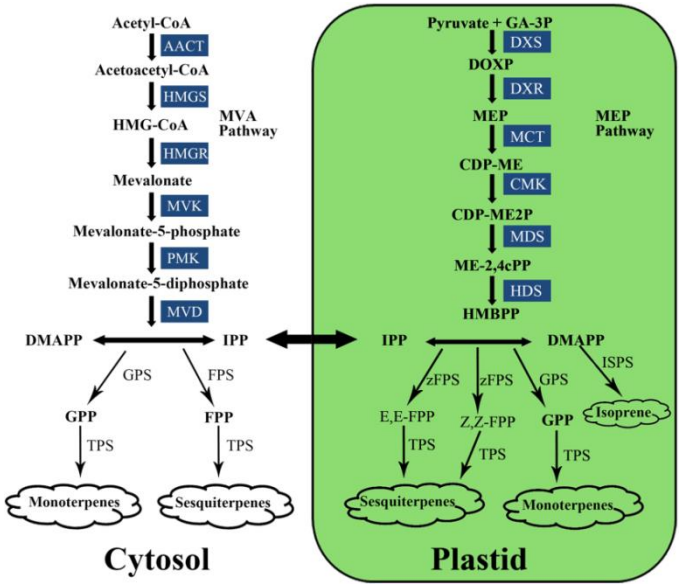
Biosynthesis

Acetyl-CoA

MAV MEP

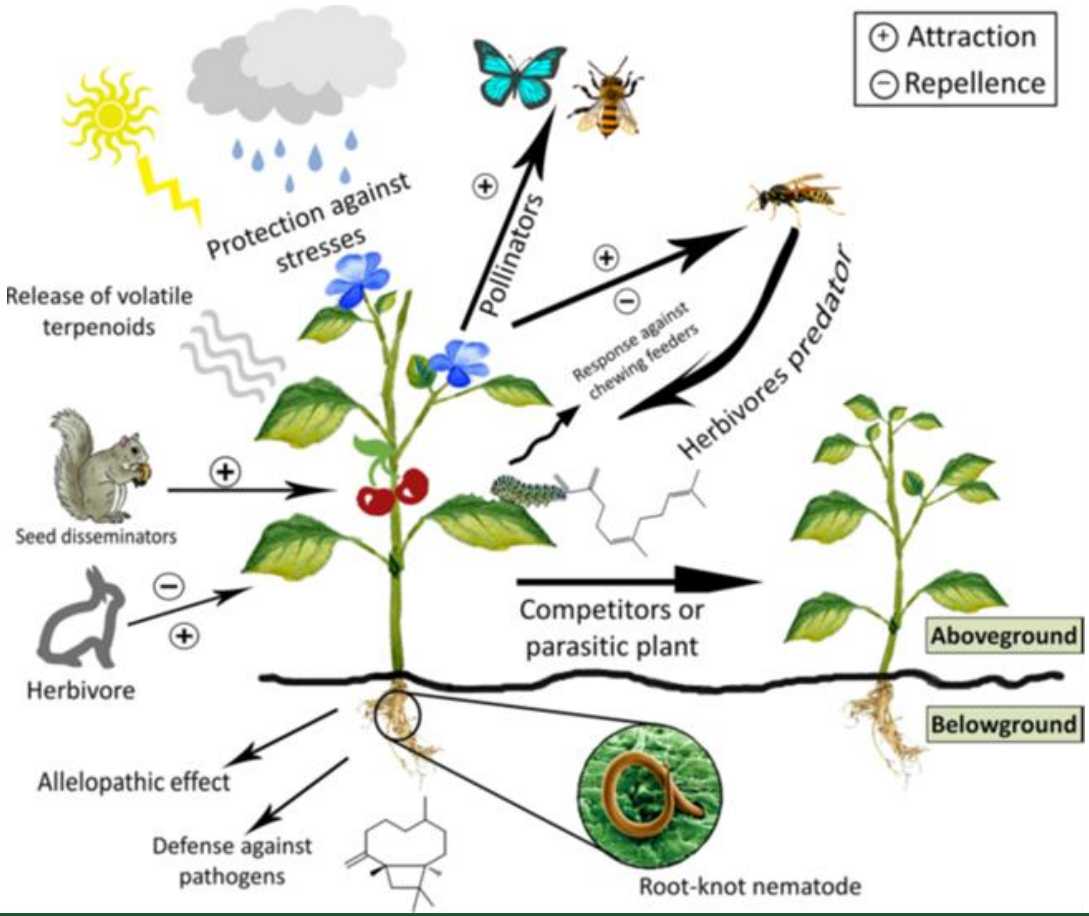
Depending on the number of C atoms, they are said:

- Monoterpenes – C_{10} **VOLATILE!**
- Sesquiterpenes – C_{15}
- Diterpenes – C_{20}
- Triterpenes – C_{30}
- Tetraterpeni – C_{40}

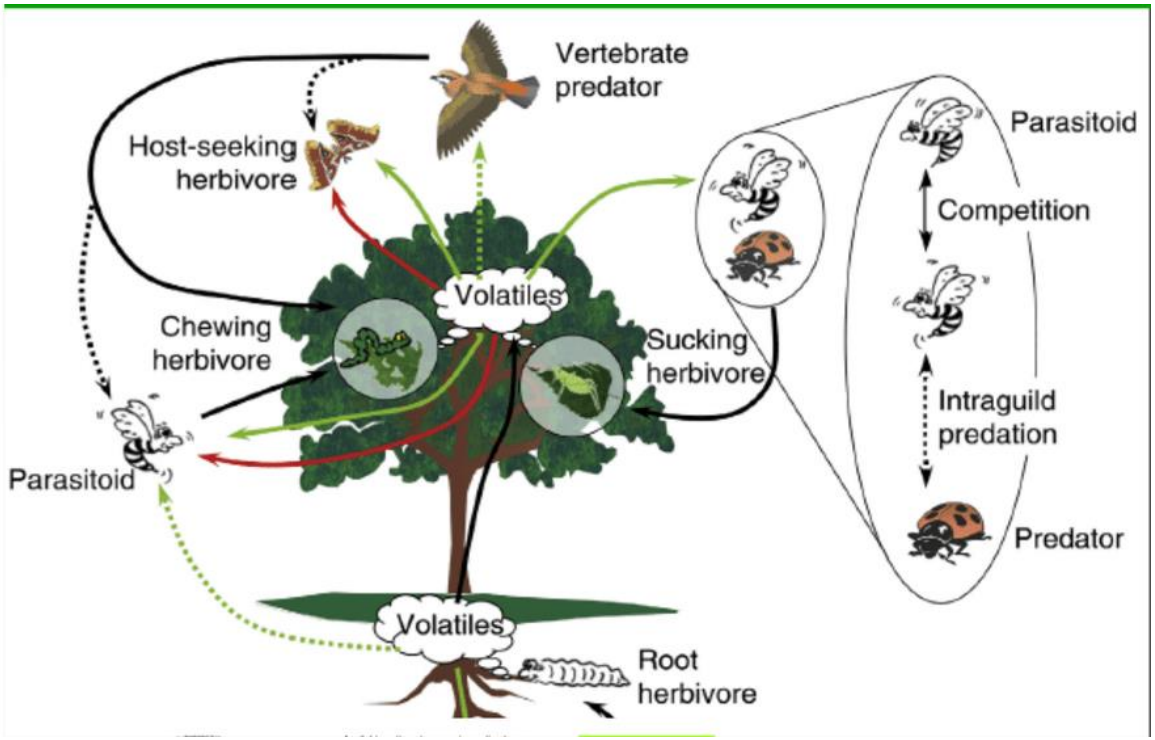


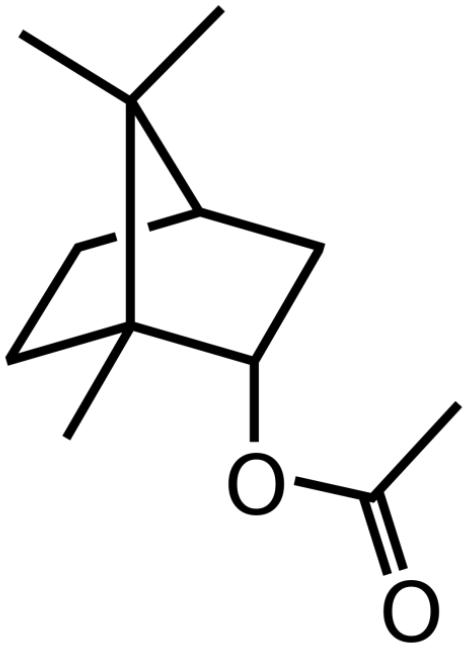
Besides being precursors of phyotohormones, photosynthetic pigments, electron carriers and membrane components, isoprenoids are also deeply involved in eco-physiological interactions:

- Plant – environment
- Plant – host
- Plant – plant

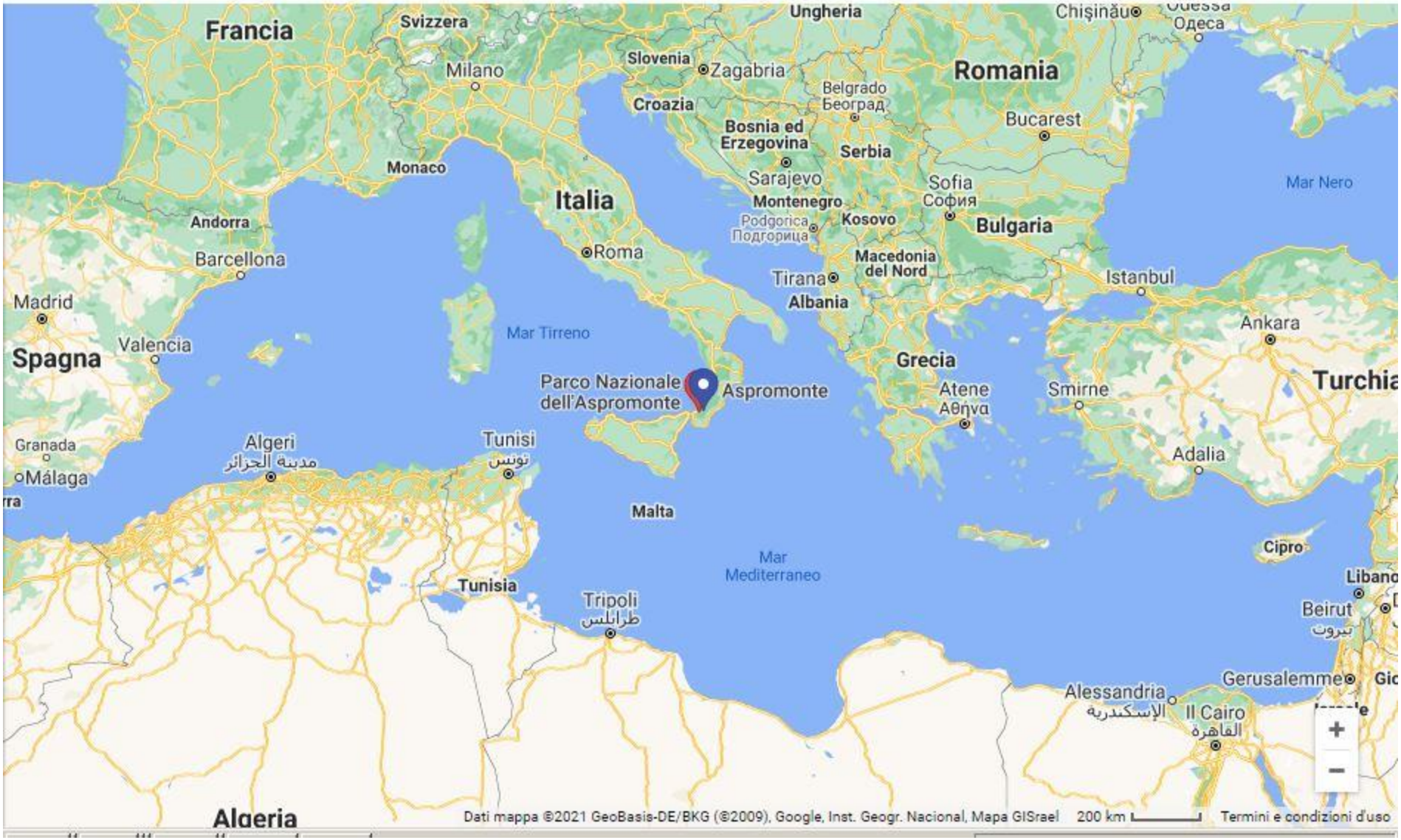


Volatile isoprenoids are thought to be involved in defence and chemical communication…..





…non-volatile isoprenoids (oleoresins) are not only bioactive molecules, but also valuable raw materials for the chemical and pharmaceutical industry, cosmetics, nutraceuticals and biofuels


Francia
Svizzera
Milano
Monaco
Andorra
Barcellona
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Málaga
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Tunisi
تونس
Tunisia
Algeria
Tripoli
طرابلس
Malta
Mar Tirreno
Mar Mediterraneo
Italia
Roma
Parco Nazionale dell'Aspromonte
Aspromonte
Slovenia
Zagabria
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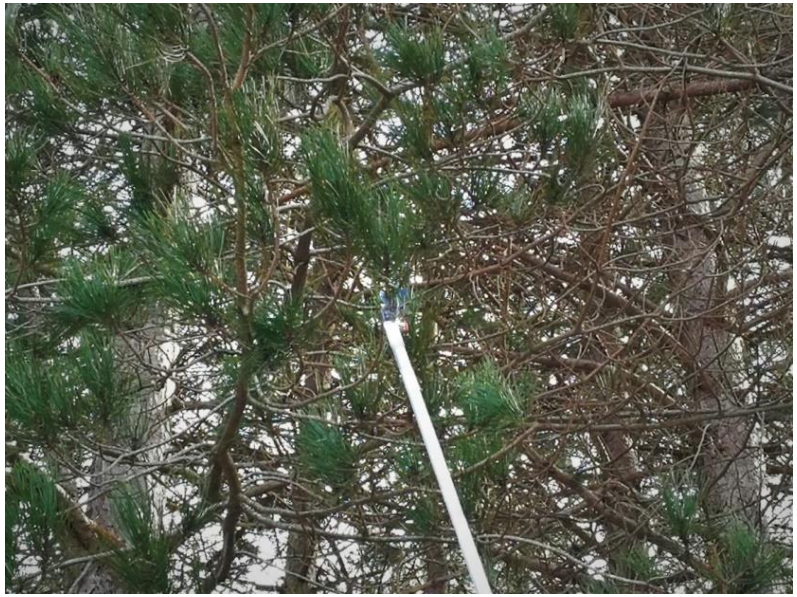
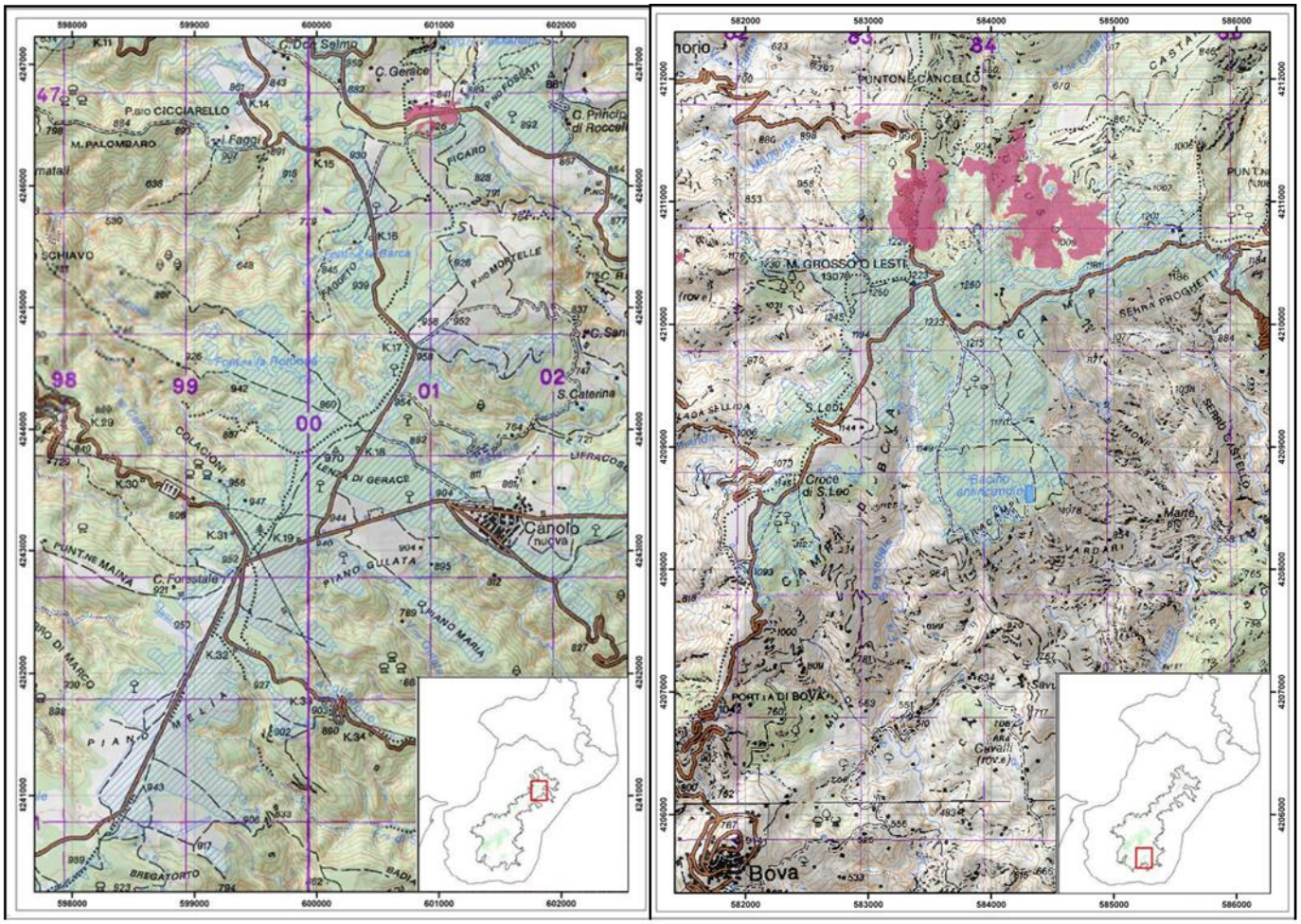
200 km
Termini e condizioni d'uso

Emission profiles of volatile terpenoids have been studied in two populations of Calabrian pine infested by the pine processionary moth (PPM)

Canolo Nuova

Bova Superiore





Plant plots were within the premises of the Aspromonte National Park, in the southmost part of continental Italy

- 1st sampling in February

- 2nd and 3rd samplings in March

- 4th and 5th samplings in April

- 6th sampling in August

Collection of pine needles was matched with the biological cycle of the PPM

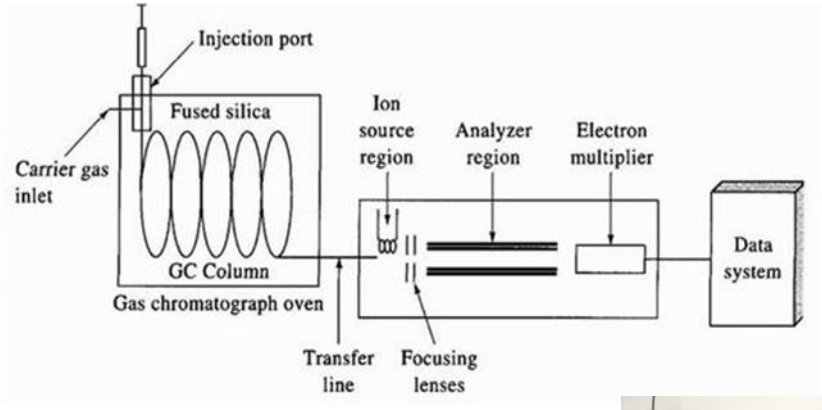
GC-MS analysis - 1

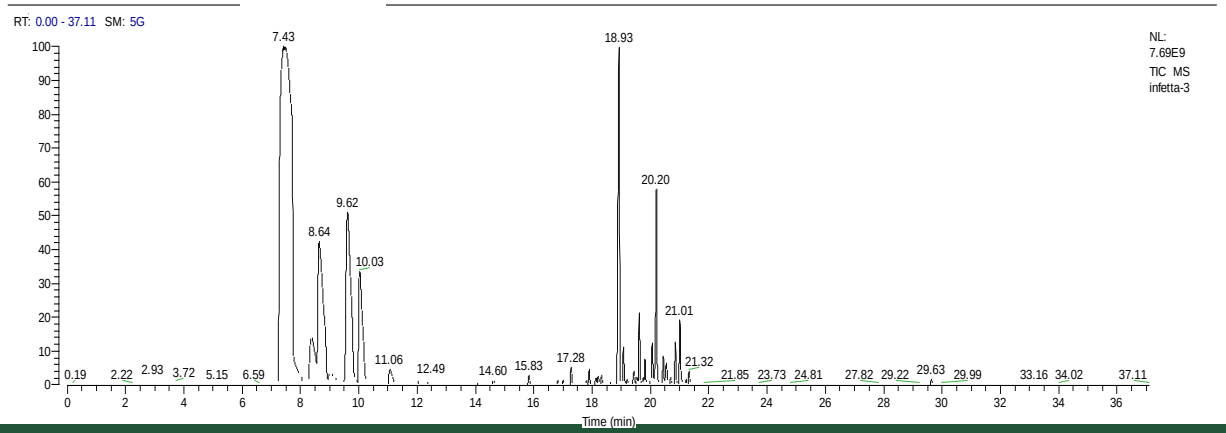
- **Sample preparation (head space):**

- Equilibration

- Adsorption on SPME fiber

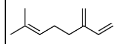
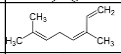
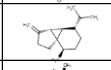
- **GC-MS analysis - 2**





Twenty-one volatile terpenoids were identified in the head space of Calabrian pine needles

Of these, bornyl acetate [(4,7,7-trimethyl-3-bicyclo[2.2.1]heptanyl) acetate] was the most frequently and selectively associated with the PPM infestation

Common name	IUPAC name	Type of terpen	RT	KI	Structural formula
Pinene alpha*	(1*S*,5*S*)-2,6,6-Trimethylbicyclo[3.1.1]hept-2-ene ((−)-α-Pinene)	monoterpenoid	7,38	939	
Pinene beta*	6,6-Dimethyl-2-methylidenebicyclo[3.1.1]heptane	monoterpenoid	8,35	982	
Myrcene beta	7-Methyl-3-methylene-1,6-octadiene	monoterpenoid	8,75	1000	
Phellandrene alpha	2-Methyl-5-(1-methylethyl)-1,3-cyclohexadiene	monoterpenoid	9,61	1035	
Limonene*	1-Methyl-4-(prop-1-en-2-yl)cyclohex-1-ene	monoterpenoid	9,8	1043	
Ocimene beta*	(*Z*)-3,7-Dimethyl-1,3,6-octatriene	monoterpenoid	10,06	1053	
Terpinolene*	4-Methyl-1-(1-methylethyl)-1,3-cyclohexadiene	monoterpenoid	11,09	1095	
Thymol methyl ether	2-methoxy-4-methyl-1-propan-2-ylbenzene	monoterpenoid	11,98	1131	
Camphor*	1,7,7-Trimethylbicyclo[2.2.1]heptan-2-one	monoterpenoid	12,48	1152	
Bornyl acetate	4,7,7-Trimethyl-3-bicyclo[2.2.1]heptanyl) acetate	monoterpenoid	15,82	1292	
Gurjunene gamma	(1R,3aR,4R,7R)-1,4-dimethyl-7-prop-1-en-2-yl-1,2,3,3a,4,5,6,7-octahydroazulene	Sesquiterpenes	16,4	1318	
Elemene delta	(3 *R* , 4 *R*) -1-Isopropil-4-metil-3- (prop-1-en- 2-il) -4-vinylcyclohex-1-ene	Sesquiterpenes	16,99	1344	
Cubebene alpha*	(1R,5S,6R,7S,10R)-10-methyl-4-methylidene-7-(propan-2-yl)tricyclo[4.4.0.0^{1,5}]decane	Sesquiterpenes	17,27	1357	
Copaene alpha*	(1S,6S,7S,8S)-1,3-dimethyl-8-(propan-2-yl)tricyclo[4.4.0.0^{2,7}]dec-3-ene	Sesquiterpenes	17,89	1384	
Bourbonene beta	1-methyl-5-methylidene-8-(propan-2-yl)tricyclo[5.3.0.0^{2,6}]decane	Sesquiterpenes	18,82	1427	
Caryophyllene*	(1*R*,4*E*,9*S*)-4,11,11-Trimethyl-8-methylidenebicyclo[7.2.0]undec-4-ene	Sesquiterpenes	18,88	1430	
Bisabolene alpha	(*E*)-1-Methyl-4-(6-methylhepta-2,5-dien-2-yl)cyclohex-1-ene	Sesquiterpenes	19,63	1466	
Humulene*	2,6,6,9-Tetramethyl-1,4-8-cycloundecatriene	Sesquiterpenes	19,93	1480	
Murolene gamma*	(1S,4aS,8aR)-7-methyl-4-methylidene-1-propan-2-yl-2,3,4a,5,6,8a-hexahydro-1H-naphthal	Sesquiterpenes	20,4	1492	
Germacrene D*	(1*E*,5*E*,8*S*)-1,5-dimethyl-8-(prop-1-en-2-yl)cyclodeca-1,5-diene	Sesquiterpenes	20,18	1502	
Candinene gamma*	(1S,4aR,8aR)-7-methyl-4-methylidene-1-propan-2-yl-2,3,4a,5,6,8a-hexahydro-1H-naphtha	Sesquiterpenes	20,89	1526	

Genes from Calabrian pine encoding for the major biosynthetic enzymes, namely terpene synthases, are being isolated and characterised, and their expression in response to PPM infestation is being quantified

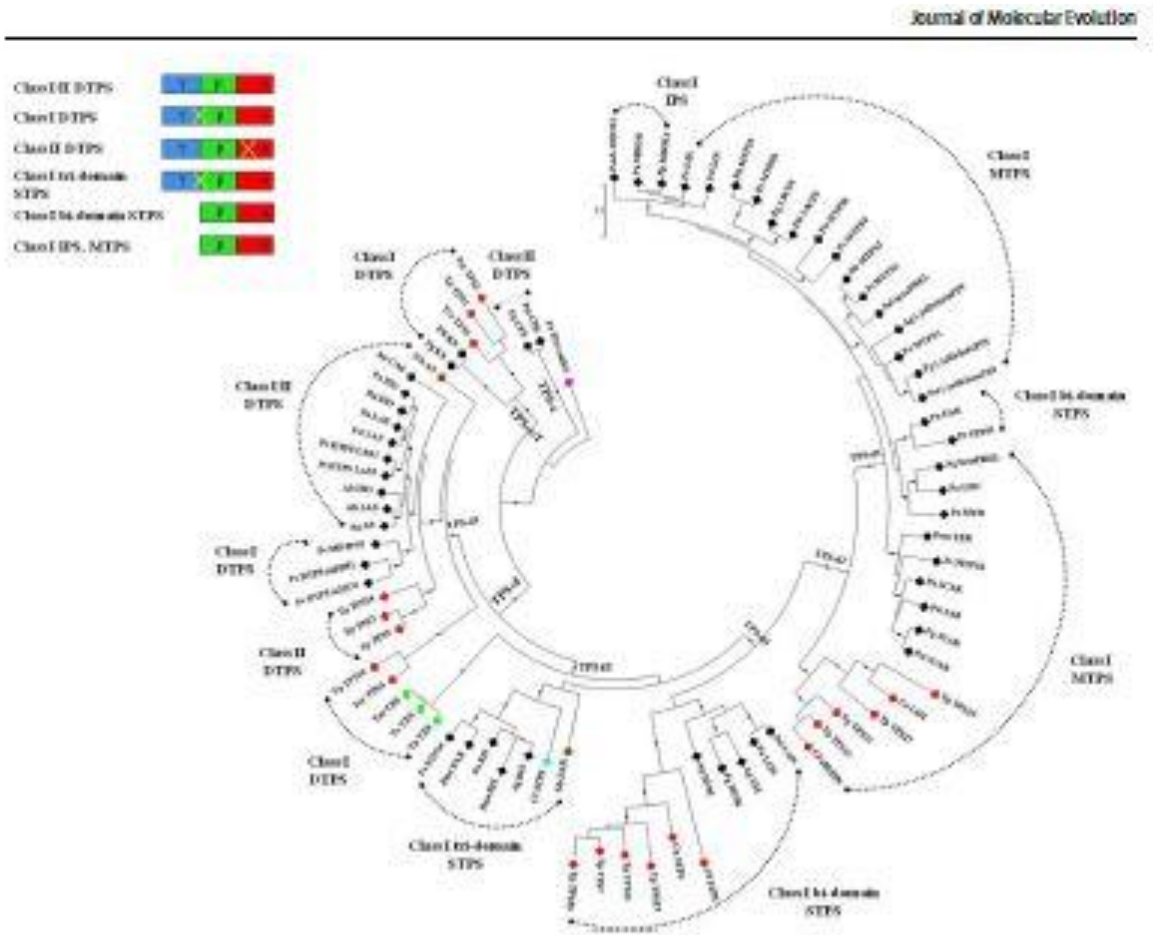


Fig. 5 Phylogenetic tree of terpene synthases (TPSs) in gymnosperms: Cupressaceae (red diamonds), Pinaceae (black), Taxaceae (green), Ginkgoaceae (brown) and Cycadaceae (heavenly). The *Physcomitrella patens ent*-kaurene synthase (PpTPS-entK.S; violet diamond) was used to root the tree. Branches indicated with dots represent bootstrap support more than 80% (100 repetitions). Modifications in the typical γ/β-domain architecture of TPS and the presence of functional active sites (a yellow cross indicate loss of function) are illustrated corresponding to the different subfamilies of the TPS plant family and to the different groups within the TPS-d3 subfamily. For acronyms denoting plants species, see Table S1. *DTPSs* diterpene synthases, *MTPSs* monoterpene synthases, *STPSs* sesquiterpene synthases

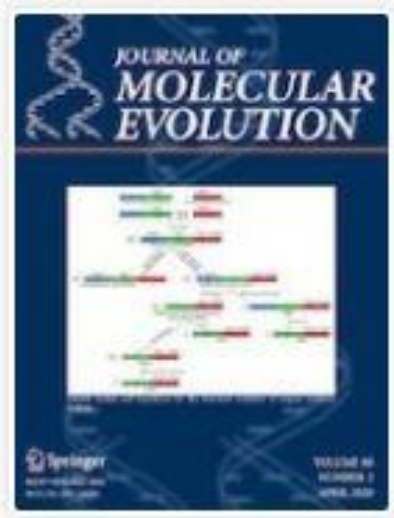
Journal of Molecular Evolution
https://doi.org/10.1007/s00239-020-09930-8

REVIEW

Check for updates

On the Evolution and Functional Diversity of Terpene Synthases in the *Pinus* Species: A Review

Enrica Alicandri[1] · Anna Rita Paolacci[2] · Samson Osadolor[2] · Agostino Sorgonà[1] · Maurizio Badiani[1] · Mario Ciaffi[2]



plants

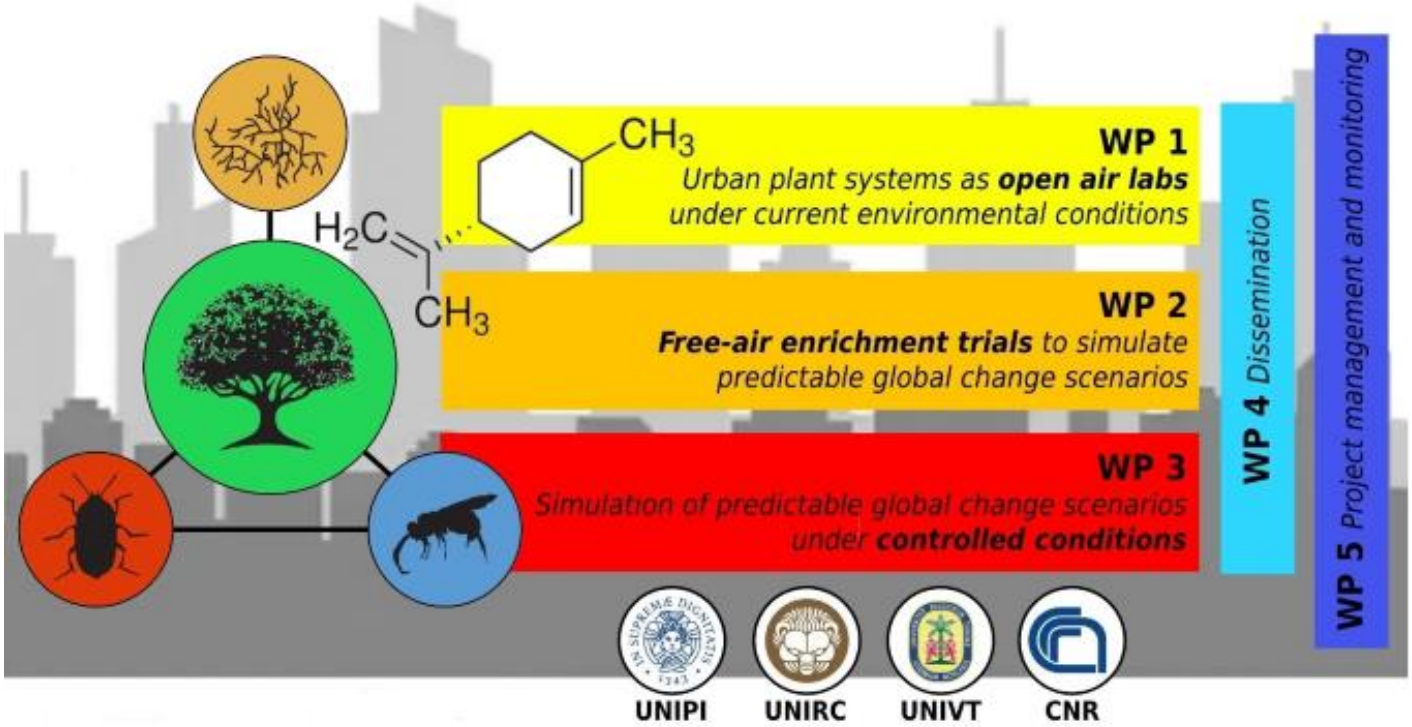
MDPI

Article

Profiling Volatile Terpenoids from Calabrian Pine Stands Infested by the Pine Processionary Moth

Vincenza Foti [1,†], Fabrizio Araniti [1,†], Francesco Manti [2], Enrica Alicandri [1], Angelo Maria Giuffrè [1], Carmelo Peter Bonsignore [2], Elvira Castiglione [2], Agostino Sorgonà [1], Stefano Covino [3], Anna Rita Paolacci [3], Mario Ciaffi [3] and Maurizio Badiani [1,*]

Terpenoids for biocontrol in UPF: prospective projects - 1



Graphical concept of **UTreeTer** showing the overall objective (i.e. the role of terpenoids in the interactions among major tree species of Italian cities, their arthropod pests and pathogens, and natural enemies of these organisms), the organization in workpackages (WPs), and the involved research units.

The UTreeTer project: terpenoids in a north-south transect of Italian UPF species and their hosts, in a changing climate

[tree/pathogen/pest/pest's natural enemies]:

(i) Pinus spp. (pine)/Sphaeropsis sapinea/Thaumetopoea pityocampa/Phrixe caudata, Villa brunnea, Calosoma sycophanta;

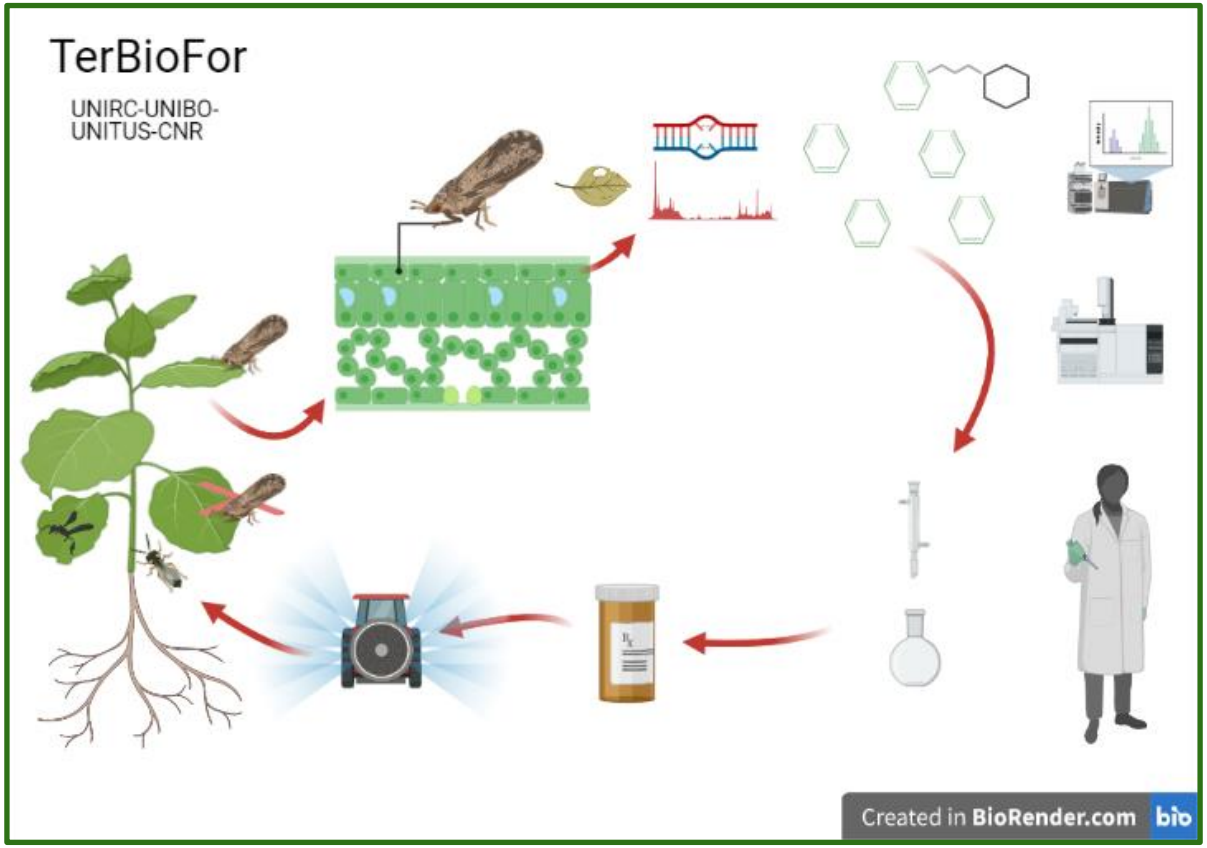
(ii) Quercus ilex (holm oak)/Phyllosticta spp., Microsphaera spp./Lymantria dispar dispar, Thaumetopoea processionea, Corythucha arcuata, Coroebus spp./P. caudata, V. brunnea, Oencyrtus pytiocampae;

(iii) Platanus × acerifolia (plane tree)/Apiognomonia platani/Corythucha ciliata/Anthocoris spp., Orius laticollis.

(iv) Special attention will be also given to Aesculus hippocastanum (horse chestnut) nand Populus spp (poplar).

Terpenoids for biocontrol in UPF: prospective projects - 2

TerBioFor - Constitutive and host-inducible terpenoids as prospective biocontrol agents in UPF



Thank you very much for your consideration!