Prospects for *Orobanche* control in Tobacco

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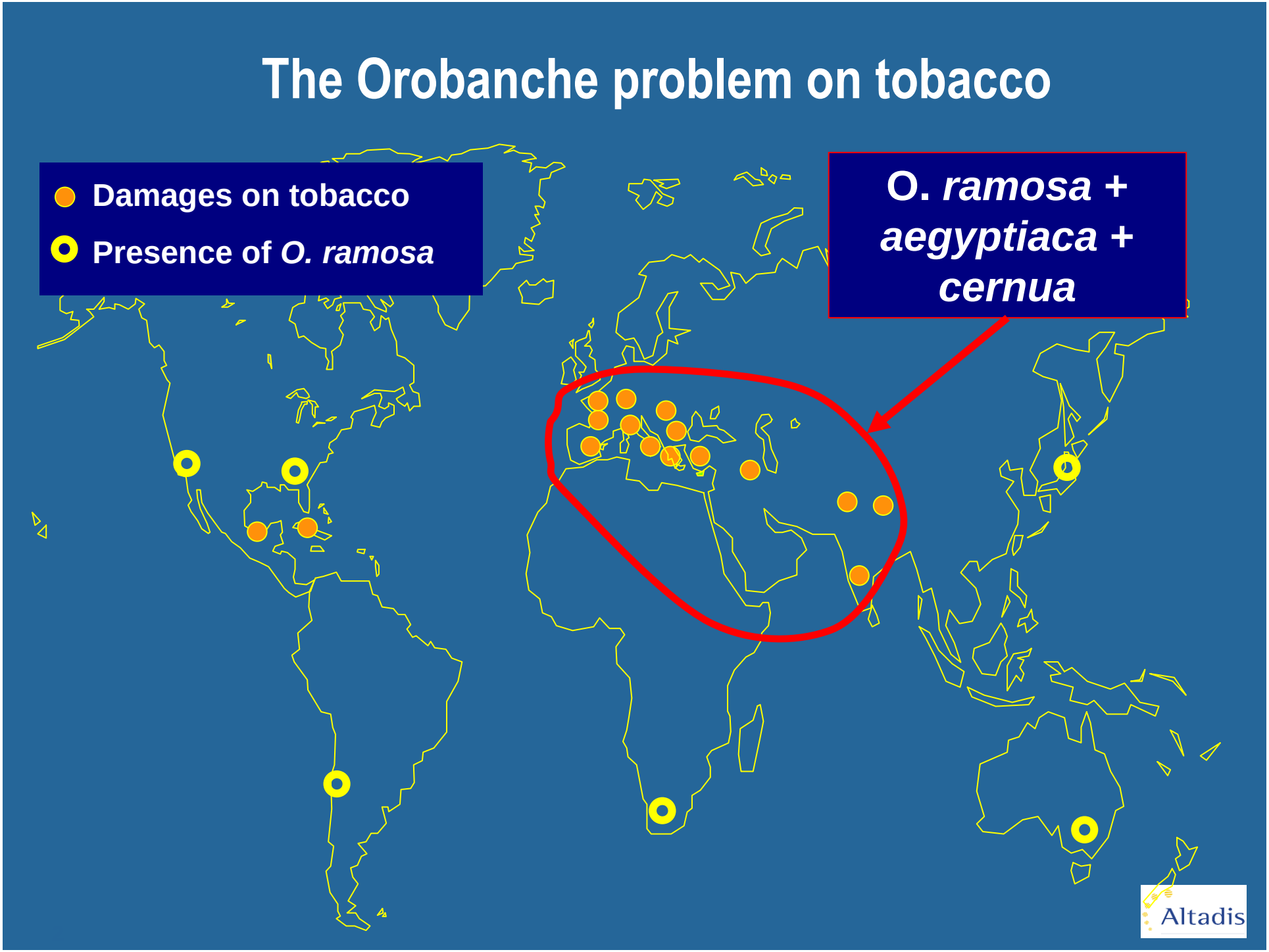
The Orobanche problem on tobacco



Orobanche: what does it look like ?

ANITTA trial,
Poitou tabac 2003

Reviews for *Orobanche* control

- ***DHANAPAL G.N. & STRUIK P.C. 1997.*** *Broomrape control in a cropping system containing bidi tobacco. J. Agronomy & Crop Sciences.*
- ***ELZEIN A. & KROSCHEL J., 2003.*** Progress on management of parasitic weeds. In "weed management for developing countries", Addendum 1. FAO Corporate Document Repository, Ag. Department.
- ***WEGMANN K., 2005.*** CORESTA Phytopatholgy Subgroup Broomrape Report 2005. CORESTA documents, CORESTA CD-ROM.
- This talk owes a lot to these reviews.
- **Recent fundamental findings concerning:**
  - ✓ Host resistance in *N. tabacum*
  - ✓ *Orobanche* seed germination stimulants in host root exudates
  - ✓ Biological control
- **Areas where research and experiments are needed ?**

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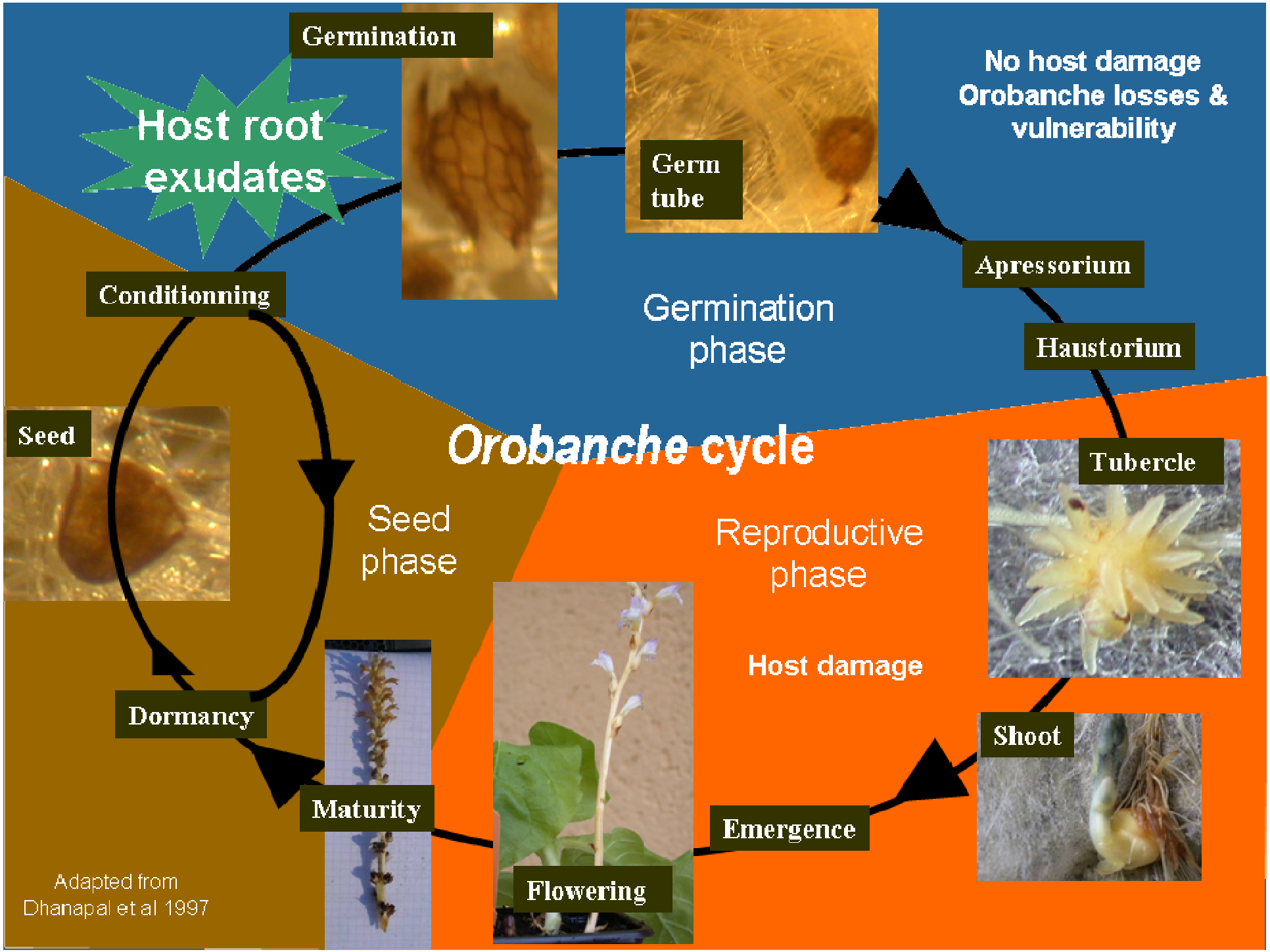
Germination
Host root exudates
Germ tube
No host damage
Orobanche losses & vulnerability
Conditionning
Germination phase
Apressorium
Haustorium
Seed
Orobanche cycle
Tubercle
Seed phase
Reproductive phase
Host damage
Dormancy
Shoot
Maturity
Emergence
Flowering
Adapted from Dhanapal et al 1997

General about Orobanche control in tobacco:

- **A lot of control measures available or needing experiments,**
  - ✓ Too many for this talk: only few will be addressed here
- **100% control does not seem to be a realistic target**
  - ✓ Combine control measures that have partial efficiency
- **Focus efforts on seed phase & germination phase.**
  - ✓ seed phase (in the absence of host): decrease the seed bank
  - ✓ germination phase : parasite vulnerability, prevention of host damage.
  - ✓ Control at the reproductive phase
    - Will only prevent the seed bank to increase
    - Most damages to the host already done

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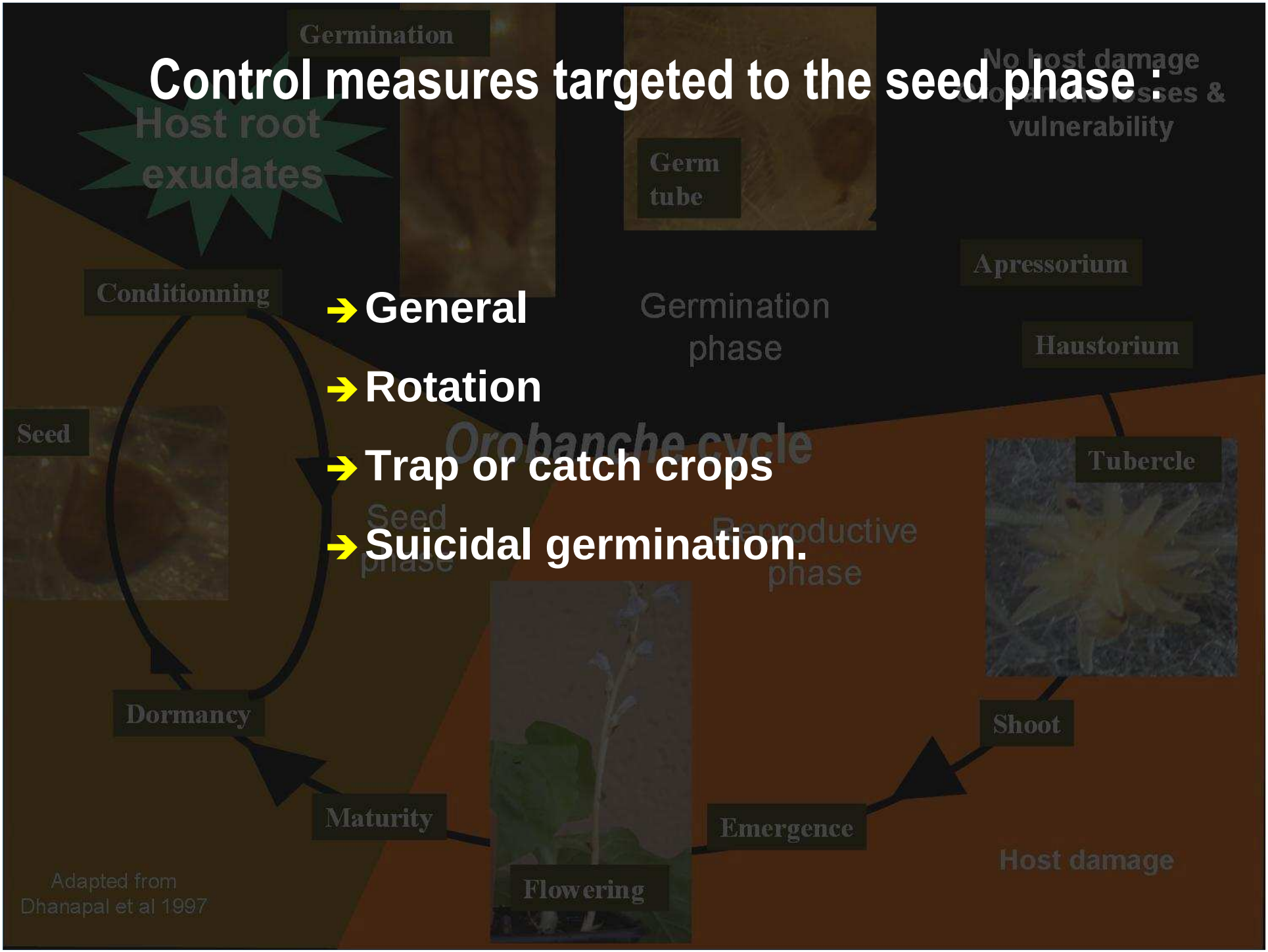
Control measures targeted to the seed phase :

- General
- Rotation
- Trap or catch crops
- Suicidal germination.



Control targeted to the seed phase: general

- **Efficiency = depletion of the *Orobanche* seed bank.**
  - ✓ Evaluation necessitates special means !
    - Soil sampling protocol, extracting & counting *Orobanche* seeds
    - Estimating viability (Tetrazolium test)…
  - ✓ Few experimental works assessed efficiency on *O. ramosa* / tobacco
- **Trap / catch crops: probably among the best control measures:**
    - reasonably efficient, possible other beneficial effects to the soil…
- **Few information concerning tobacco / *Orobanche*:**
  - ✓ Lack of "easy to see" results,
  - ✓ Lack of reported experiments / developed measures ?
  - ✓ Lack of interest ?

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Rotation

- **Natural decrease of the Orobanche seed bank in the absence of a host,**
  - ✓ Depends on soils, temperatures etc.
    - Not well known.
  - ✓ High longevity of Orobanche seed (> 20 years),
  - ✓ *O. ramosa* : the wide host spectrum makes it difficult to rotate with non hosts crops.
    - *O. ramosa* hosts: tomato, potato, tobacco, hemp, carrots, cucurbits, rapeseed, and many weeds (dicots)
- **Rotation alone: in most cases unlikely to provide control.**

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Trap / catch crops

- Trap: induce germination, first steps, but not parasitized
- Catch: parasitized → plough or kill
- Little knowledge
- Depends on Orobanche species !
- Trap/catch effect depend on cultivar !

	O. ramosa	*O. aegyptiaca*	*O. cernua*
Trap	*Carum ajowan* *Sinapis alba* Vetches Peas *Linum usitatissimum*	Sorghum	Sorghum *Capsicum annuum* Cowpea Sunnhemp Greengram
	Cotton		
Possible trap	Soybean, *Hibiscus sabdariffa*, *Dolichus uniflorus*, *Medicago* sp., Chickpea, *Guizonia abyssinica*…		
Catch		*Linum usitatissimum* *Phaseolus aureus*	

Wegmann 2005, Cubero & Moreno 1979, Kleifeld & al. 1994, Hosmani 1985, Krishna[illegible] et al. 1977, Krishnamurthy & Chandwani 1975, Dhanapal et al. 2001.

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Suicidal germination

➔ ***Orobanche*** **seed germination in the absence of a host by applying an inducing compound.**

- ✓ Conditioning period (2-3 weeks) before application: moisture, temperature > 15℃
- ✓ Tobacco transplantation not earlier than 15 days after treatment

➔ **Nijmegen 1 (formulated by BASF)**

- ✓ Efficient only on top soil layers (0-20 cm)
  - Miele et al., 2001. Improve formulation ?

➔ **Other products to be tried ? Laboratory tests:**

- ✓ “Liquid smoke”: Seed Starter ® (Chachalis & Murdoch 2006)
- ✓ Algit Super ® (Economou & Lyra 2006)

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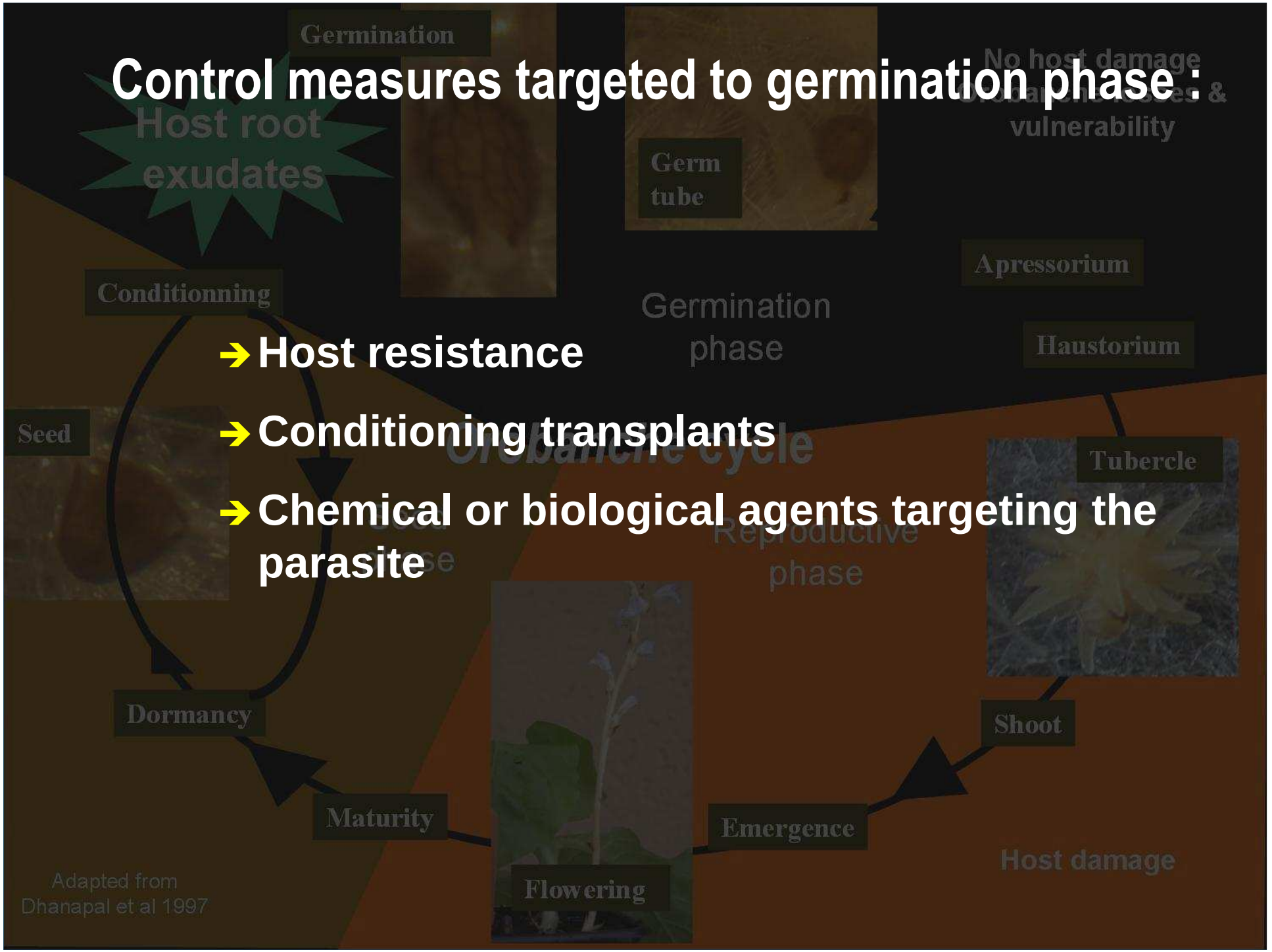
Control measures targeted to germination phase :



- Host resistance
- Conditioning transplants
- Chemical or biological agents targeting the parasite

Host resistance (1)

➔Herbicide resistance

- ✓ GM
- ✓ Non GM: chlorsulfuron, mutation breeding,
  - Gondola, 2004.

➔GM engineered resistance

- ✓ Westwood 2005,

➔Classical breeding

- ✓ No need of any compound
- ✓ Very partial success so far

Romania: Racovitza 1973, Bulgaria: Vinogradov et al. 1982, Italy: Covarelli 2000, India: Reddy et al., 1976, CTRI report 2001-02, France: Cailleteau et al. 2006

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Host resistance (2): classical breeding

➔**Breeding or screening efforts : Bulgaria, India, Romania, Turkey, France…**

- ✓ Independent, different approaches and conditions,
- ✓ No full resistance found in *Nicotianae*
- ✓ However, some variability for the intensity of parasitism, including within *N. tabacum*

➔***Low stimulation of Orobanche seed germination found to be the underlying mechanism in several cases:***

- Vinogradov et al., 1982, recessive inheritance, mutation breeding
- Covarelli 2000 (BC60 FB),
- Cailleteau et al. 2006 (Wika)

➔**Other host resistance mechanism proven in tobacco: phytoalexin synthesis (Gonsior, 2005)**

Romania: Racovitza 1973, Bulgaria: Vinogradov et al. 1982, Italy: Covarelli 2000, India: Reddy et al., 1976, CTRI report 2001-02, France: Cailleteau et al. 2006

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Conditioning transplants (1)

➔ Amino acids.

- ✓ Methionin showed some protecting effect when applied to the roots of tomato transplants
  - Vurro et al. 2006

➔Vesicular Arbuscular Mycorrhizal fungi (VAM).

- ✓ Sorghum: VAM field inoculation protected Sorghum against Striga. Lendzemo et al., 2005.
  - Linked to reduced Striga germination: Lendzemo et al. 2007
- ✓ Striga and Orobanche germination stimulant molecules fundamental in VAM / host plant interaction.
  - Akiyama, 2005.
- ✓ Tobacco does exudate GS from the strigol family
  - Xie et al., 2007. 2 new strigol molecules.

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Conditioning transplants (2)

➔Fertilization.

- ✓ Higher N & P fert. at early stage may have a protective effect.
- ✓ N: reviewed in Dhanapal, 1991.
- ✓ P: may be linked to GS exudates
  - "Phosphorus deficiency in red clover promotes exudation of Orobanchol, the signal for mycorrhizal symbionts and germination stimulant for root parasites", Yoneyama et al. 2006.

➔Inhibition of GS synthesis by applying an exogenous molecule

- ✓ GS biosynthetic pathway originates from some step in the carotenoid biosynthesis (Matusova et al, 2005, Denev et al. 2007)
- ✓ Herbicides or other compounds having an inhibiting effect on this pathway could diminish GS synthesis, therefore parasitism.

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Conditioning transplants (3)

➔ Systemic Acquired Resistance (SAR) induction:

- ✓ Gonsior et al. 2004.
- ✓ Not confirmed in field for tobacco (N. Billenkamp in CORESTA Orobanche SG report)

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Chemical or biological agents targeting the parasite

- **Many studies concerning direct effect of herbicides applied to the host on young *Orobanche***
  - ✓ Appressorium / young tubercle
  - ✓ MH seems one of the most interesting compound
- **“Pesta” ®, granular biological product containing a specific *Fusarium oxysporum* strain.**
  - ✓ Mycoherbicide (production of fusaric acid, 10611 dehydrofusaric acid and their mehtyl-esters)
  - ✓ Reviewed in Kroschel et al. 2005

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Conclusion

- **A diversified set of potential new control means**
- **Needed :**
  - ✓ New res. and field experiments,
  - ✓ Exchange of information

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