Networking / Dissemination Activity

Scientific Report Form

EuroVOL Summer school

Plant Volatiles: from lab bench to application

September, 9-12, 2013

Eurotel Victoria - Les Diablerets-Switzerland.

a) Summary

It should provide a general picture of the meeting and describe the practical organisation / general arrangements. It should also summarise the scientific objectives and agenda of the meeting and the overall conclusion(s).

Within the context of the the EuroVOL project we wanted to have an event that allows PhD students to meet experts in the field of plant volatile research. This summer school fulfilled this objective and was the ideal occasion for the PhD students and few Post-Docs of the three CRP to meet with and learn from world-renowned experts. It allowed them to expand their network and receive feedback on their respective research projects. The timing of the meeting left ample room to adapt their respective research projects and incorporate new ideas and new strategies.

The choice for an external location, away from the usual working environment was also a strategy to encourage social interactions between participants and to encourage collaborations and to allow the PhD students and Post-Docs to profile themselves, and to work on their networking, which will be of great use for their career development. Eurotel Victoria, in Les Diablerets is a well-known place for conferences as it had hosted many Gordon conferences. The facilities are well adapted for organising such events as we had ample place to create separate working groups. Moreover, the pleasant atmosphere at the Hotel ensured that everybody stayed highly motivated. This was further reinforced by an outdoor excursion to explore the mountain plants and the ecological particularities of the region. This part of the summer school also created a great opportunity for informal interactions with the senior scientists.

The summer school was entitled “Plant Volatiles: from lab bench to application”, the idea behind this title was to encourage the participants to think about the application of the Eurovol projects. The first day was dedicated to more general and fundamental aspects of plant volatiles and the mechanisms that lead to their emissions, and then the focus shifted to the methods of analysis of volatile compounds. The two following days were dedicated to the ecological importance and roles of plant volatiles and their possible applications in, for example, agriculture. Evenings were dedicated to poster sessions, and an odour quiz was organised to create discussion about plant odours. An additional free evening was used for further fruitful discussions among the participants.

The organizers were fully satisfied with the outcome of the summer school. We consider it vital for future scientists to understand the significance of their research and its possible application and the school clearly contributed to this objective. EuroVOL projects study the production, effects and roles of plant volatiles at different levels, from molecular to ecological impact. The summer school was the perfect occasion to bring together the different research domains of the CRP. The *Les Diablerets meeting* was highly inspiring for the attending PhD students and Post-Doc and they left the event highly motivated and full of new ideas for their projects, and ready to further contribute the success of the Eurovol consortium.

b) Final programme of the event

Monday 9	**Session 1: Mechanisms of Plant Volatile production**
13h00-13h45	Registration
13h45-14h00	Summer school Opening
14h00-15h00	Natalia Dudareva: The biosynthesis of plant volatiles
15h00-15h30	coffee break
15h30-16h30	Edward Farmer: External and internal signals leading to plant volatile emissions
16h30-18h30	Welcome reception / Poster session
18h30-20h00	dinner
20h00-22h00	Poster session

Tuesday 10	**Session 2: How to capture and detect plant volatiles.**
9h00-10h00	Francesco Loreto: Plant volatiles in the atmosphere.
10h00-10h30	Coffee break
10h30-11h30	Armin Hansel: Real-time detection.
11h30-12h30	Discussion
12h30-18h00	Lunch and excursion
18h30-20h00	Dinner
20h15-21h15	Odor quiz

Wednesday 11	**Session 3: Ecological implications of plant volatiles**
9h00-10h00	Marcel Dicke: Multitrophic interactions
10h00-10h30	Coffee break
10h30-12h30	Group work
12h30-14h00	Lunch
14h00-15h00	Florian Schiestl: Pollination
15h00-16h00	Group work

16h00-16h30 Coffee break

16h30-18h30 Group work / presentation

18h30-20h00 Dinner

Thursday 12 **Session 4: Application of plant volatiles in agriculture.**

9h30-10h30 Mike Birkett: attracting beneficial insects, while repelling pests.

10h30-11h00 Coffee Break

11h00-12h00 Ted Turlings: protecting roots by exploiting plant volatiles.

12h00-12h30 Closing remarks - Departure

c) Description of the scientific content of the event (abstracts can be provided)

It should provide a detailed picture of what went on during the meeting: brief summaries of presentations, synopsis of subsequent discussions (agreements/disagreements/highlights).

The summer school was organized in different sessions ranging from more general aspects of plant volatiles to the use of plant volatiles in agricultural systems.

Natalia Doudareva (Purdue University, USA) The Biosynthesis of Plant Volatiles

Plant secondary metabolites play essential roles in the survival of plants in their ecosystems by mediating their interactions with surrounding environment including plant-insect, plant-microorganism, and plant-plant interactions. In the presentation, Prof Doudareva gave an overview of secondary natural products. She presented the terpenes through their general pathways of biosynthesis, the mevalonate and non-mevalonate pathways, their function and structure. The presentation was very well illustratred by examples of plants producing these specific compounds. Then she gave an overview of phenylpropanoid/benzenoid compounds and their biosynthesis and function.

Ted Farmer (University of Lausanne, Switzerland) External and internal plant signals leading to plant volatile emissions

Physical damage to plant tissues caused by herbivores activates the expression of defence genes and accelerates the release of volatiles that can attract predatory organisms. Several signal pathways are involved in this process, but a predominant role is played by the jasmonate pathway. Interestingly, this signal pathway is active both near and distal to wounds and this has been investigated in Arabidopsis. We see this signalpathway as playing roles in both the unwounded plant and the plant that is under attack. Firstly, in undamaged plants the enzyme LIPOXYGENASE 2 (LOX2) appears to pre-load thylakoid membranes with oxygen so that green leaf volatiles can be released from these membranes when a plant is wounded. Then, once damage occurs, LOX2 also generates high concentrations of defence metabolites called arabidopsides which accumulate within damaged tissues and along the borders of wounds. At long distances from wounds, for example in distal leaves, another lipoxygenase (LOX6) initiates jasmonate signalling leading to defence. A question is how is LOX6 activated in

tissues far from wounds? We recently found that electrical signals operating through two closely related GLUTAMATE RECEPTOR-LIKE proteins travel though tissues in the speed range of 3 to 8 cm per min to somehow activate LOX6. A current question is whether these long distance signals also play roles in the systemic release of volatiles.

Francesco Loreto (Consiglio Nazionale delle Ricerche (CNR)Istituto per la Protezione delle Piante (IPP)Area della Ricerca del CNR di FirenzeSesto Fiorentino, Italy) Plant volatiles in the atmosphere

Abstract not sent

The presentation was about the interaction between biosphere and atmosphere with emphasis on biosynthesis and emissions of biogenic volatile organic compounds, and on primary and secondary metabolism of plants under environmental constraints.

Armin Hansel (University of Innsbruck, Austria) Real-time detection

Abstract not sent

The presentation focused on PTR-MS (proton-transfer-reaction mass spectrometry). This is an innovative technique that enables fast detection of volatile organic compounds (VOCs) in the pptv-range. This technic may be used by research projects in the EuroVOL consortium.

Marcel Dicke (Laboratory of Entomology, Wageningen, The Netherlands) Herbivore-induced plant volatiles: from individual interaction to community

Herbivore attack elicits changes in the bouquet of volatiles released from plants. These herbivore-induced plant volatiles (HIPVs) can attract carnivorous natural enemies of the herbivores, such as parasitoids and predators, a phenomenon that is called indirect plant defense. The volatile blends of infested plants can be very complex, sometimes consisting of hundreds of compounds. Most of the HIPVs can be classified as terpenoids (e.g., (*E*)-β-ocimene, (*E*,*E*)-β-farnesene, (*E*)-4,8-dimethyl-1,3,7-nonatriene), green leaf volatiles (e.g., hexanal, (*Z*)-3-hexen-1-ol, (*Z*)-3-hexenyl acetate), phenylpropanoids (e.g., methyl salicylate, indole), and sulphur- or nitrogen-containing compounds such as nitriles or isothiocyanates. One highly intriguing question has been which volatiles out of the complex blend are the most important ones for the carnivorous natural enemies to locate suitable host plants. Various methods and techniques have been used to elucidate the carnivore-attracting compounds. Electrophysiological methods such as electroantennography (EAG) have been used with parasitoids to elucidate which compounds can be perceived by the antennae. Different types of elicitors and inhibitors have widely been applied to manipulate plant volatile blends. Furthermore, transgenic plants that were genetically modified in specific steps in one of the signal transduction pathways or biosynthetic routes have been used to find steps in HIPV emission crucial for indirect plant defense.

Apart from carnivores, also herbivores, pathogens, pollinators, and competitors respond to HIPV and adjacent plants in native populations emit volatiles as well. These considerations enrich the evolutionary context of HIPV and complicate predictions about the adaptive value of HIPVs. Molecular advances in our understanding of HIPV signaling and biosynthesis is allowing for the creation of HIPV-'mute' and possibly HIPV-'deaf' plants Such plants provide the promise of unbiased examinations of the fitness value of HIPV emissions under natural conditions.

Ted Turlings (University of Neuchâtel, Switzerland)-Protecting roots by exploiting plant volatiles

Larvae of the beetle *Diabrotoca virgifera virgifera* (Western corn rootworm) cause tremendous damages to maize roots in the USA. Since its incidental introduction into the Balkan region in the 1990s it has rapidly spread and become a serious problem in Europe as well. We think we have revealed the primary reason why the insect is so successful on maize. In feeding assays the larvae preferred to feed on highly nutritious crown roots of maize plants. These valuable roots were found to be well-defended with toxic benzoxazinoids that normally deter herbivores from feeding on these roots. The rootworm larvae, however, are completely unaffected by the toxins and use them to identify crown roots, which are rich in sugars and amino acids. How then can we fight this pest? One solution may be entomopathogenic nematodes, tiny parasitic worms that kill the larvae within days. We discovered that the nematodes are attracted to sesquiterpene *E*-(β)-caryophyllene a chemical signal that is specifically emitted from maize roots after rootworm attack. Using genetic transformation we restored caryophyllene emission in an American maize line that had lost the signal, resulting in enhanced protection by nematodes against rootworm damage. Yet, caryophyllene-producing roots were also found to attract the rootworm larvae themselves. Using our knowledge of the system, we are currently developing capsules of biodegradable polymers that can be planted in pest-infested fields. The capsules shells will contain attractants and feeding stimulants that will attract the pest larvae and induce them to feed on the deadly capsules.

Mike Birkett (Rothamsted Research,UK)-Protecting roots by exploiting plant volatiles

Abstract not sent.

The presentation was about the effect of plant volatiles in agricultures. Different example of successful applications of plant volatile researches were shown. The talk gave a very good overview of the importance of plant volatiles implication to manage agricultural problems.

d) Assessment of the results and impact of the event on the EUROCORES programme.

It should describe what was gained from the meeting. Concrete or follow-up actions to be taken as a result (i.e. dissemination plan) should appear in this section.

The meeting allowed PhD students to interact together, as well as with senior scientists. The group work enhanced the discussions and allowed to reveal the aspects that were not fully understood by the participants. It was also the occasion for debates on subjects like the genetic transformation of plants. A concrete action taken after this meeting was to request for a prolongation of the program in order to allow PhD students to finish with their project in the context of the EuroVOL program. More over different meetings were announced to inform participants on opportunities to present their results to an international audience (Gordon conference on Plant Volatiles, Jan. 26-31, 2014,Ventura, USA; SIP 15, Aug. 17-22, 2014, Neuchatel, Switzerland).

As some participants were not part of the EuroVOL project, the summer school was also a great chance for these PhD students to know more about our EuroVOL project and on the other hand for CRP to discover new promising scientists in the field of Plant Volatiles.

Future publications were discussed on an informal way during the summer school as it facilitated the direct discussion and comments on the papers to be submitted.

The participation of Prof Doudareva (a review panel member) was also particularly useful as she could estimate the potential of results from PhD research projects on the EuroVOL program.

e) List of speakers and participants

Name and affiliation are sufficient. The detailed list will be uploaded online directly.

Invited speakers and organization committee

Name	First Name	Affiliation	Country
Dudareva	Natalia	Purdue University	USA
Hansel	Armin	Institut für Ionenphysik & Angewandte Physik Universität Innsbruck	Austria
Schiestl	Florian	University of Zurich	Switzerland
Dicke	Marcel	WU Plant Sciences	The Netherlands
Birkett	Mike	Rothamsted Research	UK
Turlings	Ted	University of Neuchatel	Switzerland
Loreto	Francesco	Dipartimento di Scienze Bio-Agroalimentari (DISBA)	Italy
Farmer	Edward (Ted)	University of Lausanne	Switzerland
Gouinguené	Sandrine	University of Neuchâtel	Switzerland

Participants

Name	First Name	University affiliation	Country
Ahrar	Mastaneh	University of Innsbruck	Austria
Bonnet	Christelle	University of Lausanne	Switzerland
Canaval	Eva	University of Innsbruck	Austria
CATALETTO	PIA ROSA	UNIVERSITA' DI NAPOLI FEDERICO II	
Cepulyte-Rakauskiene	Rasa	Nature Research Centre Institute of Ecology Laboratory of Chemical and Behavioral Ecology	Lithuania
Cheesman	Stephanie	ETHZ	Switzerland
Chervet	Noémie	University of Neuchâtel	Switzerland
Cuny	Maximilien	University of Neuchâtel	Switzerland
Danner	Holger	Radboud University Nijmegen	The Netherlands
De Lange	Elvira	University of Neuchâtel	Switzerland
Degen	Thomas	Université de Neuchâtel	Switzerland
Desurmont	Gaylord	University of Neuchâtel	Switzerland
Gaillard	Mickaël	University of Neuchâtel	Switzerland
Hernandez-Cumplido	Johnattan	University of Neuchatel	Switzerland
Jaffuel	Geoffrey	University of Neuchâtel	Switzerland
Jud	Werner	University of Innsbruck	Austria

KASK	Kaia	Estonian University of Life Sciences	Estonia
Khaling	Eliezer	Univeryity of Eastern Finland	Finland
Köhler	Angela	University of Neuchâtel	Switzerland
LAPLANCHE	Diane	University of Neuchâtel	Switzerland
Lucas-Barbosa	Dani	Wageningen University	The Netherlands
Maag	Daniel	University of Neuchatel	Switzerland
Marcari	Veronica	University of Neuchatel	Switzerland
Menzel	Tila Romina	Wageningen University	The Netherlands
Papazian	Stefano	Umeå Plant Science Centre	
Paschalidou	Foteini	Wageningen University	The Netherlands
Ponzio	Camillle	Wageningen University	The Netherlands
Shlichta	Jennifer (Gwen)	University of Neuchatel	Switzerland
Trunz	Vincent	University of Neuchâtel	Switzerland
Xu	Hao	University of Neuchatel	Switzerland
Zolotarjova	Valentina	Estonian University of Life Sciences	Estonia
Zu	Pengjuan	University of Zurich	Switzerland

Total number of participants: 41