Conspecific and non-conspecific airborne cues prime Brassica napus defence response

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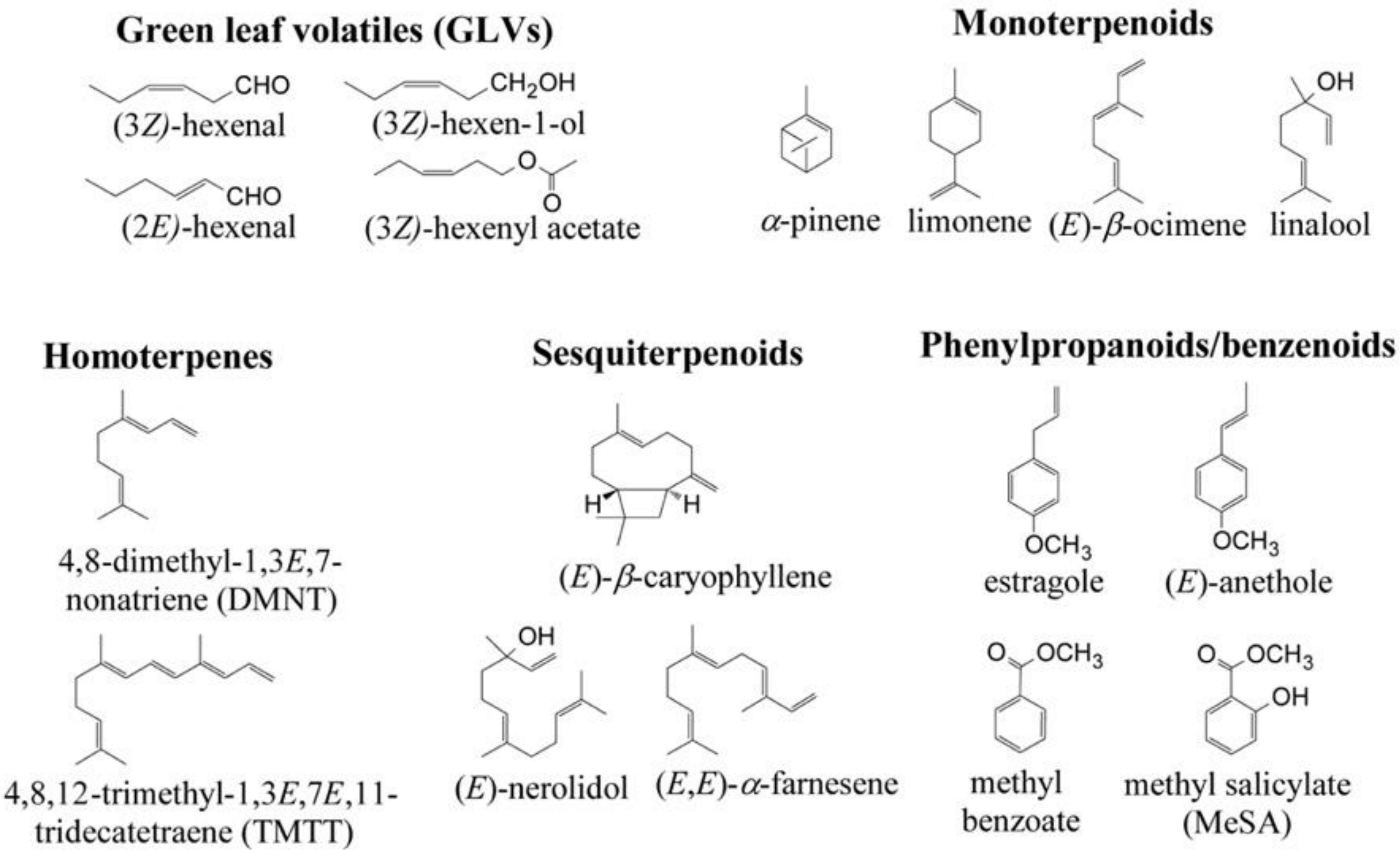
@foteini_pas, @Ottiuspo

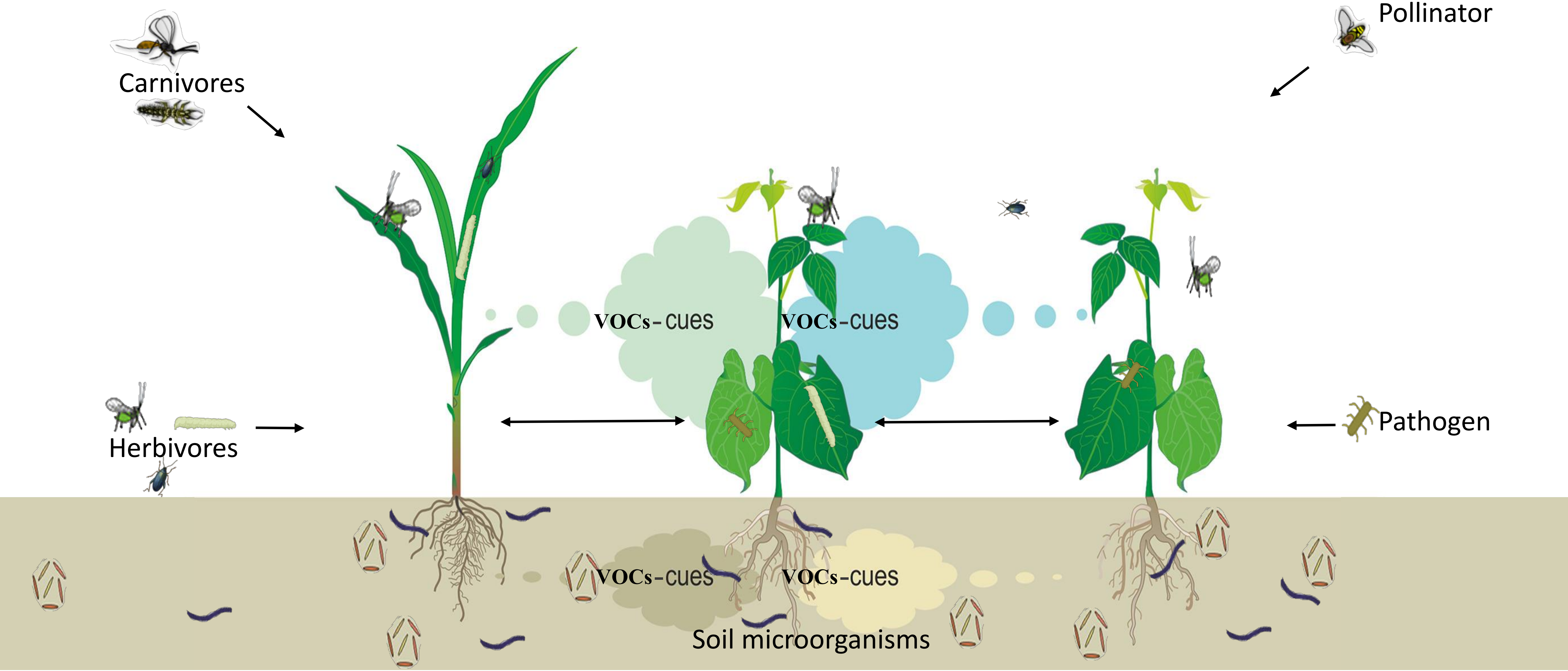
Plant Volatile Organic Compounds (VOCs)



VOCs – (Volatile organic compounds)

(Niinemets et al ., 2013)

Plant volatile organic compounds (VOCs)

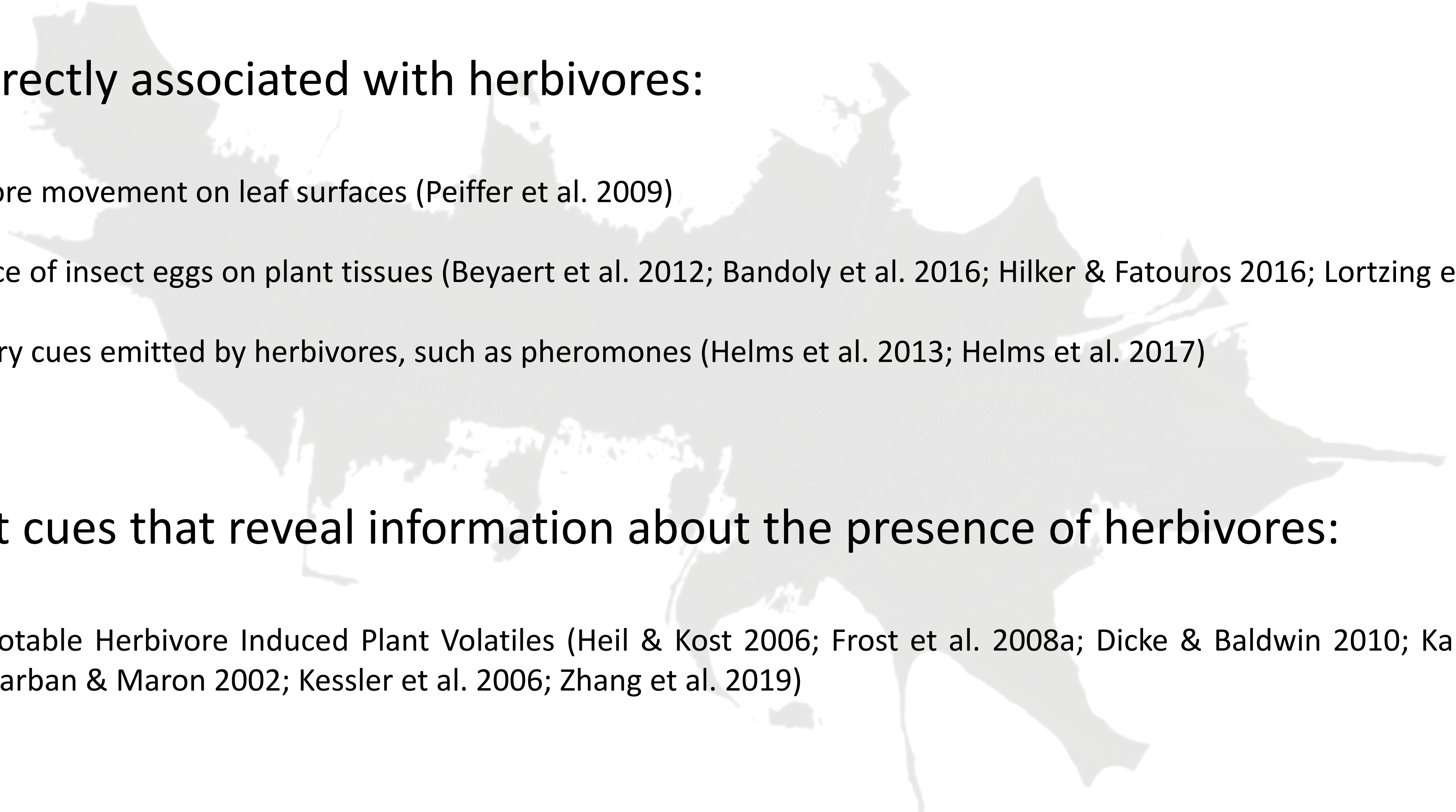


(Ninkovic et al., 2020 ; Dicke & Baldwin, 2010)

Plant defences

- Defense traits may be effective against different classes of antagonists (Zangerl & Rutledge 1996; Cipollini & Heil 2010; Dicke & van Loon 2000)
- Inducible defences –period of vulnerability (Kabran & Myers 1989; Agrawal 1999; Orrock et al. 2015);
- Plants can shorten this period by adjusting their defences in response to early warning cues (Dicke & Baldwin 2010; Hilker & Fatouros 2015; Mescher & De Moraes 2015)

Plant priming



Cues directly associated with herbivores:

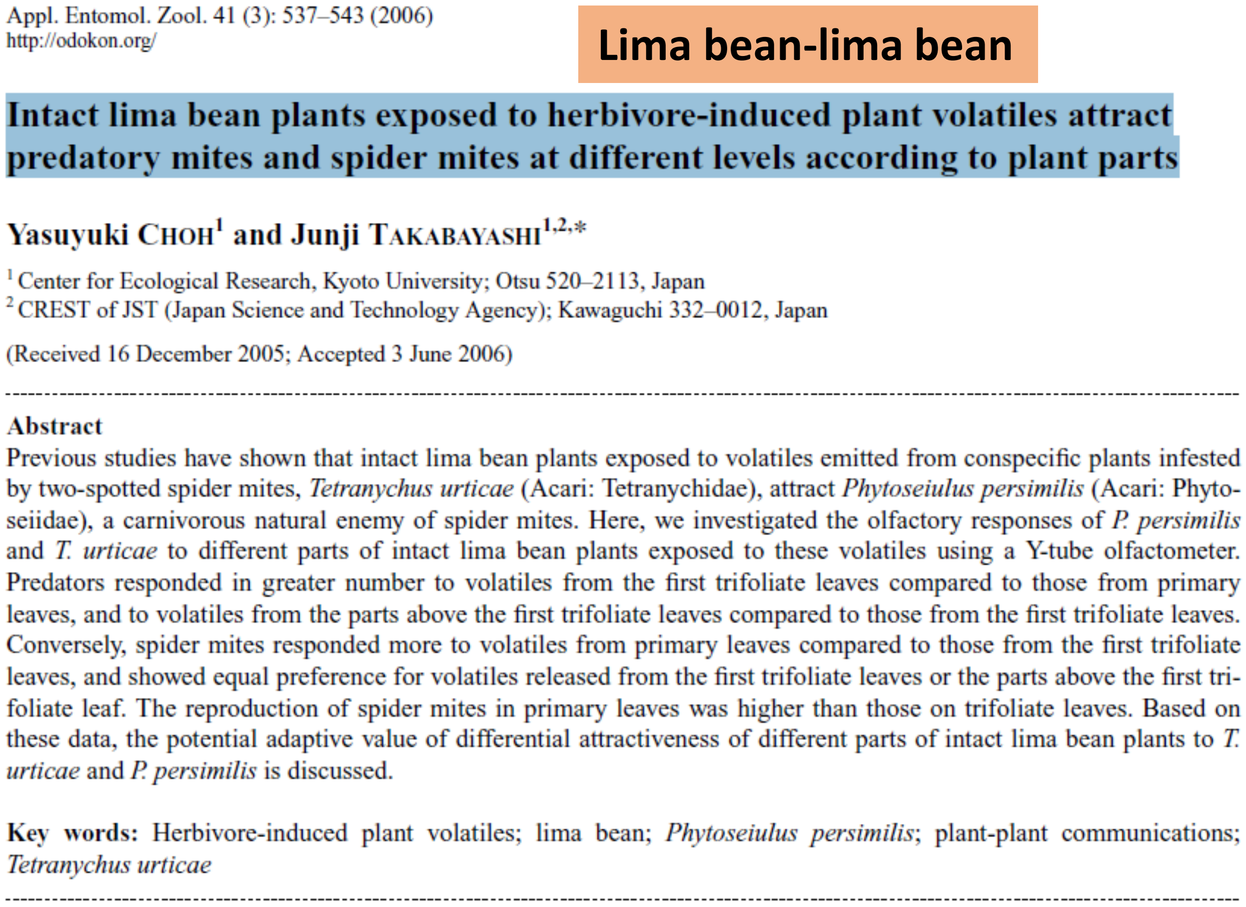
1. Herbivore movement on leaf surfaces (Peiffer et al. 2009)
2. Presence of insect eggs on plant tissues (Beyaert et al. 2012; Bandoly et al. 2016; Hilker & Fatouros 2016; Lortzing et al. 2019)
3. Olfactory cues emitted by herbivores, such as pheromones (Helms et al. 2013; Helms et al. 2017)

Indirect cues that reveal information about the presence of herbivores:

1. Most notable Herbivore Induced Plant Volatiles (Heil & Kost 2006; Frost et al. 2008a; Dicke & Baldwin 2010; Karban et al. 2014, Karban & Maron 2002; Kessler et al. 2006; Zhang et al. 2019)

Plant priming

Lima bean-lima bean



Appl. Entomol. Zool. 41 (3): 537–543 (2006)
http://odokon.org/

Intact lima bean plants exposed to herbivore-induced plant volatiles attract predatory mites and spider mites at different levels according to plant parts

Yasuyuki CHOH[1] and Junji TAKABAYASHI[1,2,*]

[1] Center for Ecological Research, Kyoto University; Otsu 520–2113, Japan
[2] CREST of JST (Japan Science and Technology Agency); Kawaguchi 332–0012, Japan

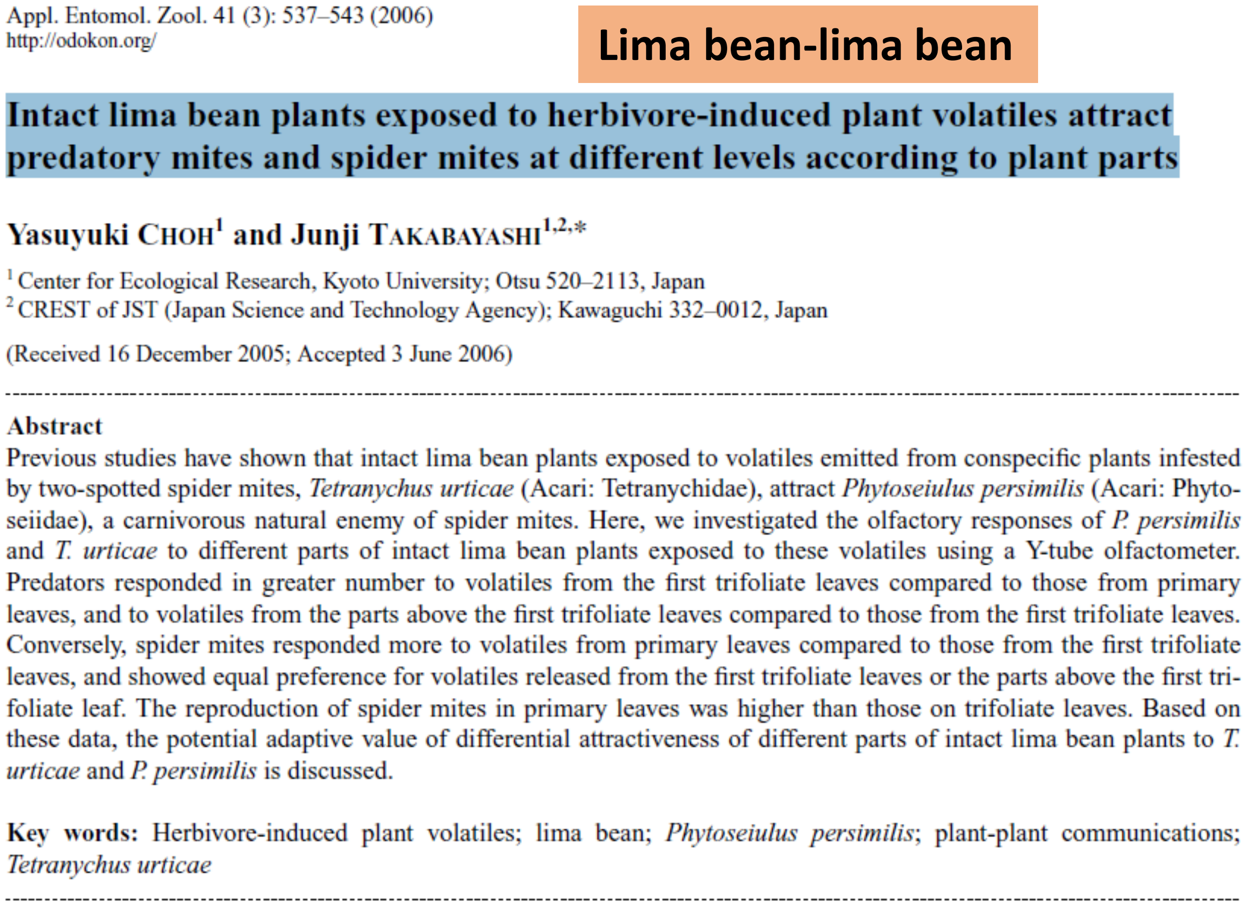
(Received 16 December 2005; Accepted 3 June 2006)

Abstract

Previous studies have shown that intact lima bean plants exposed to volatiles emitted from conspecific plants infested by two-spotted spider mites, *Tetranychus urticae* (Acari: Tetranychidae), attract *Phytoseiulus persimilis* (Acari: Phytoseiidae), a carnivorous natural enemy of spider mites. Here, we investigated the olfactory responses of *P. persimilis* and *T. urticae* to different parts of intact lima bean plants exposed to these volatiles using a Y-tube olfactometer. Predators responded in greater number to volatiles from the first trifoliate leaves compared to those from primary leaves, and to volatiles from the parts above the first trifoliate leaves compared to those from the first trifoliate leaves. Conversely, spider mites responded more to volatiles from primary leaves compared to those from the first trifoliate leaves, and showed equal preference for volatiles released from the first trifoliate leaves or the parts above the first trifoliate leaf. The reproduction of spider mites in primary leaves was higher than those on trifoliate leaves. Based on these data, the potential adaptive value of differential attractiveness of different parts of intact lima bean plants to *T. urticae* and *P. persimilis* is discussed.

Key words: Herbivore-induced plant volatiles; lima bean; *Phytoseiulus persimilis*; plant-plant communications; *Tetranychus urticae*

Plant priming



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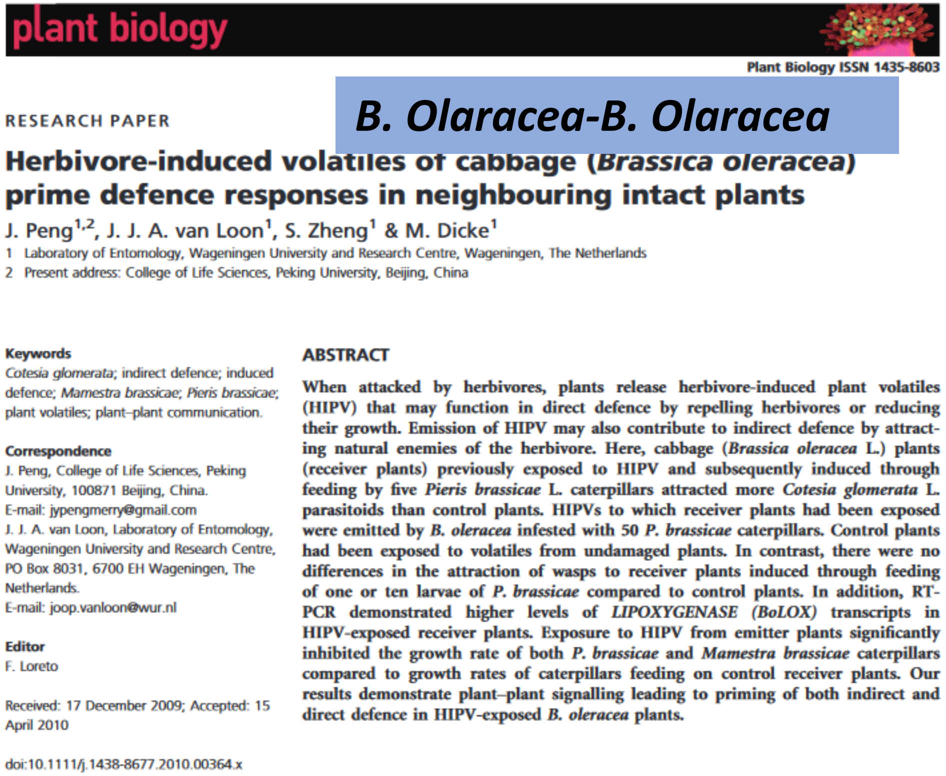

B. Olaracea-B. Olaracea

plant biology

Plant Biology ISSN 1435-8603

RESEARCH PAPER

Herbivore-induced volatiles of cabbage (*Brassica oleracea*) prime defence responses in neighbouring intact plants

J. Peng[1,2], J. J. A. van Loon[1], S. Zheng[1] & M. Dicke[1]

1 Laboratory of Entomology, Wageningen University and Research Centre, Wageningen, The Netherlands
2 Present address: College of Life Sciences, Peking University, Beijing, China

Keywords
Cotesia glomerata; indirect defence; induced defence; *Mamestra brassicae*; *Pieris brassicae*; plant volatiles; plant–plant communication.

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F. Loreto

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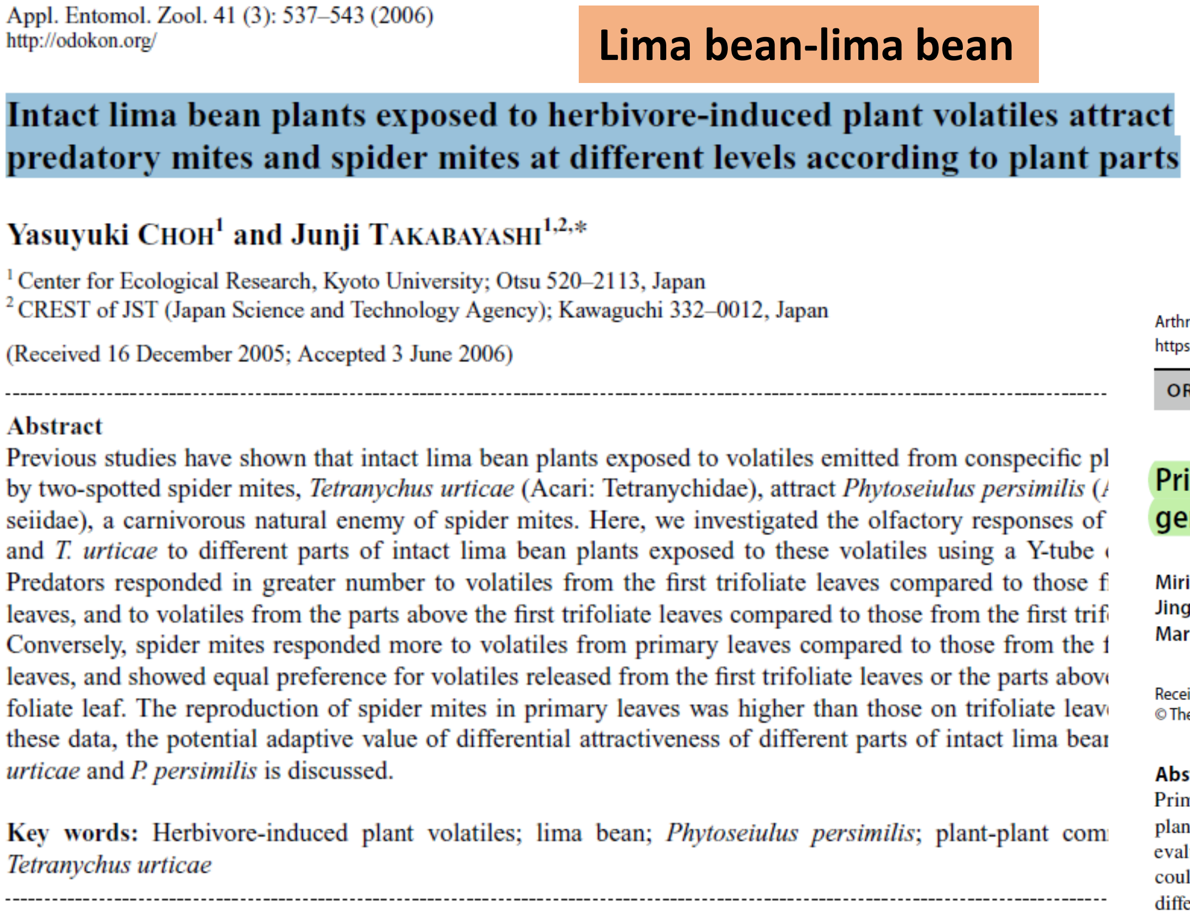
ABSTRACT

When attacked by herbivores, plants release herbivore-induced plant volatiles (HIPV) that may function in direct defence by repelling herbivores or reducing their growth. Emission of HIPV may also contribute to indirect defence by attracting natural enemies of the herbivore. Here, cabbage (*Brassica oleracea* L.) plants (receiver plants) previously exposed to HIPV and subsequently induced through feeding by five *Pieris brassicae* L. caterpillars attracted more *Cotesia glomerata* L. parasitoids than control plants. HIPVs to which receiver plants had been exposed were emitted by *B. oleracea* infested with 50 *P. brassicae* caterpillars. Control plants had been exposed to volatiles from undamaged plants. In contrast, there were no differences in the attraction of wasps to receiver plants induced through feeding of one or ten larvae of *P. brassicae* compared to control plants. In addition, RT-PCR demonstrated higher levels of *LIPOXYGENASE (BoLOX)* transcripts in HIPV-exposed receiver plants. Exposure to HIPV from emitter plants significantly inhibited the growth rate of both *P. brassicae* and *Mamestra brassicae* caterpillars compared to growth rates of caterpillars feeding on control receiver plants. Our results demonstrate plant–plant signalling leading to priming of both indirect and direct defence in HIPV-exposed *B. oleracea* plants.

Plant priming



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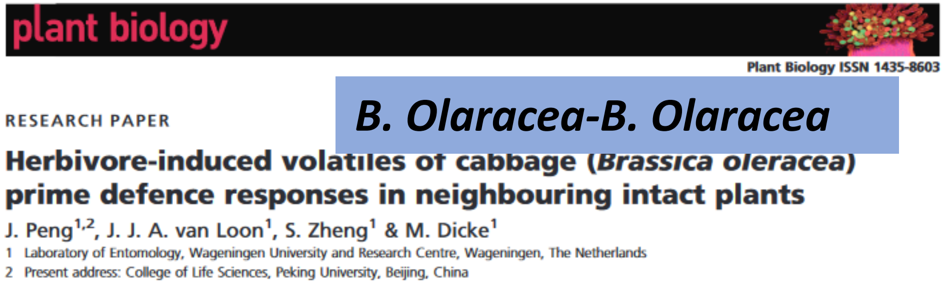

plant biology
Plant Biology ISSN 1435-8603

B. Olaracea-B. Olaracea

RESEARCH PAPER

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Arthropod-Plant Interactions (2021) 15:313–328
https://doi.org/10.1007/s11829-021-09826-4

ORIGINAL PAPER

Priming of indirect defence responses in maize is shown to be genotype-specific

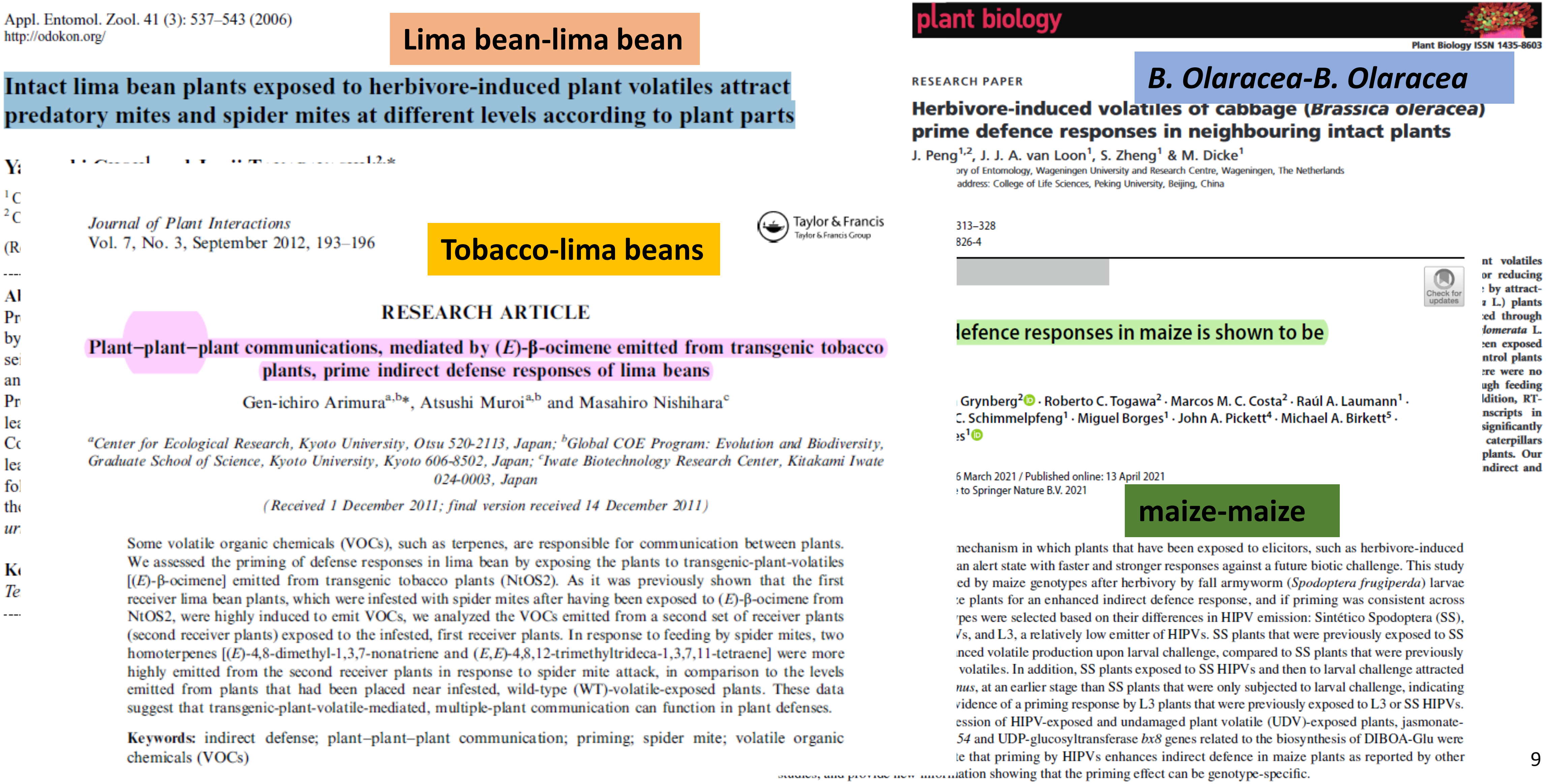
Mirian F. F. Michereff[1] · Priscila Grynberg[2] · Roberto C. Togawa[2] · Marcos M. C. Costa[2] · Raúl A. Laumann[1] · Jing-Jiang Zhou[3] · Pedro H. C. Schimmelpfeng[1] · Miguel Borges[1] · John A. Pickett[4] · Michael A. Birkett[5] · Maria Carolina Blassioli-Moraes[1]

Received: 24 August 2020 / Accepted: 26 March 2021 / Published online: 13 April 2021

maize-maize

Abstract
Priming is an induced defence mechanism in which plants that have been exposed to elicitors, such as herbivore-induced plant volatiles (HIPVs), go into an alert state with faster and stronger responses against a future biotic challenge. This study evaluated whether HIPVs emitted by maize genotypes after herbivory by fall armyworm (*Spodoptera frugiperda*) larvae could prime neighbouring maize plants for an enhanced indirect defence response, and if priming was consistent across different genotypes. Two genotypes were selected based on their differences in HIPV emission: Sintético Spodoptera (SS), a relatively high emitter of HIPVs, and L3, a relatively low emitter of HIPVs. SS plants that were previously exposed to SS HIPVs initiated earlier and enhanced volatile production upon larval challenge, compared to SS plants that were previously exposed to SS undamaged plant volatiles. In addition, SS plants exposed to SS HIPVs and then to larval challenge attracted an egg parasitoid, *Telenomus remus*, at an earlier stage than SS plants that were only subjected to larval challenge, indicating a priming effect. There was no evidence of a priming response by L3 plants that were previously exposed to L3 or SS HIPVs. When comparing the gene expression of HIPV-exposed and undamaged plant volatile (UDV)-exposed plants, jasmonate-induced protein *GRMZM2G05154* and UDP-glucosyltransferase *bx8* genes related to the biosynthesis of DIBOA-Glu were upregulated. These data indicate that priming by HIPVs enhances indirect defence in maize plants as reported by other studies, and provide new information showing that the priming effect can be genotype-specific.

Plant priming



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Journal of Plant Interactions
Vol. 7, No. 3, September 2012, 193–196

Taylor & Francis
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Tobacco-lima beans

RESEARCH ARTICLE

Plant–plant–plant communications, mediated by (*E*)-β-ocimene emitted from transgenic tobacco plants, prime indirect defense responses of lima beans

Gen-ichiro Arimura[a,b]*, Atsushi Muroi[a,b] and Masahiro Nishihara[c]

[a]*Center for Ecological Research, Kyoto University, Otsu 520-2113, Japan;* [b]*Global COE Program: Evolution and Biodiversity, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan;* [c]*Iwate Biotechnology Research Center, Kitakami Iwate 024-0003, Japan*

(Received 1 December 2011; final version received 14 December 2011)

Some volatile organic chemicals (VOCs), such as terpenes, are responsible for communication between plants. We assessed the priming of defense responses in lima bean by exposing the plants to transgenic-plant-volatiles [(*E*)-β-ocimene] emitted from transgenic tobacco plants (NtOS2). As it was previously shown that the first receiver lima bean plants, which were infested with spider mites after having been exposed to (*E*)-β-ocimene from NtOS2, were highly induced to emit VOCs, we analyzed the VOCs emitted from a second set of receiver plants (second receiver plants) exposed to the infested, first receiver plants. In response to feeding by spider mites, two homoterpenes [(*E*)-4,8-dimethyl-1,3,7-nonatriene and (*E,E*)-4,8,12-trimethyltrideca-1,3,7,11-tetraene] were more highly emitted from the second receiver plants in response to spider mite attack, in comparison to the levels emitted from plants that had been placed near infested, wild-type (WT)-volatile-exposed plants. These data suggest that transgenic-plant-volatile-mediated, multiple-plant communication can function in plant defenses.

Keywords: indirect defense; plant–plant–plant communication; priming; spider mite; volatile organic chemicals (VOCs)

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6 March 2021 / Published online: 13 April 2021
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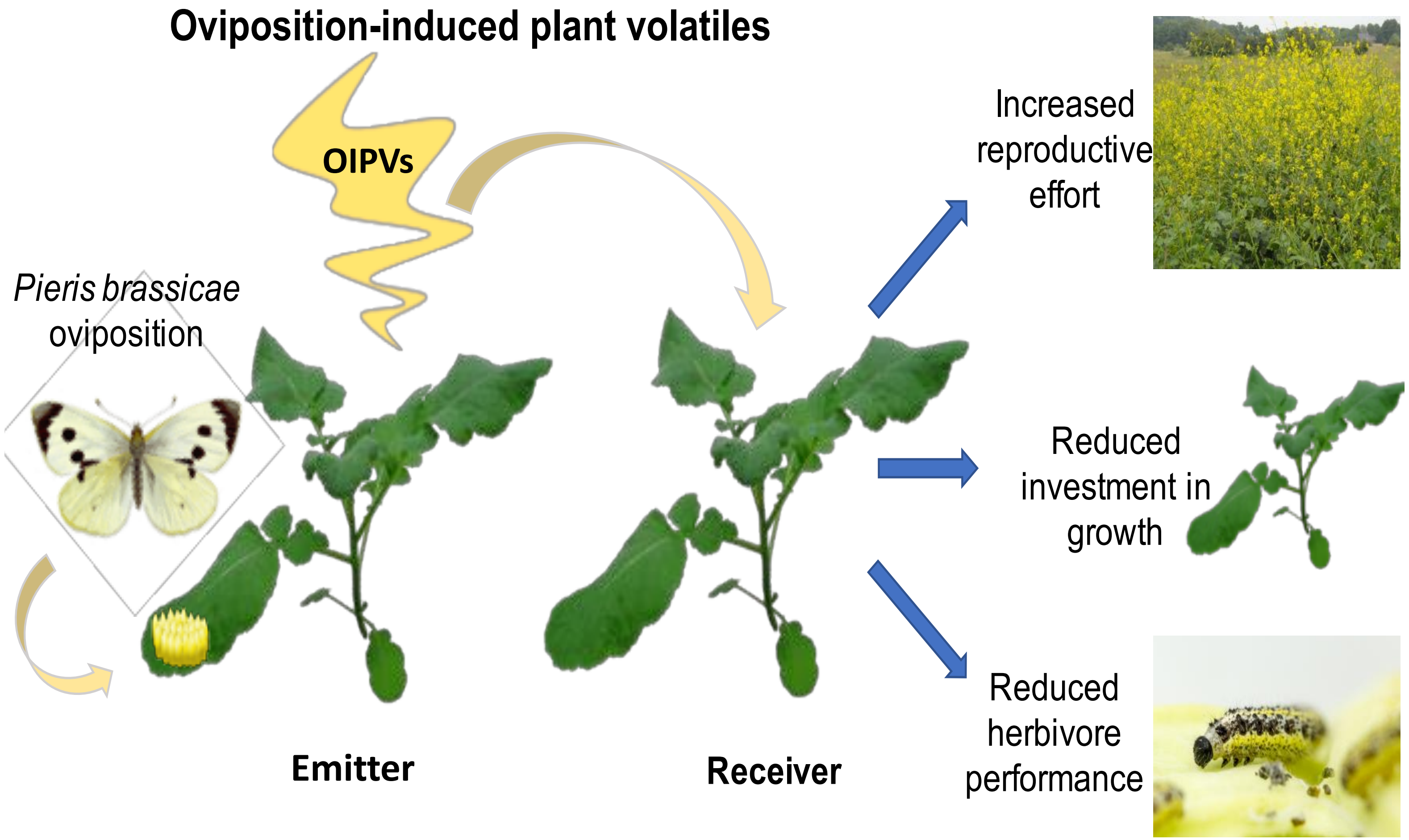
But we have limited knowledge on oviposition induced plant volatiles and their effects on neighbouring plants.

Oviposition and volatile organic compounds



Oviposition-induced plant volatiles

OIPVs

Pieris brassicae oviposition

Emitter

Receiver

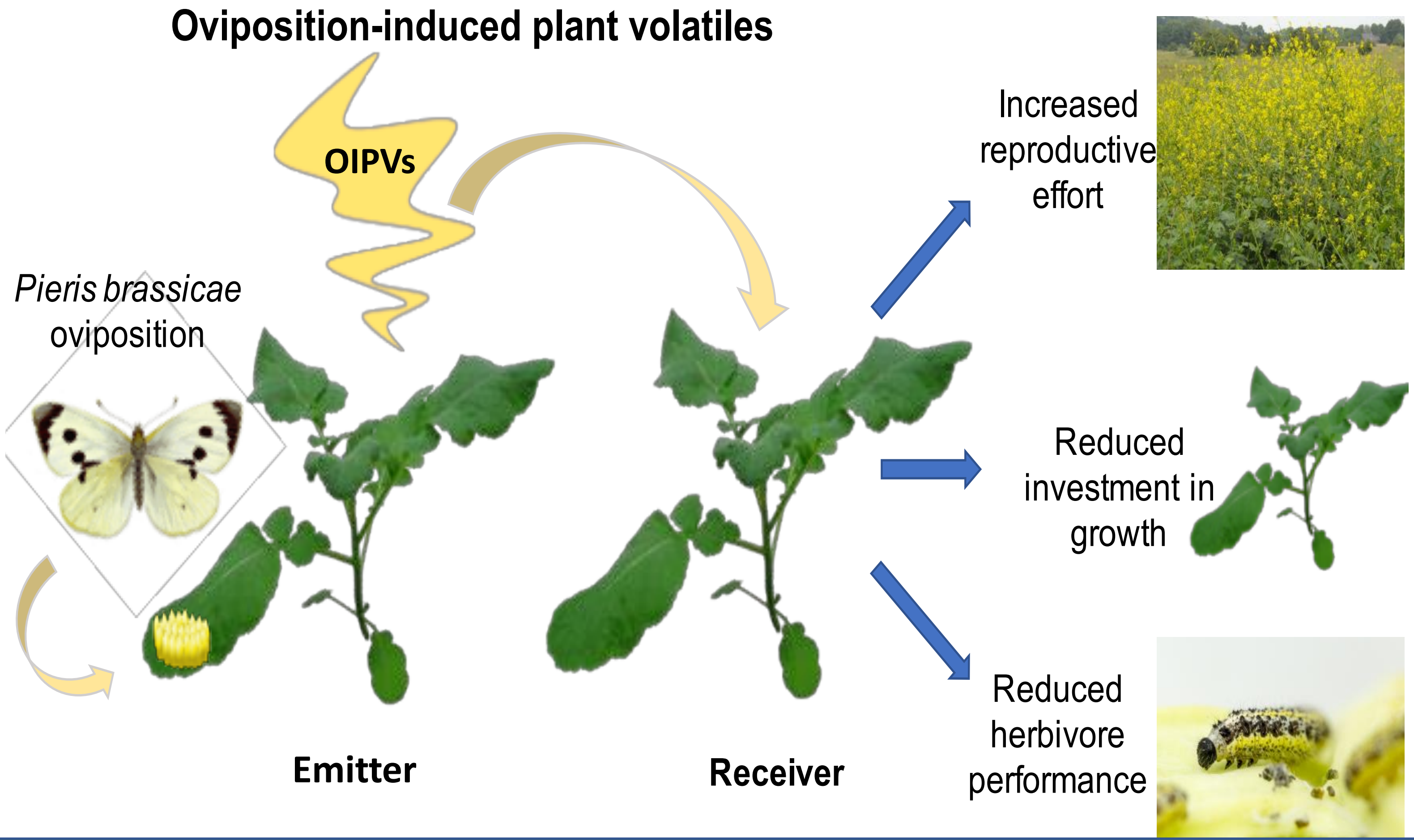
Increased reproductive effort

Reduced investment in growth

Reduced herbivore performance

Pashalidou et al 2020, Ecology Letters

Oviposition and volatile organic compounds



Oviposition-induced plant volatiles

OIPVs

Pieris brassicae oviposition

Emitter

Receiver

Increased reproductive effort

Reduced investment in growth

Reduced herbivore performance

Plant volatiles induced by herbivore eggs prime defences and mediate shifts in the reproductive strategy of receiving plants

Objectives and hypotheses

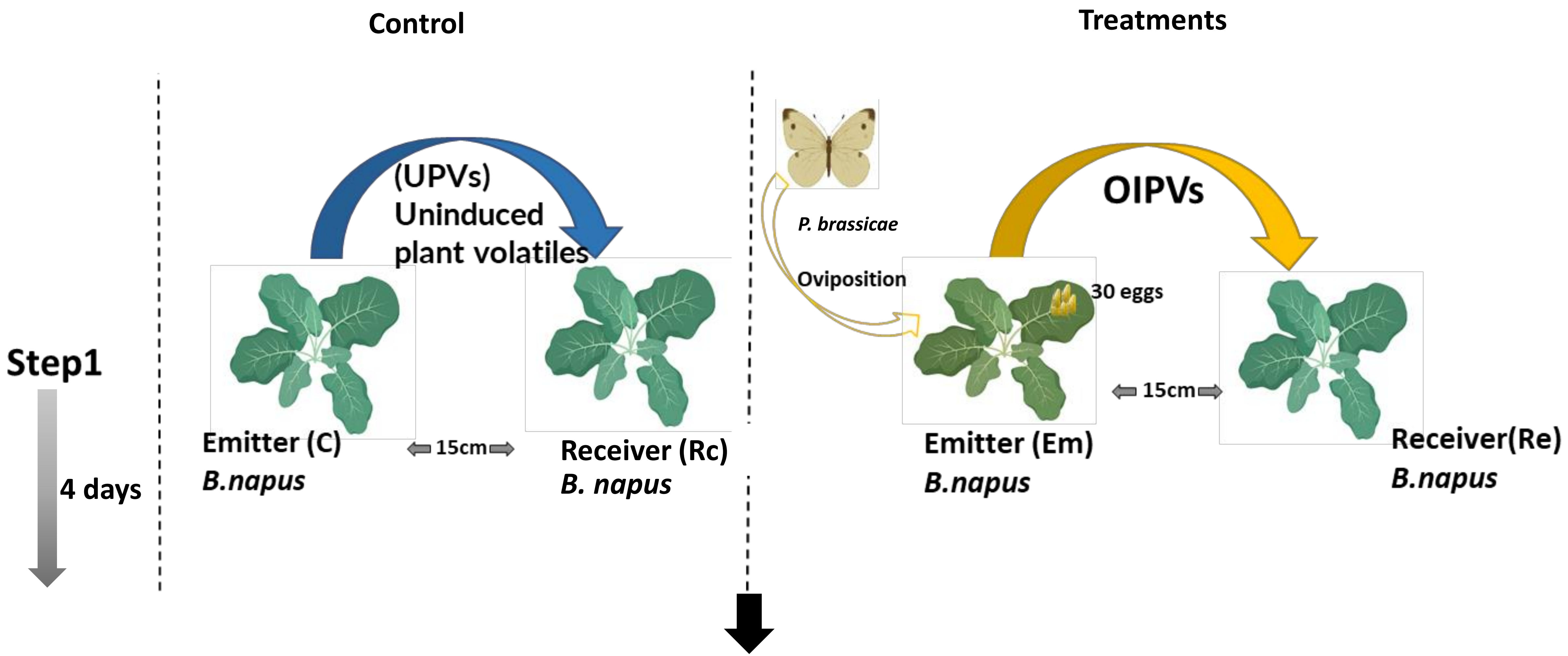
Objective: Test in the lab whether *B. napus* responds with priming of plant defences to oviposition-induced plant volatiles (OIPVs) emitted by neighbouring plants of the same or different species infested with *Pieris brassicae* eggs.

Hypothesis 1: *Brassica napus* receiver recognises OIPVs from the emitter neighbours.

Hypothesis 2: Receiver plants perceive OIPVs as early warning cues to prime defences against future herbivores.

Hypothesis 3: Specific volatiles act as early warning cues.

Materials and methods



Control

Treatments

Step1

4 days

(UPVs)
Uninduced
plant volatiles

Emitter (C)
B.napus

15cm

Receiver (Rc)
B. napus

P. brassicae

Oviposition

OIPVs

30 eggs

Emitter (Em)
B.napus

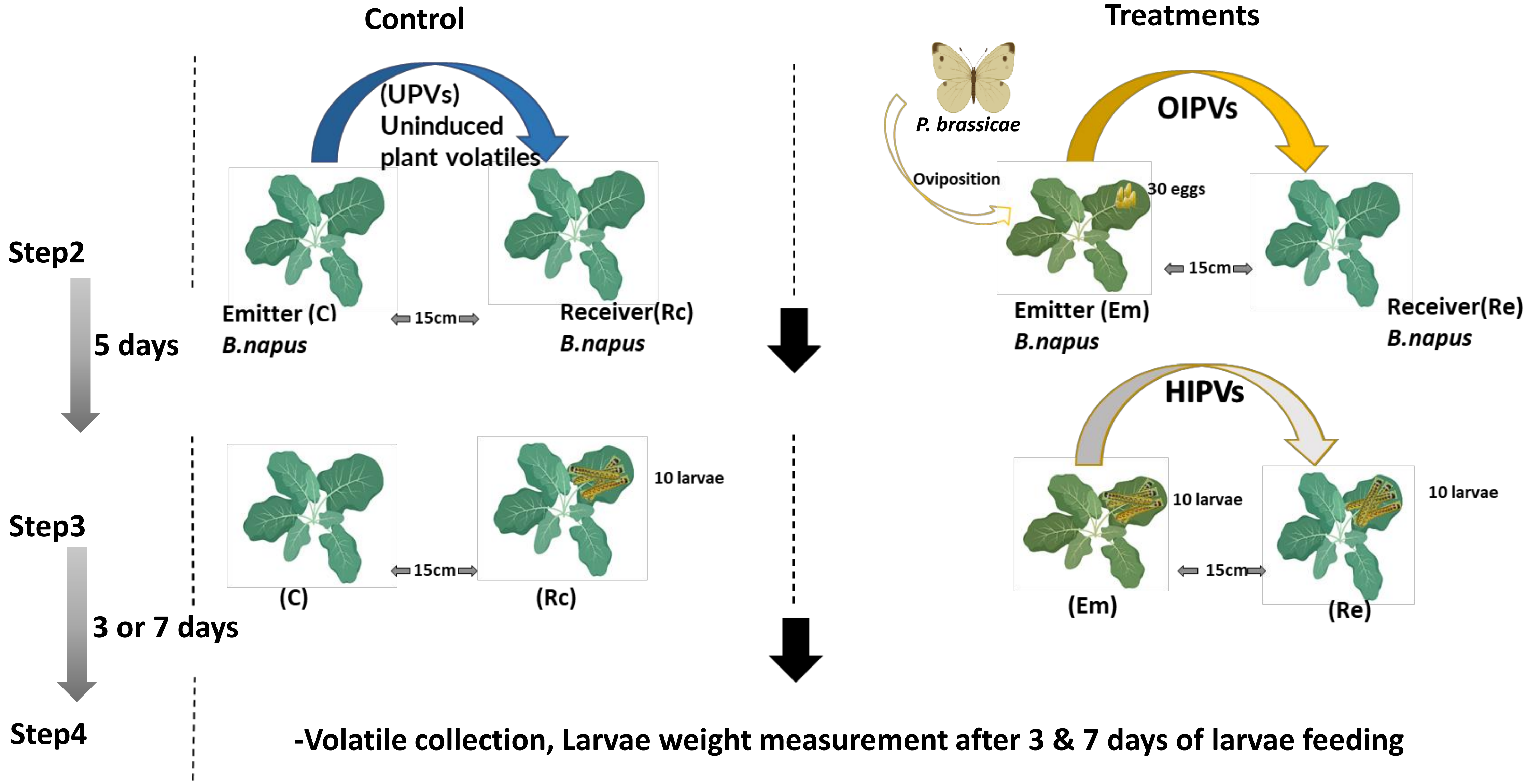
15cm

Receiver(Re)
B.napus

-Volatile collection of induced plants by 4-day-old eggs & control

OIPVs – (oviposition-induced plant volatiles)

Materials and methods



Control

Treatments

Step2

5 days

(UPVs) Uninduced plant volatiles

Emitter (C) *B.napus*

15cm

Receiver(Rc) *B.napus*

P. brassicae

Oviposition

30 eggs

OIPVs

Emitter (Em) *B.napus*

15cm

Receiver(Re) *B.napus*

Step3

3 or 7 days

(C)

15cm

10 larvae

(Rc)

HIPVs

10 larvae

15cm

(Em)

10 larvae

(Re)

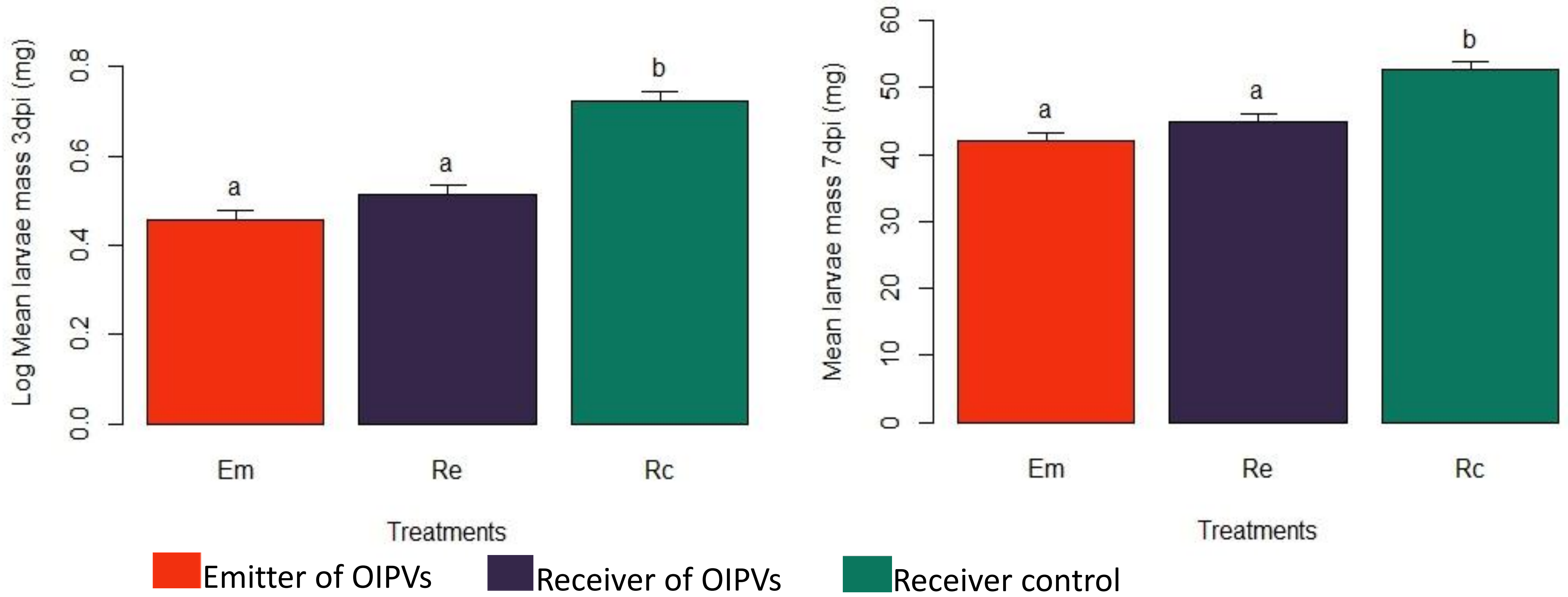
Step4

-Volatile collection, Larvae weight measurement after 3 & 7 days of larvae feeding

OIPVs – (oviposition-induced plant volatiles), HIPVs – (Herbivore-induced plant volatiles)

Results

1. Herbivore performance after 3 & 7 days feeding



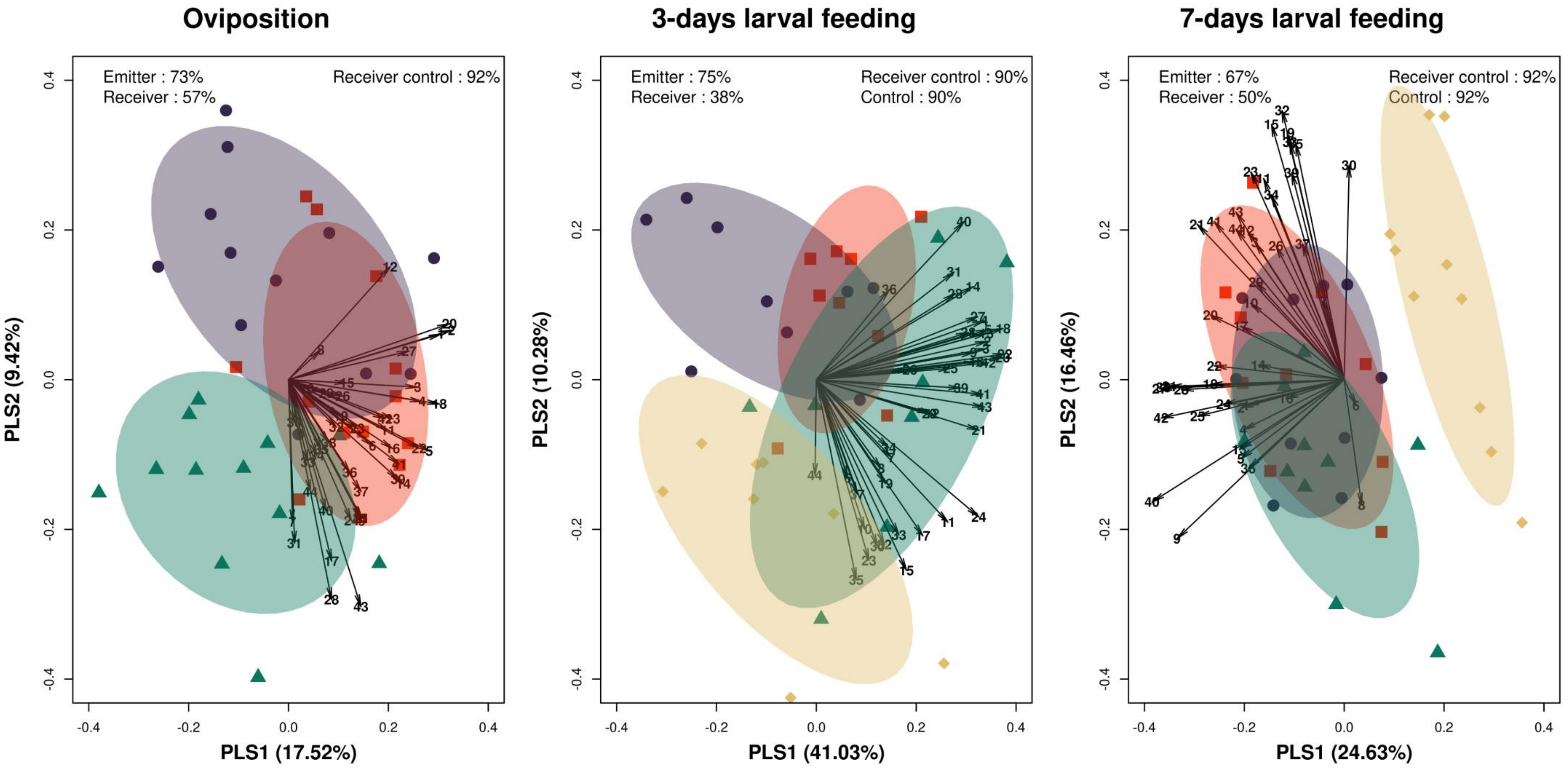
(A) 3-days feeding
LMM: $X^2(2)=70.64, p=4.56e^{-16}$

(B) 7-days feeding
Kruskal Wallis: $\chi^2(2) = 20.008, p = 4.52e\text{-}^{05}$

OIPVs – (oviposition-induced plant volatiles)

Results

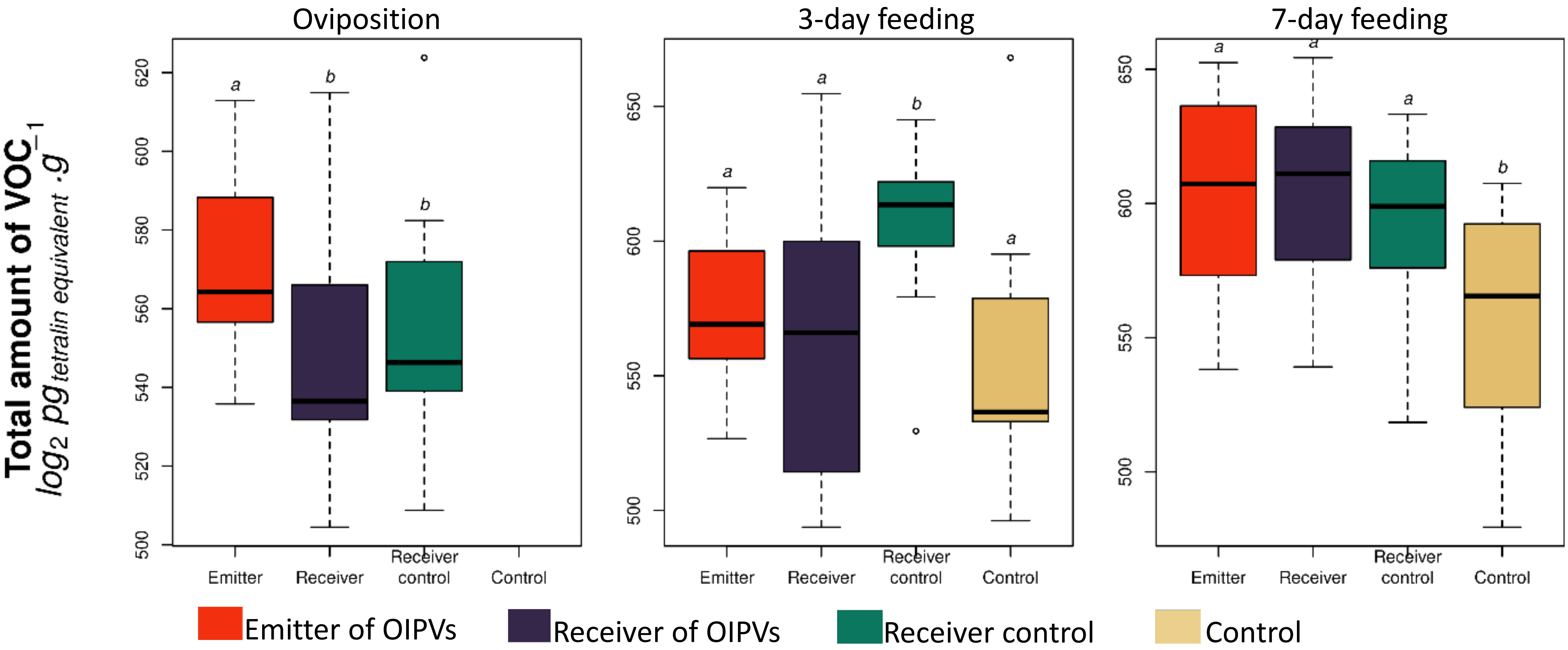
2. PLSDA analysis of volatile profiles for treatments and controls



🟥 Emitter of OIPVs 🟪 Receiver of OIPVs 🟩 Receiver control 🟨 Control

Results

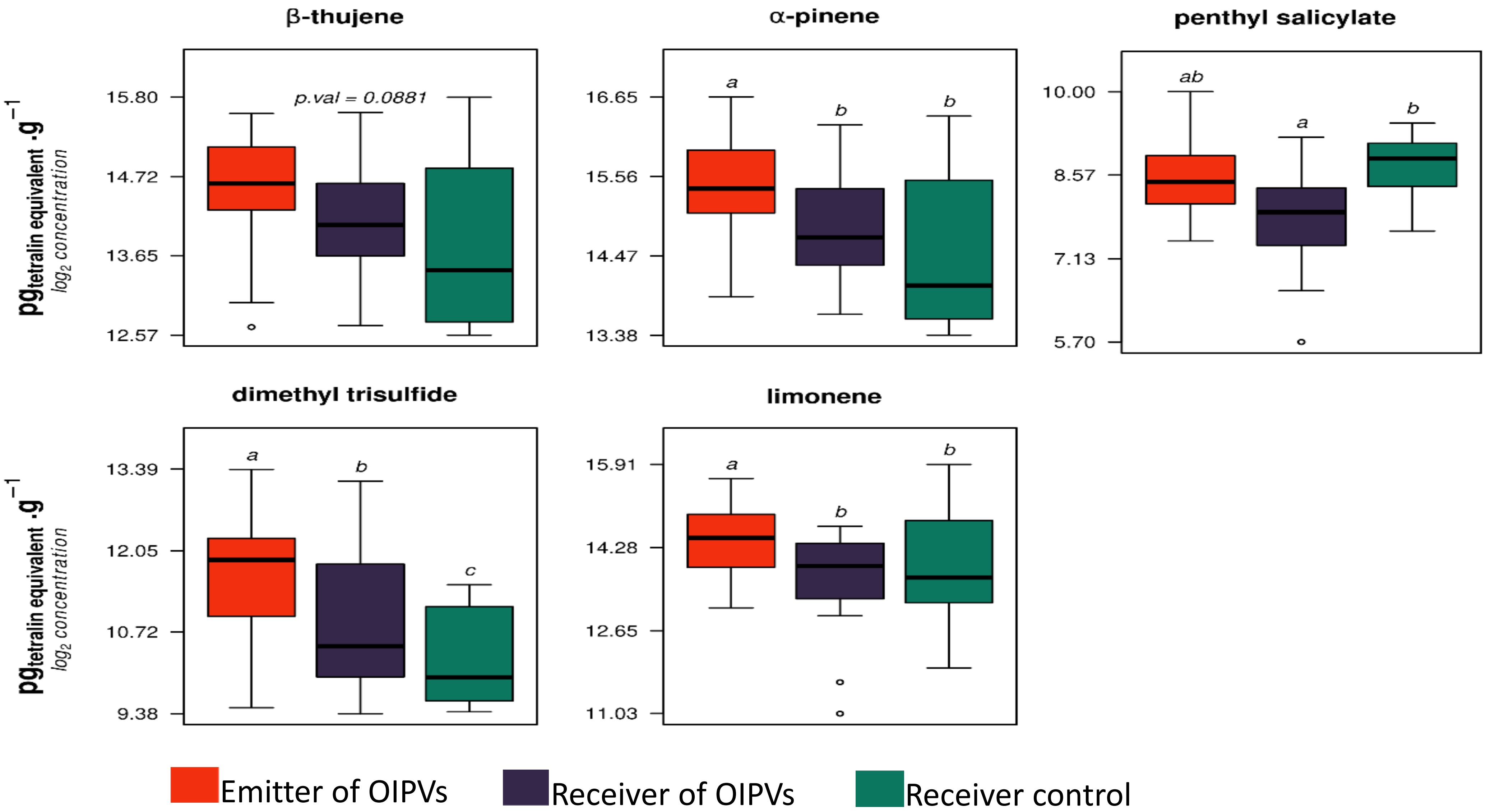
3. Total amount of volatile organic compounds



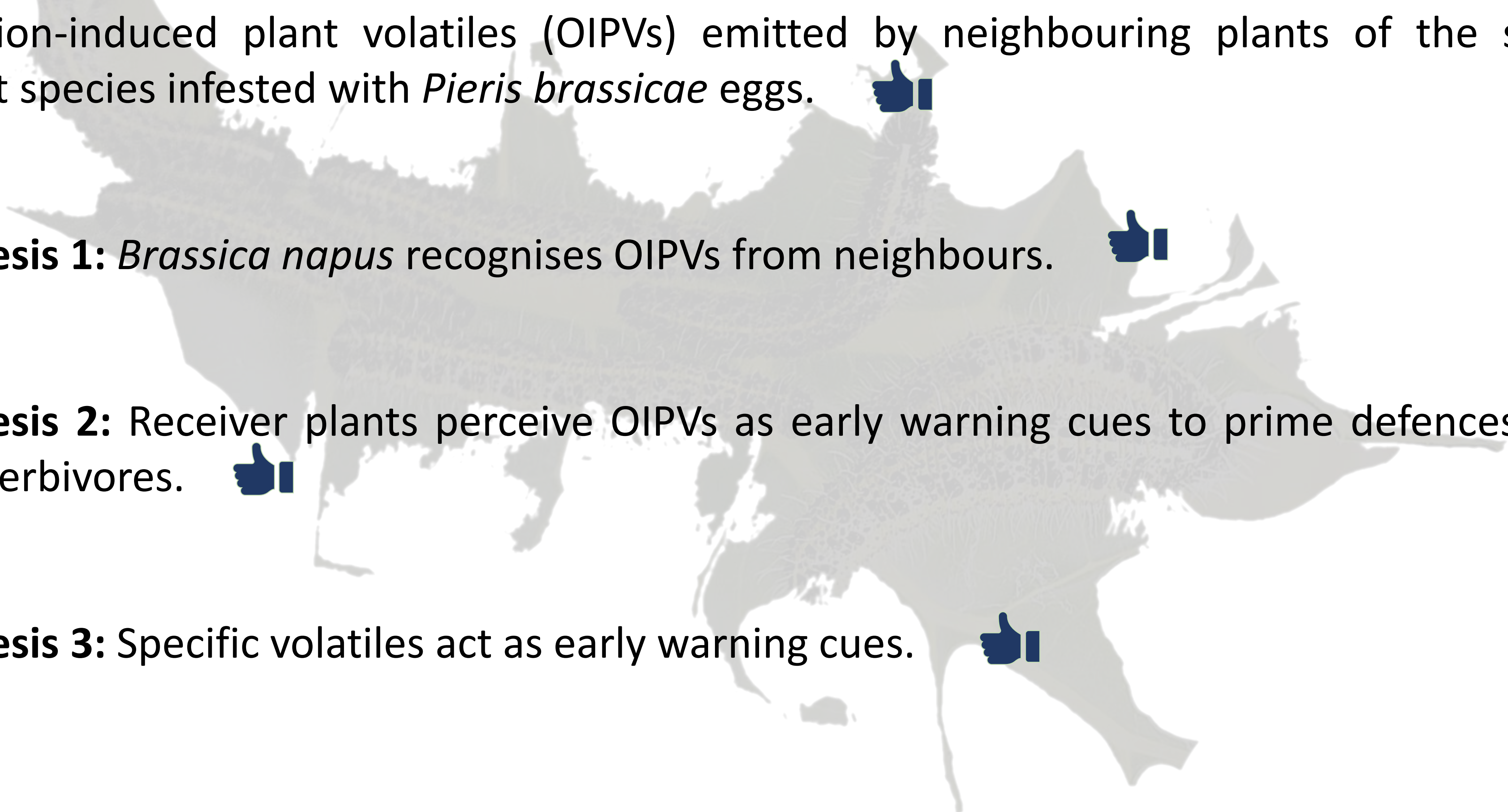
OIPVs – (oviposition-induced plant volatiles)

Results

4. Univariate analysis of Oviposition induced plant volatiles (OIPVs)



Discussion



Objective: Test in the lab whether *B. napus* responds with priming of plant defences to oviposition-induced plant volatiles (OIPVs) emitted by neighbouring plants of the same or different species infested with *Pieris brassicae* eggs. 👍

Hypothesis 1: *Brassica napus* recognises OIPVs from neighbours. 👍

Hypothesis 2: Receiver plants perceive OIPVs as early warning cues to prime defences against future herbivores. 👍

Hypothesis 3: Specific volatiles act as early warning cues. 👍


Dr. Alan Kergunteuil

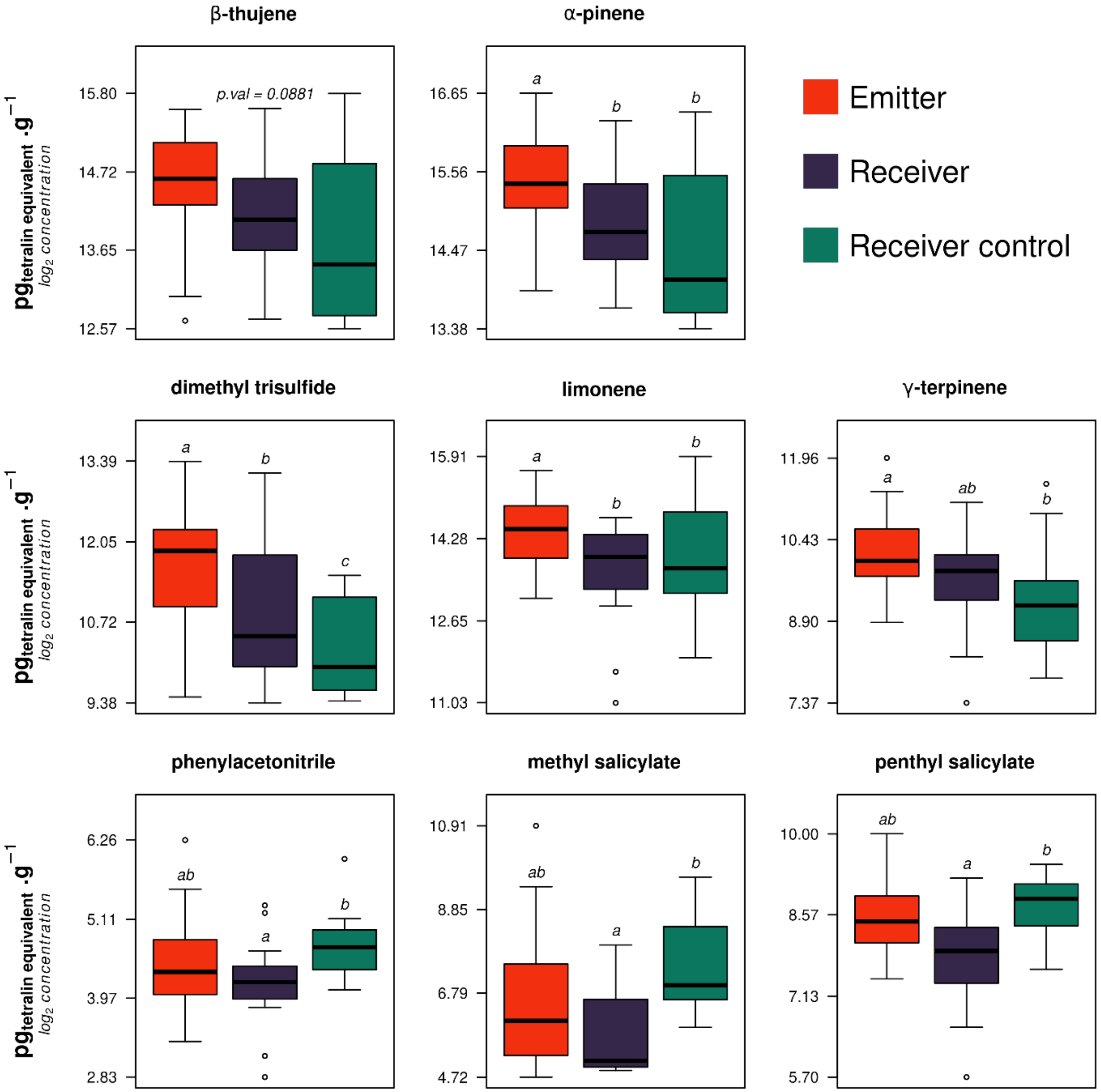

Dr. Foteini Pashalidou


Dr. Muriel Valentin-Morison

Thank you.

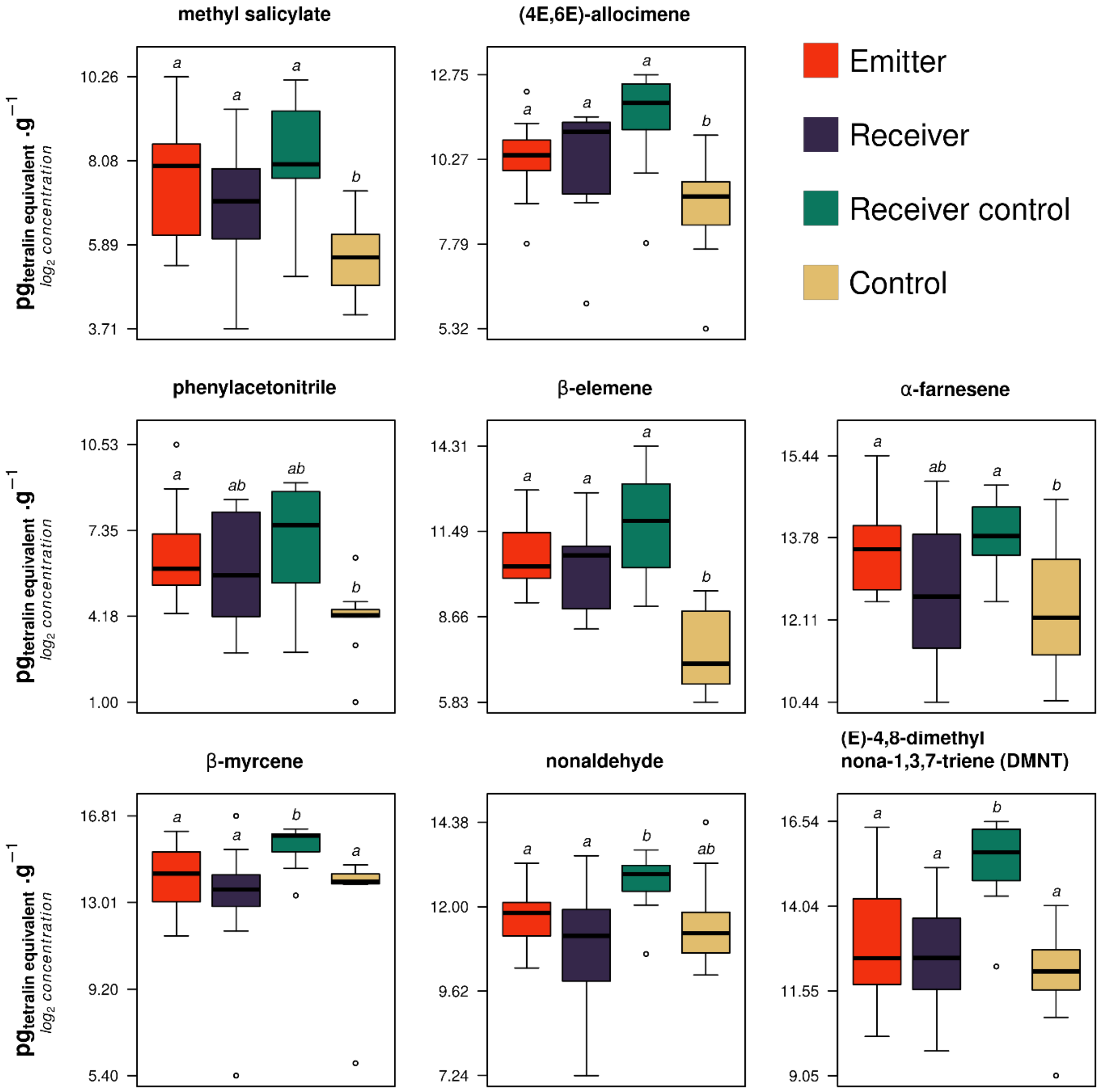
@foteini_pas, @Ottiuspo

Univariate analysis of Oviposition induced plant volatiles (OIPVs)



Current results

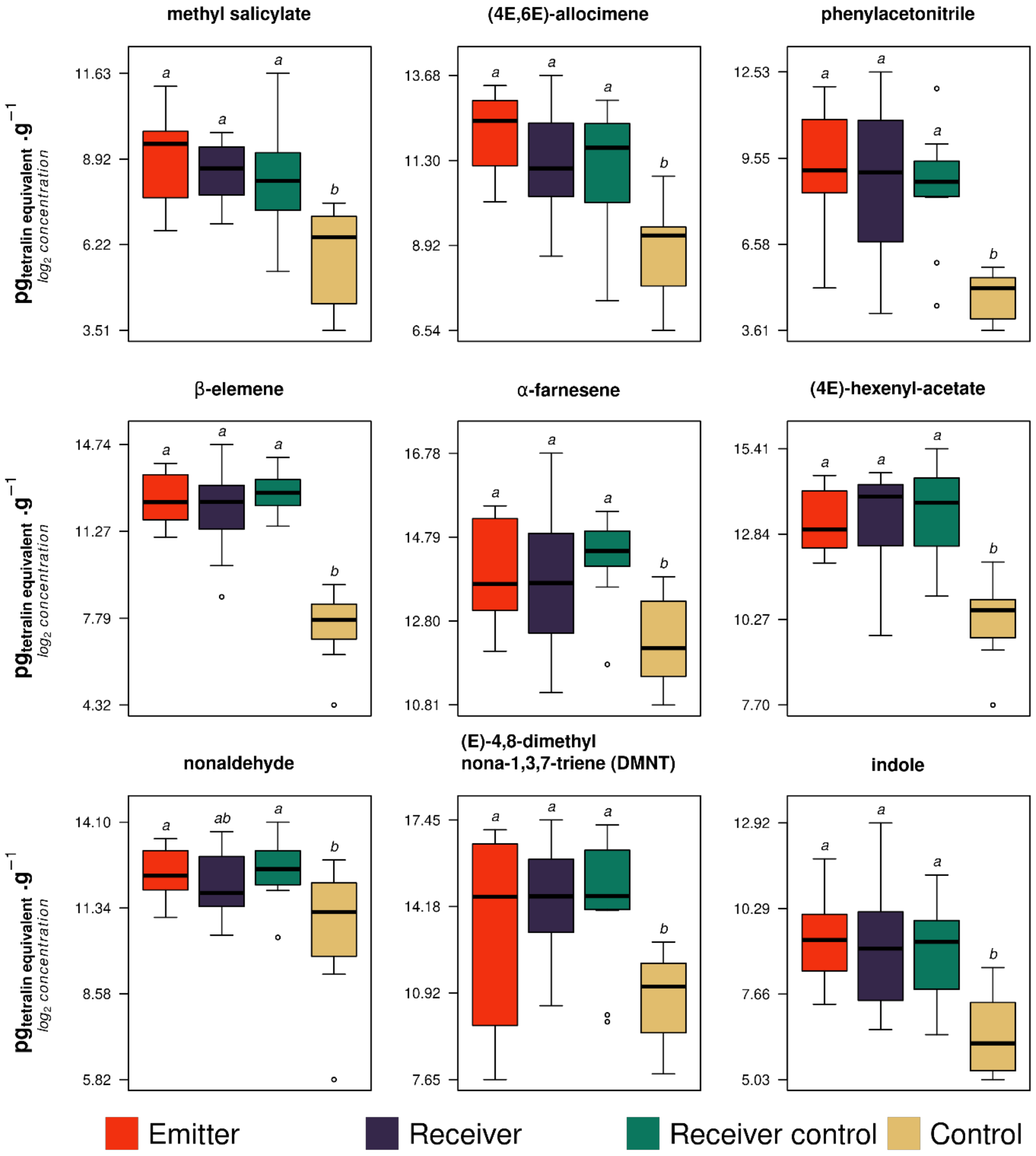
5. **Univariate analyses of 3dpi volatiles**



3-days larval feeding: *n* = 11 Emitter, 11 Receiver, 9 Receiver control & 9 Control plants

Current results

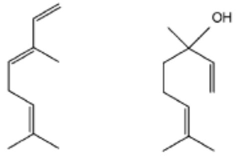
6. **Univariate analyses of 7dpi volatiles**



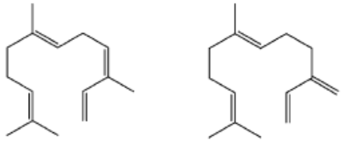
7-days larval feeding: *n* = 12 Emitter, Receiver, Receiver control, & Control plants each.

gap of knowledge

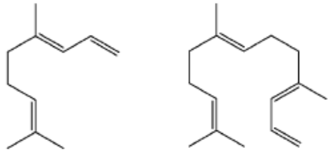
Monoterpenes


(*E*)-β-Ocimene Linalool

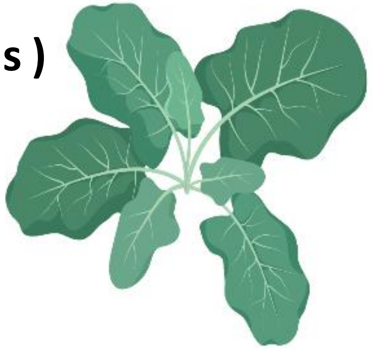
Sesquiterpenes


(*E*,*E*)-α-Farnesene (*E*)-β-Farnesene

Homoterpenes


(*E*)-4,8-Dimethyl-1,3,7-nonatriene (*E*,*E*)-4,8,12-Trimethyl-1,3,7,11-tridecatetraene

VOCs – (Volatile organic compounds)



- Potato-potato (Martín-Cacheda et al., 2023)
- Sweet potato-Sweet potato (Meents et al., 2019)
- Barley-Barley (Pettersson et al., 1999; Ninkovic et al., 2002)
- Brussels sprouts-Brussels sprouts (Peng et al., 2011)
- Lima bean-Lima bean (Kost & Heil, 2006; 2008)
- Sagebrush-tobacco (Karban et al., 2003; Kessler et al., 2006)
- Tobacco-Lima bean (Muroi et al., 2011)