A close-up photograph of a wheat spikelet, showing the green, pointed glumes and the developing grain. The background is a clear, bright blue sky. The text is overlaid on the right side of the image.

Intro to aphid resistance in wheat

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Aphids as wheat pests

- Direct and indirect damages
- Yield reduction (30-40%)
- Transmission of viral diseases (60%)
- Honey dew (black molds)
- Wide distribution



Wheat pests and climate change

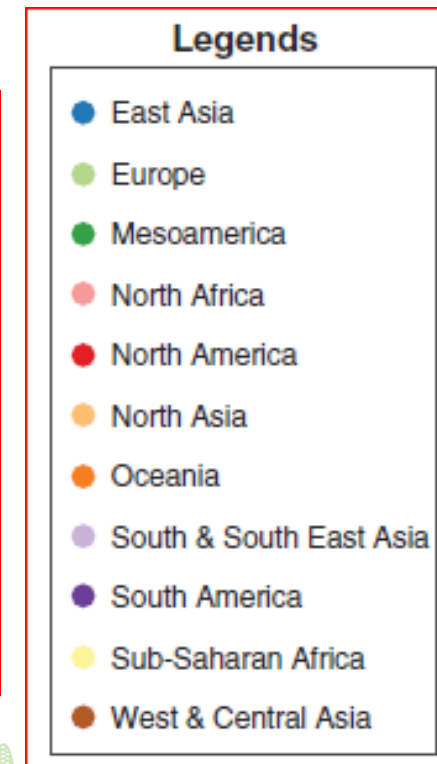
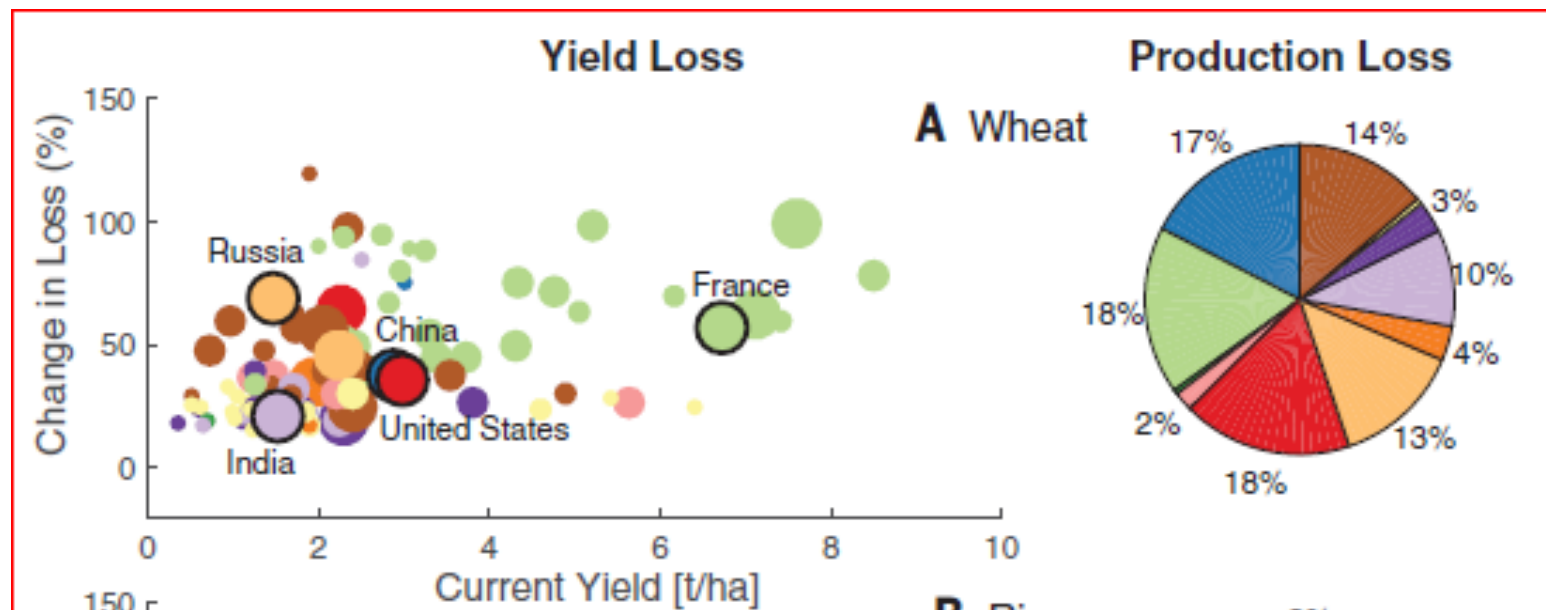
- Insect physiology, behavior, voltinism and distribution are expected to be modified.
- Direct effects:
 - Temperature
 - CO₂
- Indirect effects:
 - Plant C:N ratio
 - Activation of basal defenses
 - Secondary metabolites (defensive compounds)



Wheat pests and climate change

“Global warming will increase pest population growth and overwinter survival rates, leading to large population increases in the growing season”

The increased adaptation will likely conduce to a greater use of pesticides

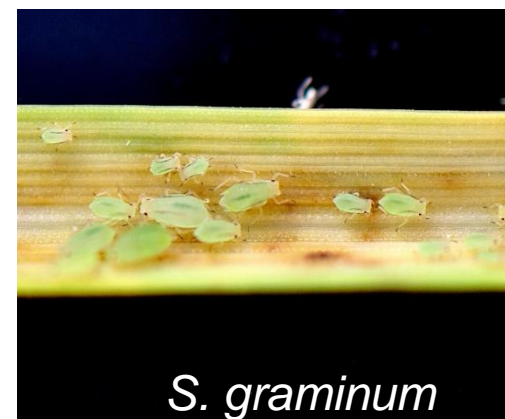


Deutsch et al., Science 361, 916–919 (2018)

Aphid species in wheat

- Aphid species:

- Greenbug [*Schizaphis graminum* (R.)]
- Bird cherry-oat aphid (*Rhopalosiphum padi* L.)
- English grain aphid [*Sitobion avenae* (F.)]
- Russian wheat aphid (*Diuraphis noxia* M.)
- Rose grain aphid [*Metopolophium dirhodum* (W.)]
- Corn leaf aphid [*Rhopalosiphum maidis* (Fitch)]
- Root aphid [*Rhopalosiphum rufiabdominalis* (Sasaki)]
- Sugar cane aphid [(*Sipha flava* (Forbes))]
- *Sitobion fragariae* (W.)
- ...



The categories of resistance to insects, and how to measure it

- Plant resistance to insects definition: **Set of plant characteristics with genetic base that make the plants to avoid, reduce or endure insect damage.**
 - Antixenosis
 - Antibiosis
 - Tolerance

Categories of resistance \neq Mechanisms of resistance



Antixenosis

Painter in 1951 called this "non-preference". Kogan and Ortman in 1978 suggested **Antixenosis**.

First defensive line of plants, but... **Not very reliable in large scales!!!**

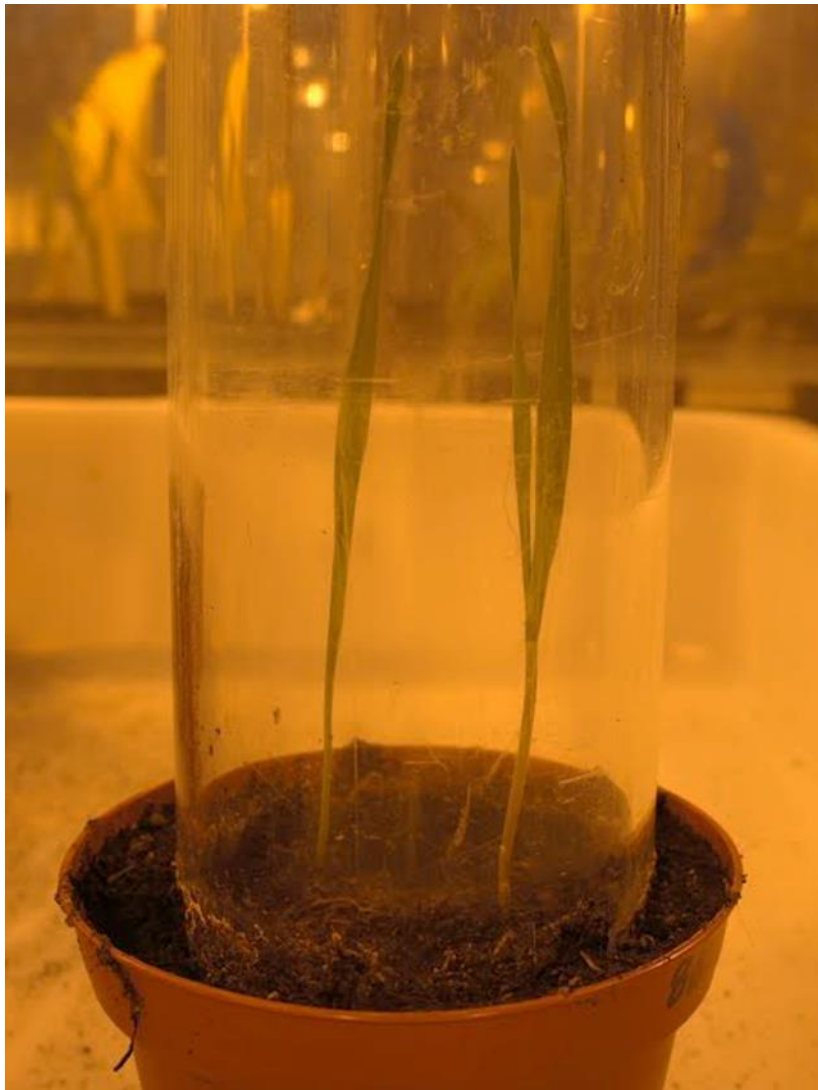
It affects host finding and acceptance processes

The sensory systems of the insects are engaged, i.e. olfaction, vision, gustation, thigmoreception, etc.

HOW DO WE MEASURE ANTIXENOSIS



No-choice evaluations & Free-choice evaluations



Antibiosis

Leads to higher mortality rates, reduced body size and fecundity, etc.

Measured on the aphid side

- Intrinsic rate of increase (r_m)
 - $r_m = 0.74 * [\ln(\text{No. of nymphs})/d]$
- Mean relative growth rate (MRGR)
 - $MRGR = [\ln(w_2) - \ln(w_1)]/T$
- Aphid weight (Relative growth)

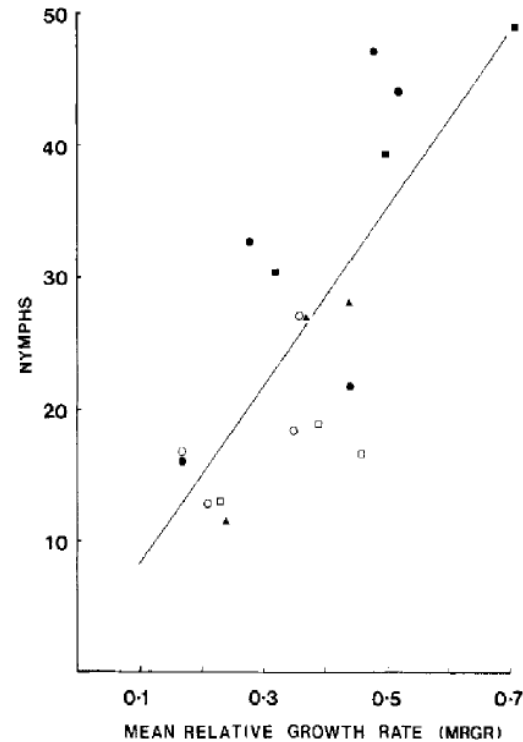


Fig. 2. The number of nymphs produced in seven days on different grasses in relation to the aphids MRGR: $y = 66.7x + 1.6$, $r = 0.77$, $df = 16$, $P < 0.001$.

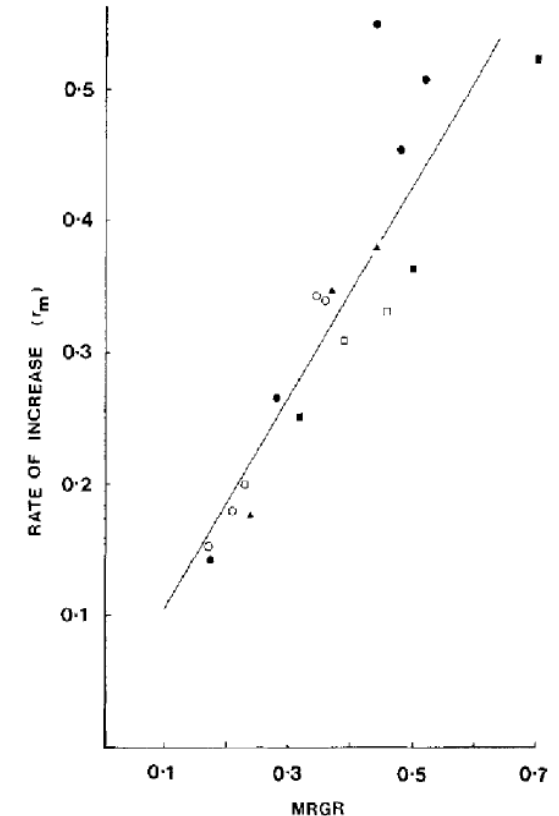
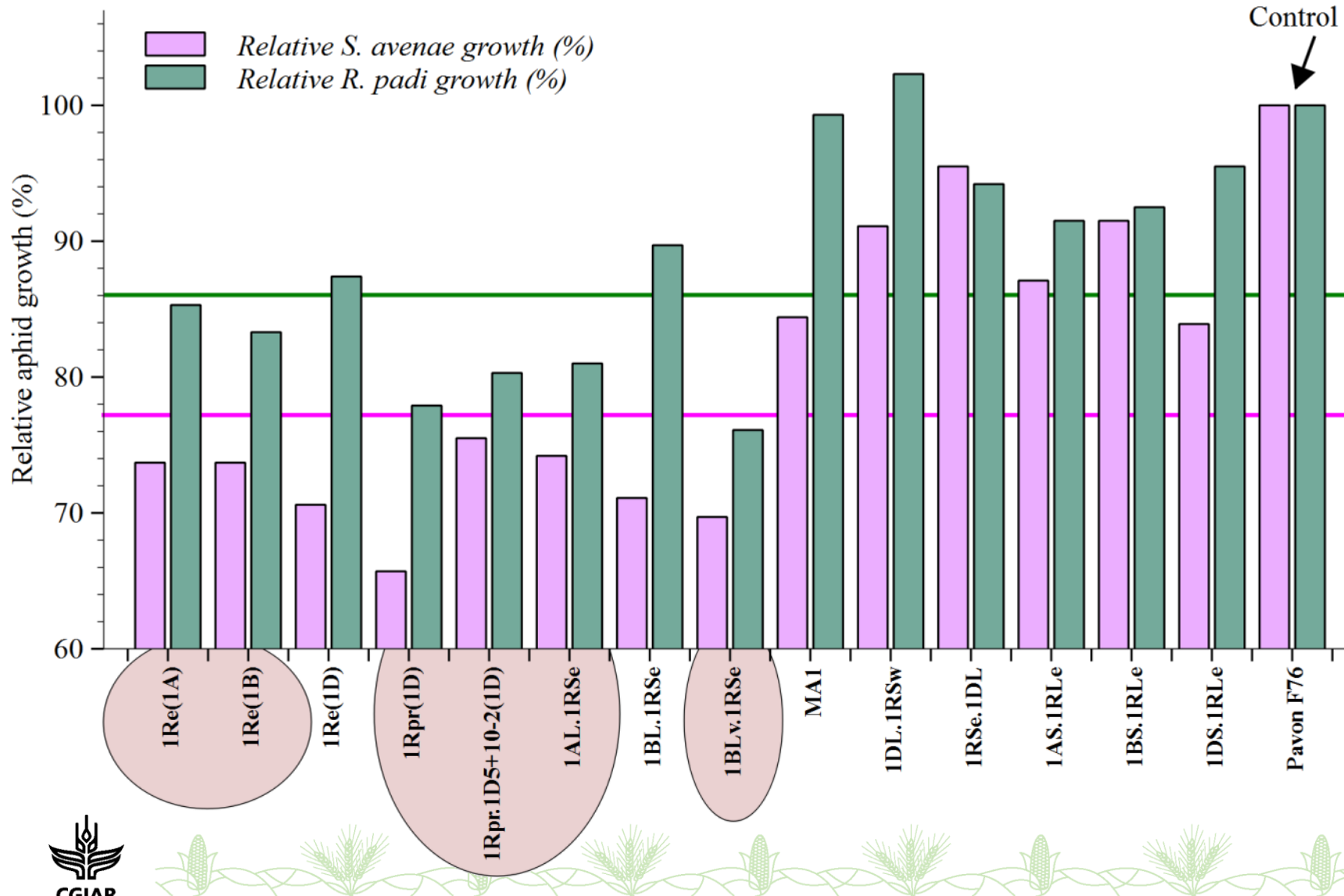


Fig. 3. The intrinsic rate of natural increase (r_m) in relation to the mean relative growth rate (MRGR) of *R. padi* on different hosts at different temperatures.

We measure antibiosis in No-choice tests



R. padi & *S. avenae*



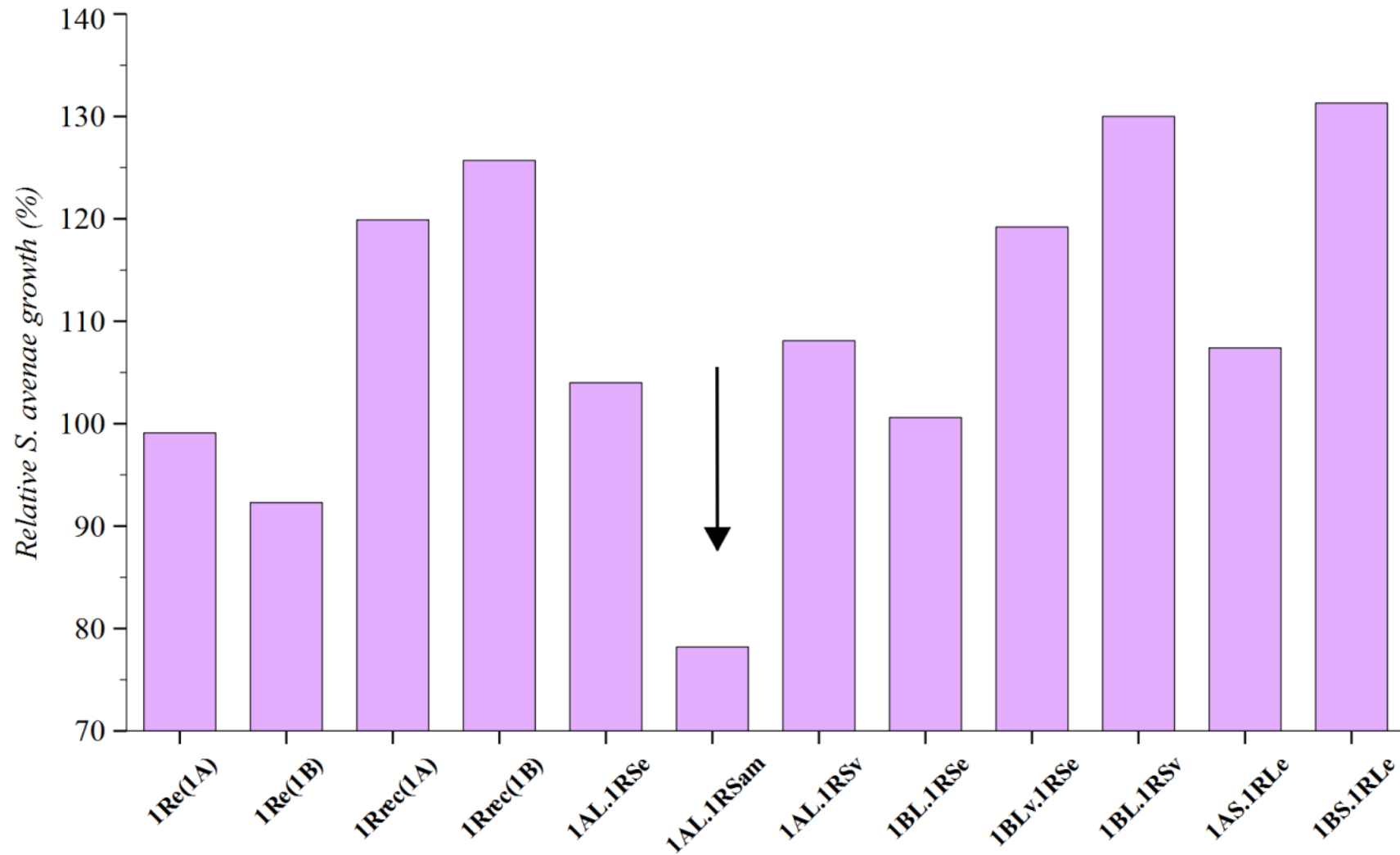
Arthropod-Plant Interactions
DOI 10.1007/s11829-013-9267-y

ORIGINAL PAPER

Resistance to multiple cereal aphids in wheat–alien substitution and translocation lines

Leonardo A. Crespo-Herrera · C. Michael Smith · Ravi P. Singh · Inger Ahman

S. avenae - adult plant tests

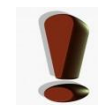


Tolerance

Highly complex.

Tolerant plants can:
continue growing
recover
add new growth

It is very important to consider the aphid species to be evaluated



TOLERANCE IS MEASURED ON THE PLANT NOT ON THE INSECT SIDE

- Biomass
- Chlorophyll (for certain species)
- Symptoms
- Yield

How do we reduce the confounding effects

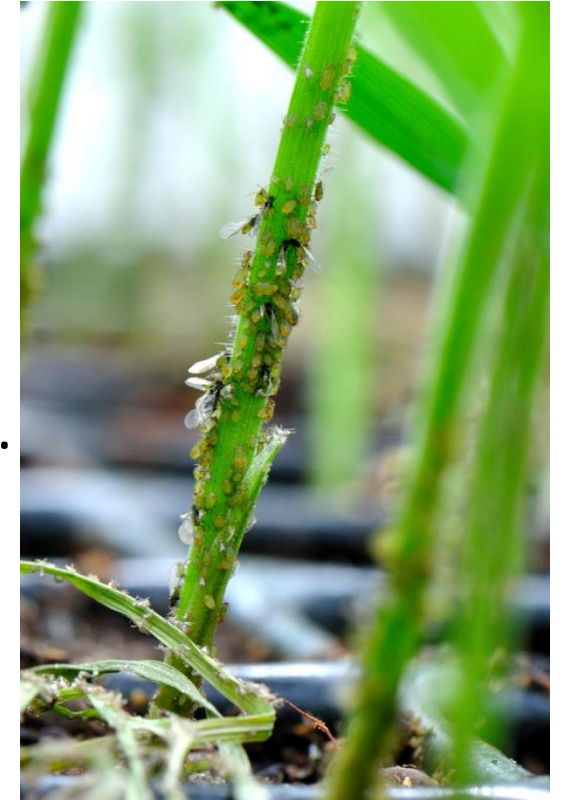


Infested plants should have the same insect density

Non-infested



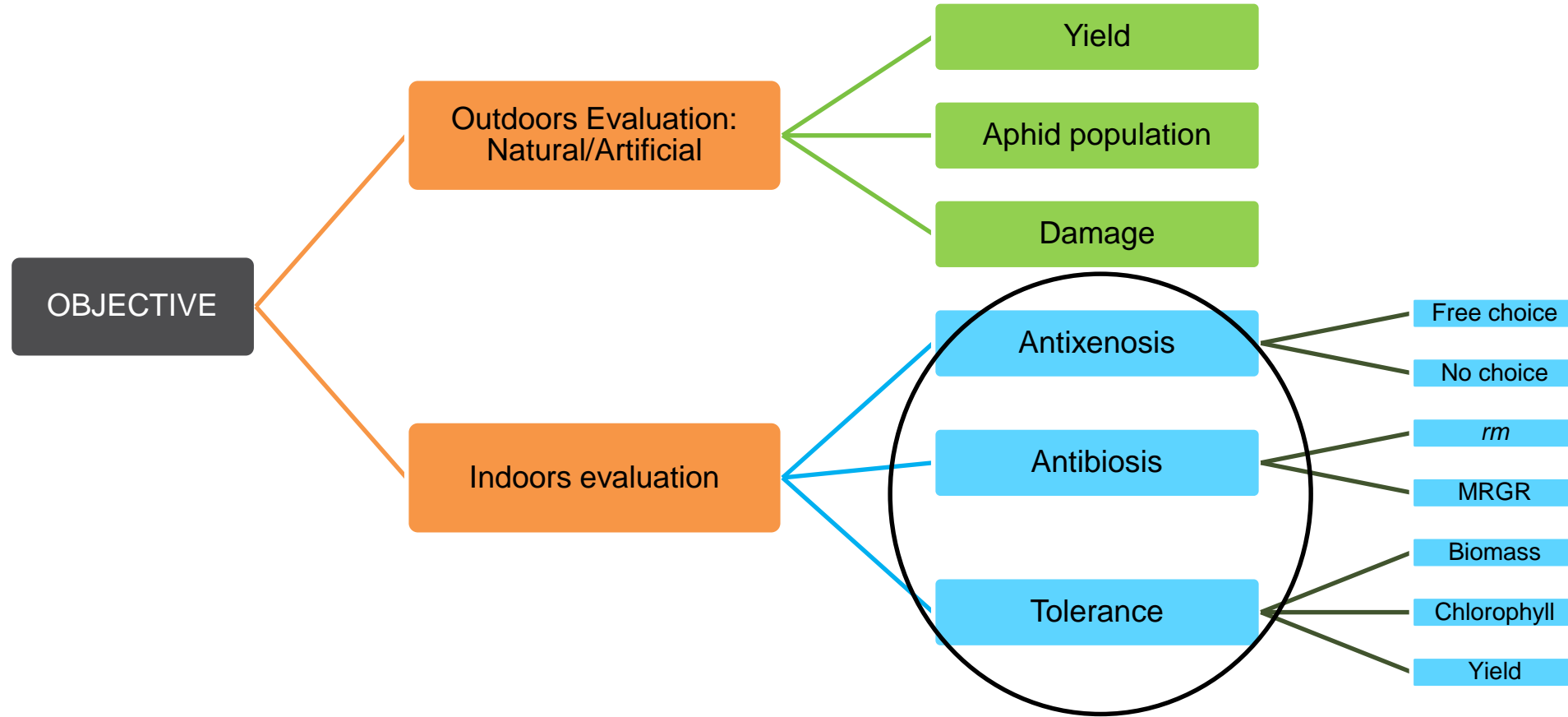
Infested



VS.

Objective of the evaluation

What questions we want to answer
What do we want to achieve?



Categories of resistance



Rearing establishment

S. graminum

22 °C \pm 2.0 °C; 16:8 photoperiod

Susceptible host

R. padi

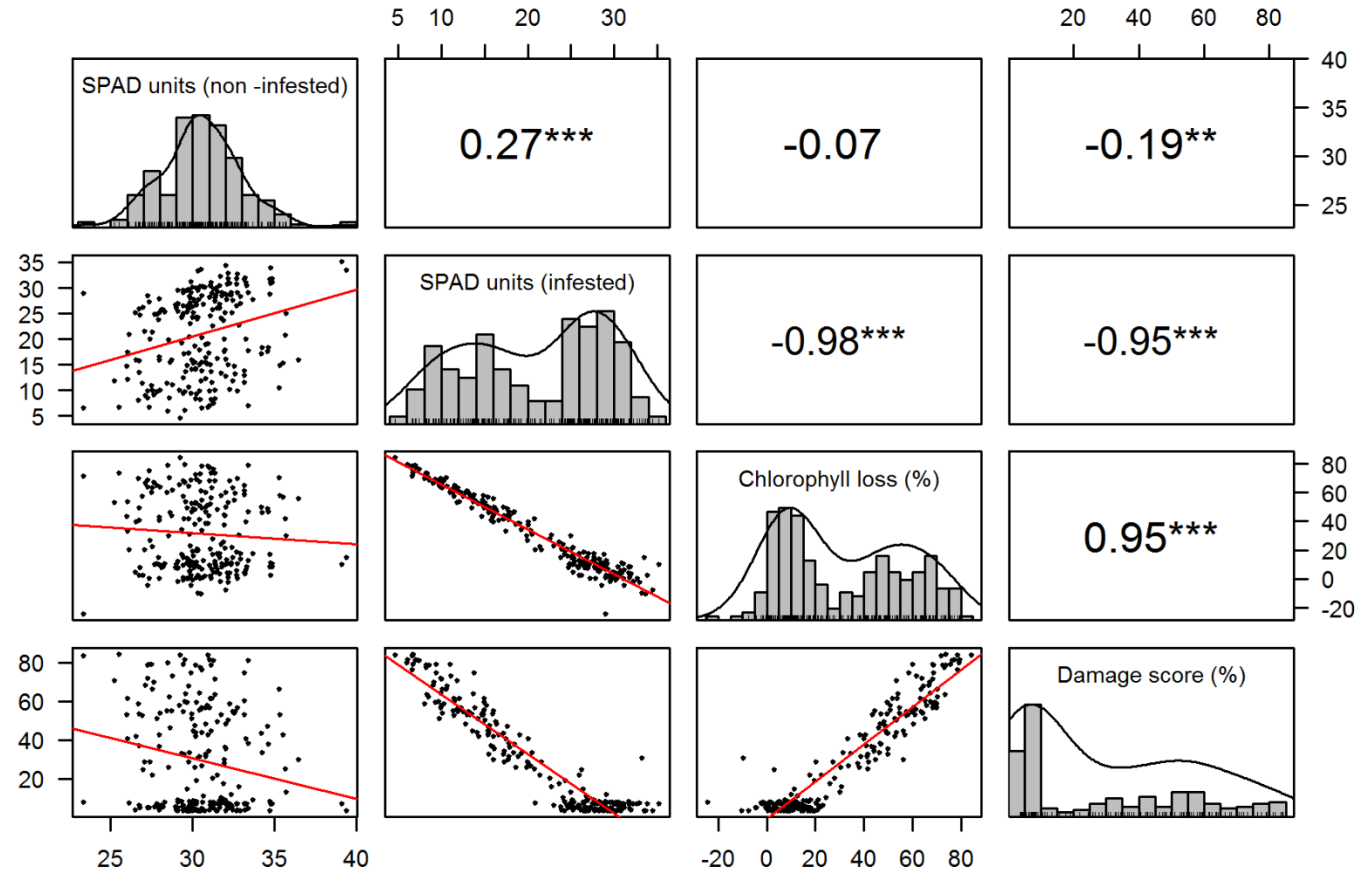
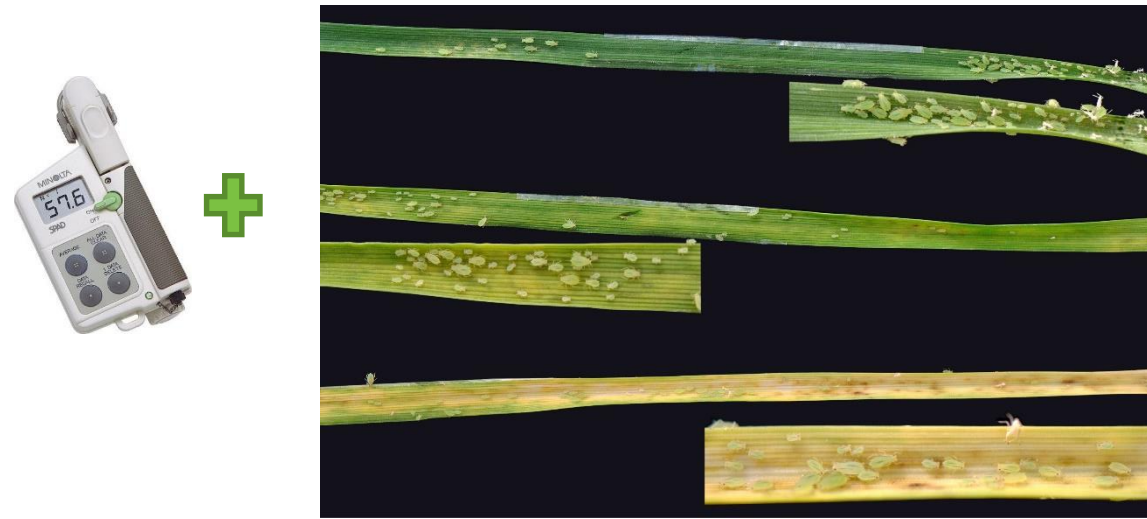


Testing conditions

- For seedling tests:
 - Controlled temperature ($22^{\circ}\text{C} \pm 2^{\circ}\text{C}$)
 - Controlled photoperiod (16:8)
 - Enough space for seedlings to grow



Tolerance to *S. graminum* feeding



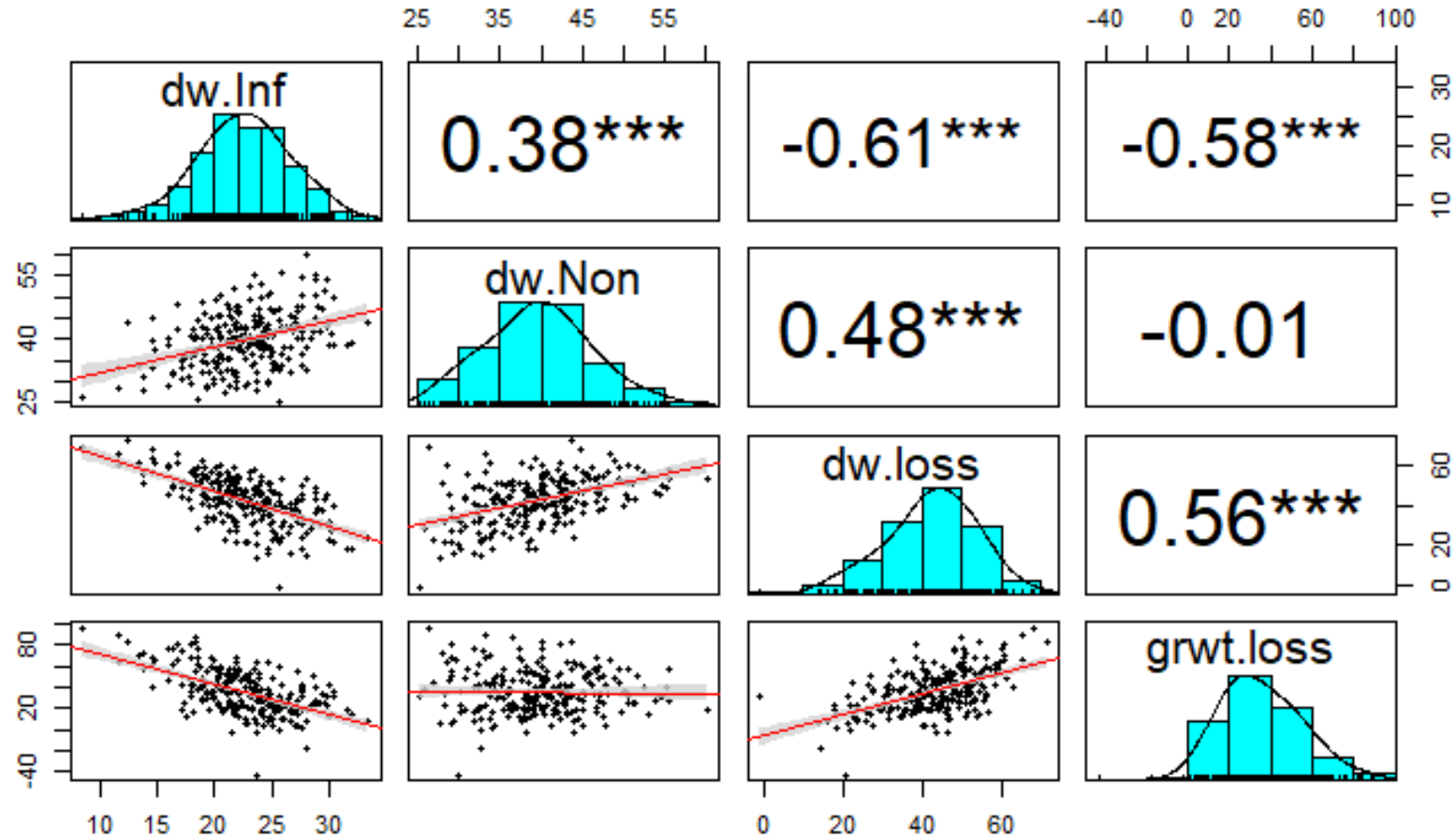
Genetics of Greenbug Resistance in Synthetic Hexaploid Wheat Derived Germplasm

Leonardo Crespo-Herrera^{1*}, Ravi P. Singh¹, Matthew Reynolds¹ and Julio Huerta-Espino²

¹ Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT), Global Wheat Program, Mexico, Mexico, ² Campo Experimental Valle de Mexico, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP), Chapingo, Mexico



Tolerance to *R. padi*

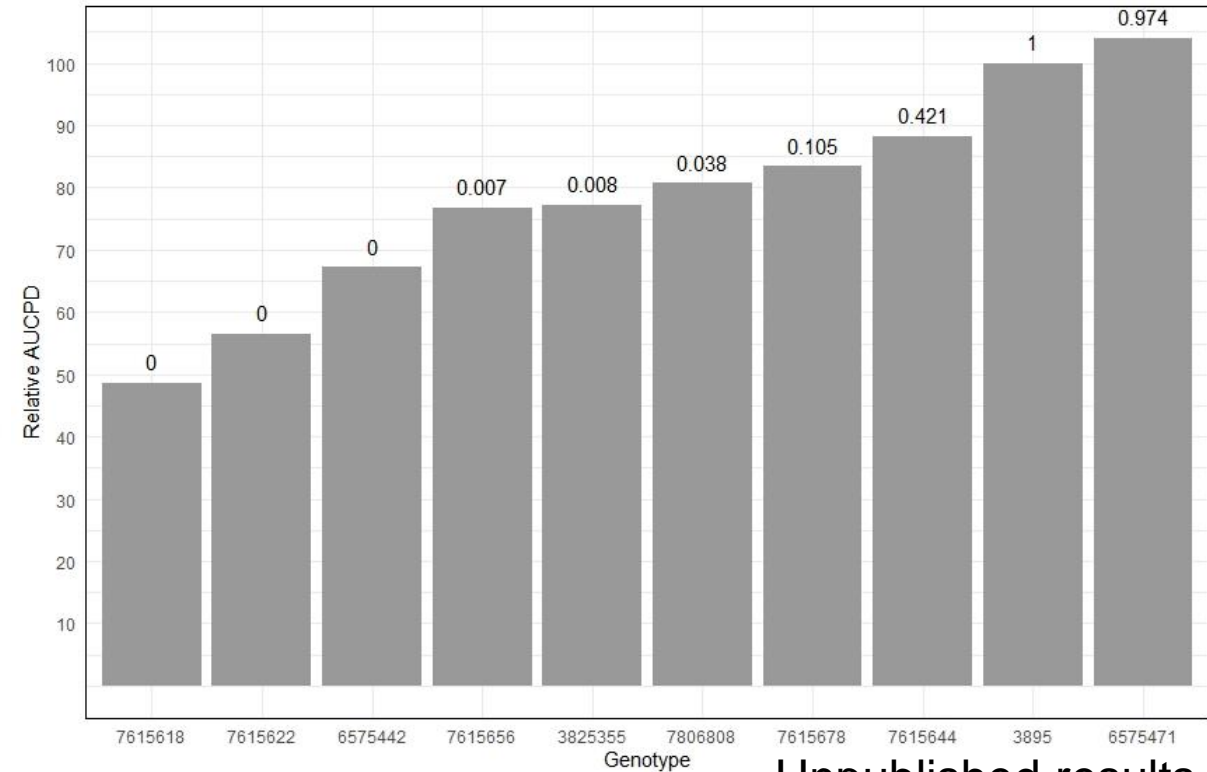
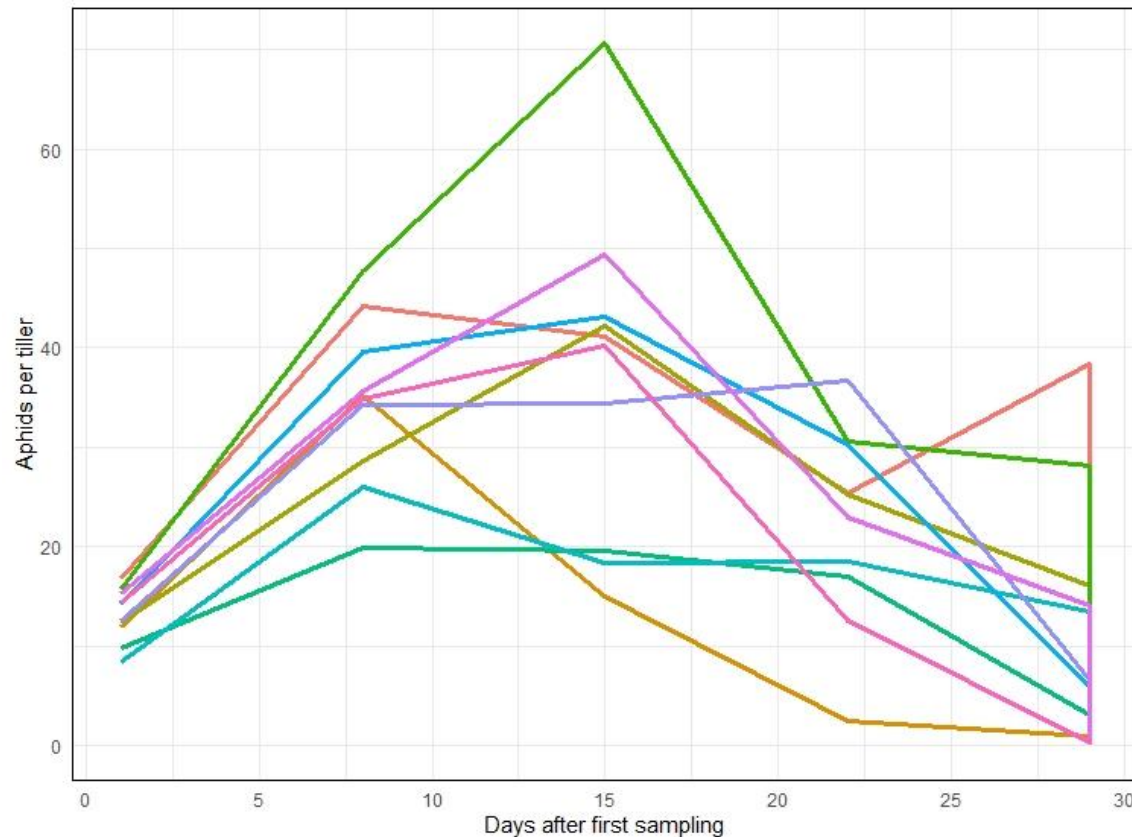


Field infestations

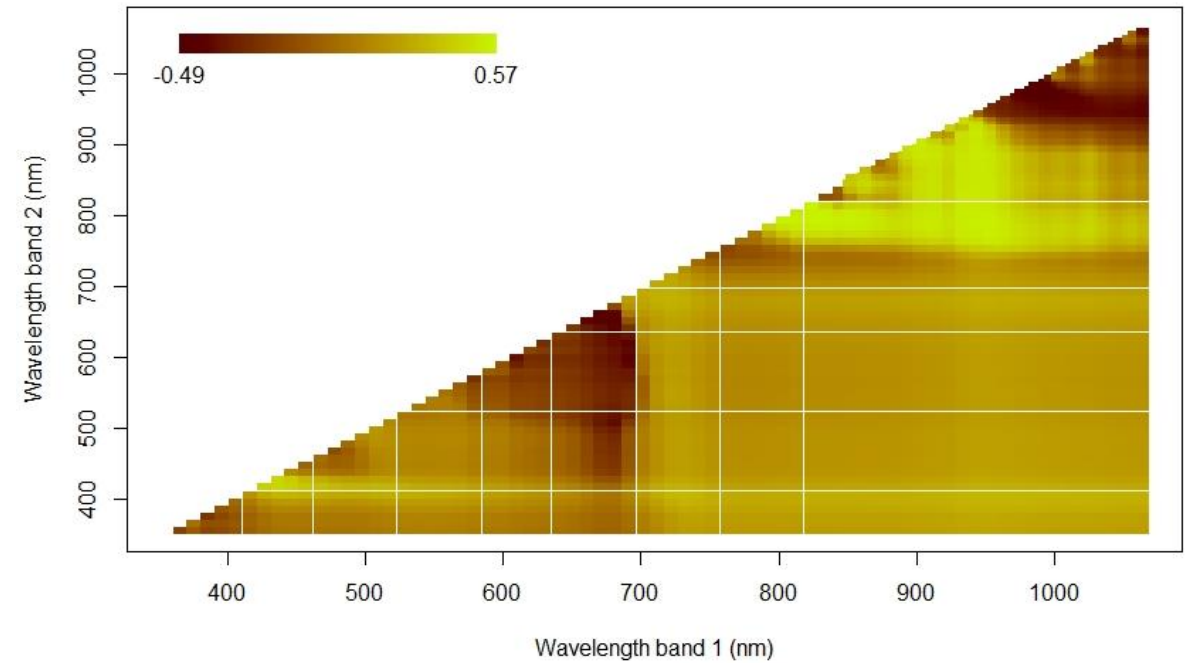
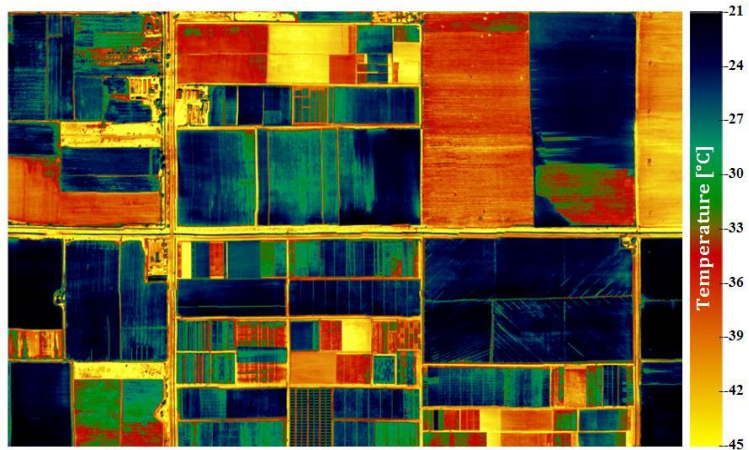


Population development in the field

R. padi field population with artificial infestation (early January)
Weekly samplings, one year evaluations



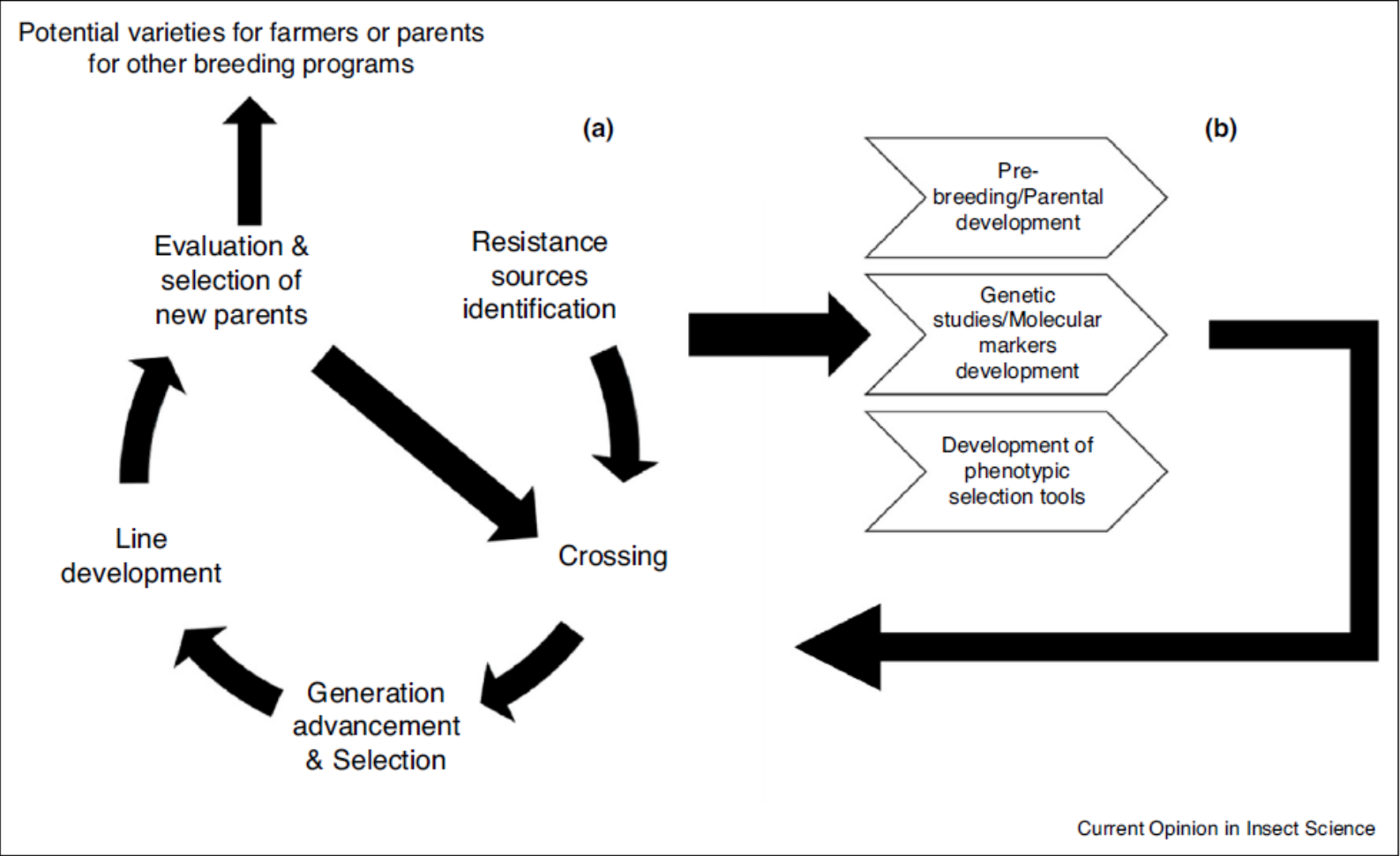
Remote Sensing



Unpublished results



Breeding



Aradottir and Crespo-Herrera, Current Opinion in Insect Science 45, 59-68 (2021)



Final remarks

- Classical aphid resistance phenotyping is very challenging: time consuming and labor intensive. Exploration of new phenotyping tools.
- It is important to consider what aphid species is going to be evaluated
- Having a rearing in good shape is fundamental
- Testing conditions can be relatively simple and cheap for quick evaluations and no so complex experiments



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