Sustainable global food production

Prof Toby Bruce

Keele University

Reaping the benefits

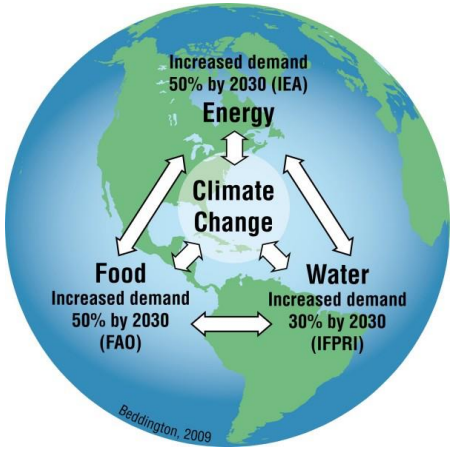
Science and the sustainable intensification of global agriculture

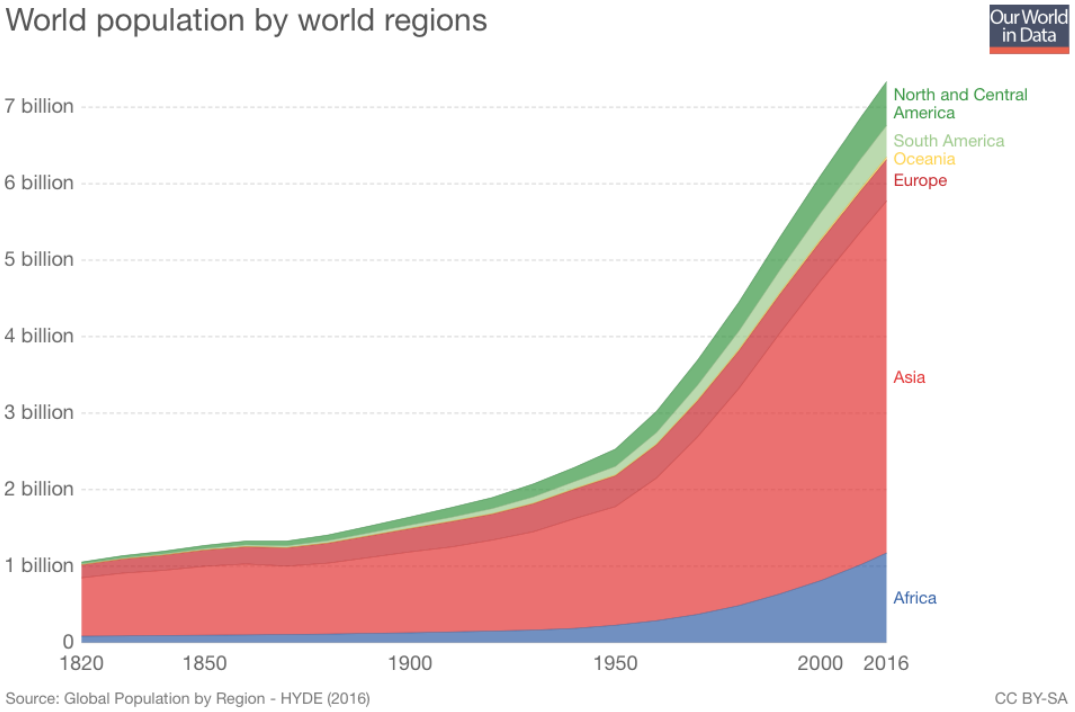
October 2009

"*There is a pressing need for the '**sustainable intensification**' of global agriculture in which yields are increased without adverse environmental impact and without the cultivation of more land*".

CELEBRATE 350 YEARS

THE ROYAL SOCIETY





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Agricultural environments are simplified and are vulnerable to pests

Lush monocultures of artificially selected high yielding varieties grown with fertiliser

“High yielding varieties”






Wild plants have evolved to withstand attack from insects

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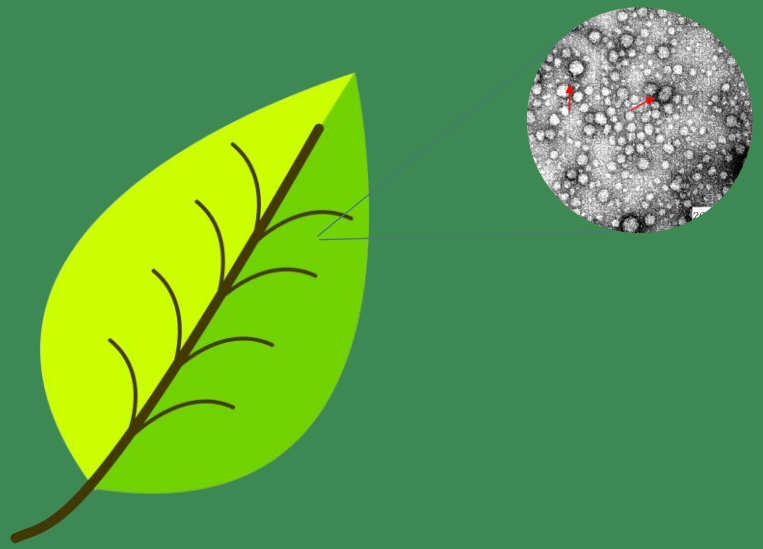
Nanoformulations of novel phytochemical treatments

Crop plants have lost many of the phytochemicals that protect wild plants.

Here we provide a means for treating crops with specialised metabolites from other plants that will defend them from attacking pests…



- Antibiotics
  - -> contact
  - -> fumigant
- Antifeedants
- Oviposition inhibitors
- Fecundity inhibitors
- Repellents
- Attractants for natural enemies



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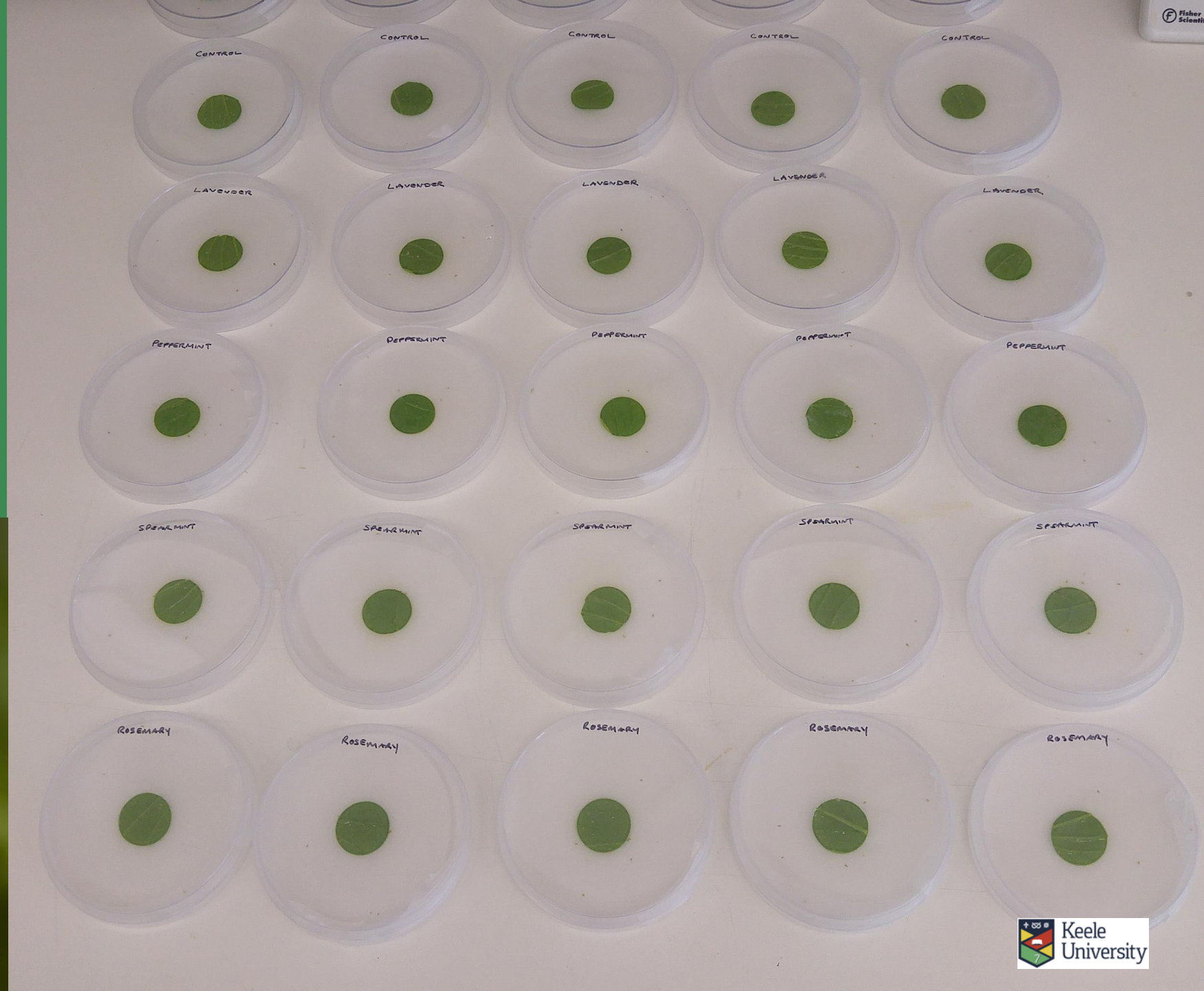
Aphid (*Myzus persicae)* bioassay



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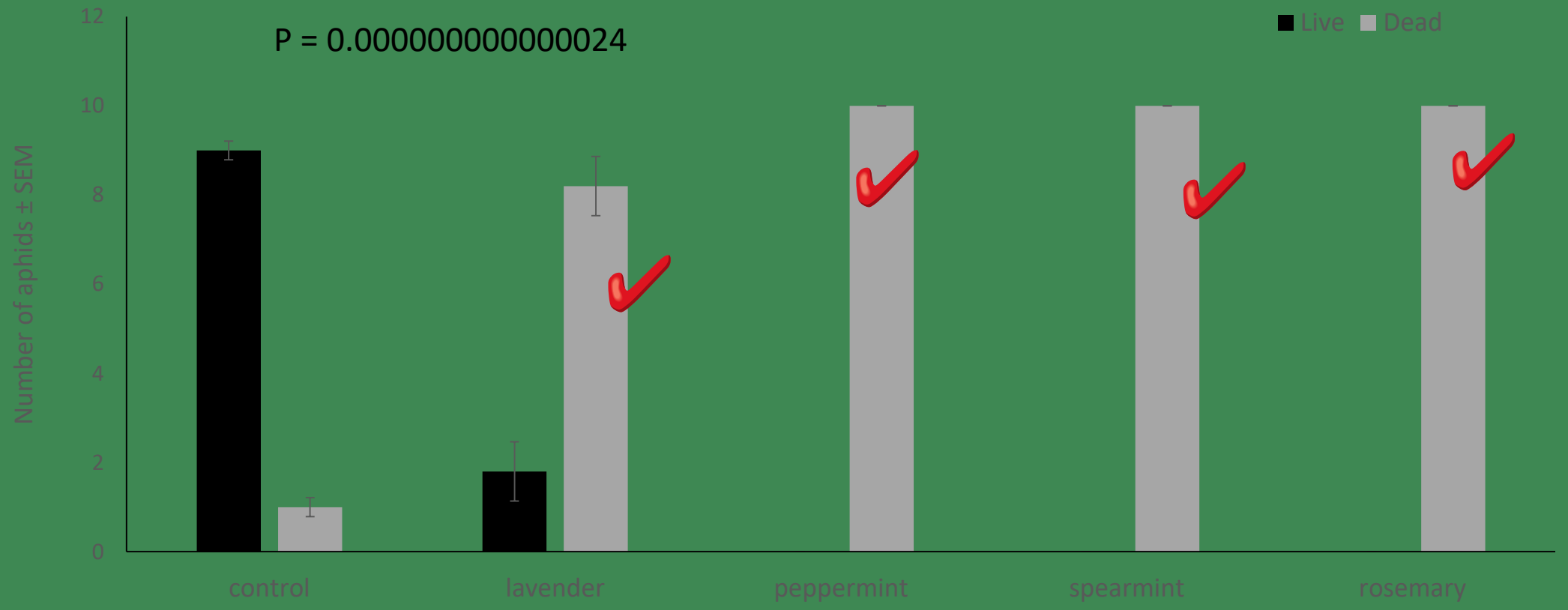
Aphid mortality after 24h, oils in PAA nanoformulation



Survival of *Myzus persicae* after 24h in Petri dish bioassay with treated leaf discs - **PAA nanotech formulation**. Control has a blank formulation. Essential oils were 7mg/ml solutions, 75 µL per disc. Difference between means; ANOVA: $P < 0.001$

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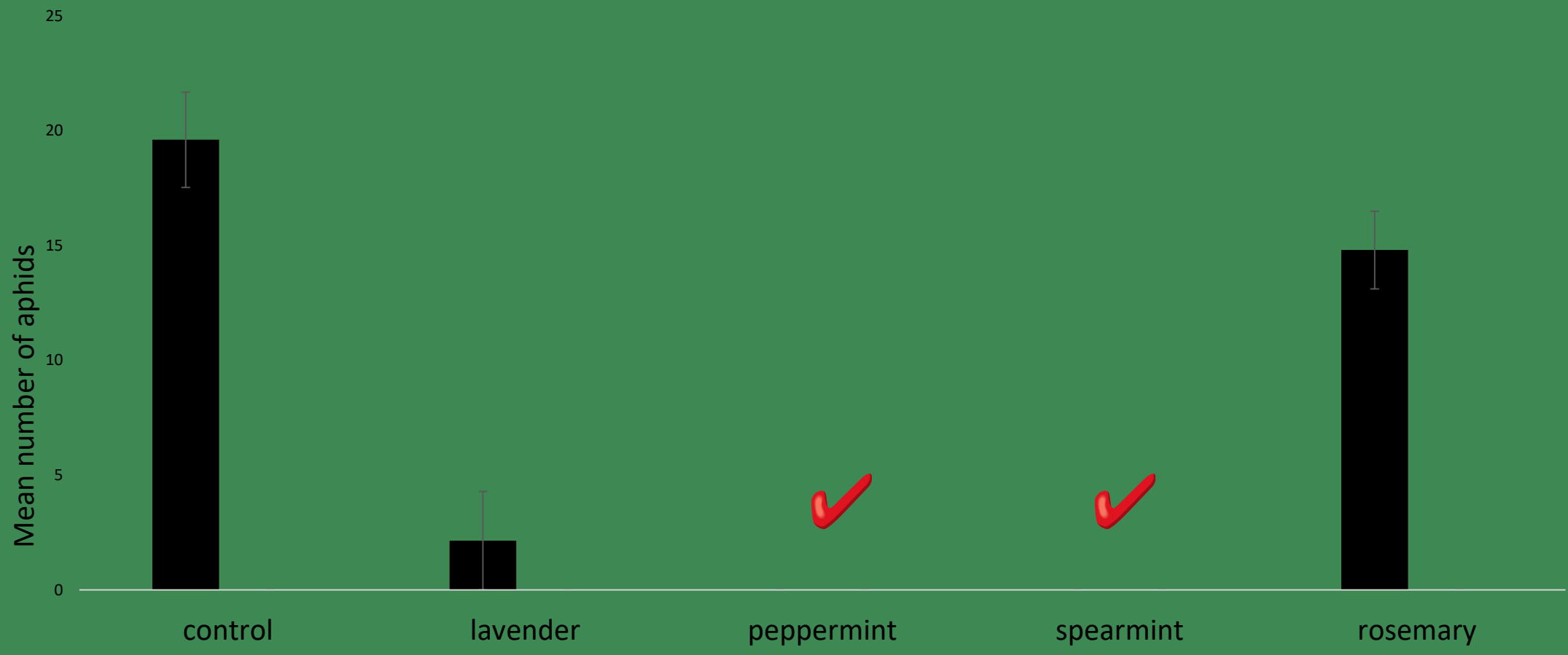
Aphid fecundity, after 24h, oils in PAA nanoformulation – treated 24h before start



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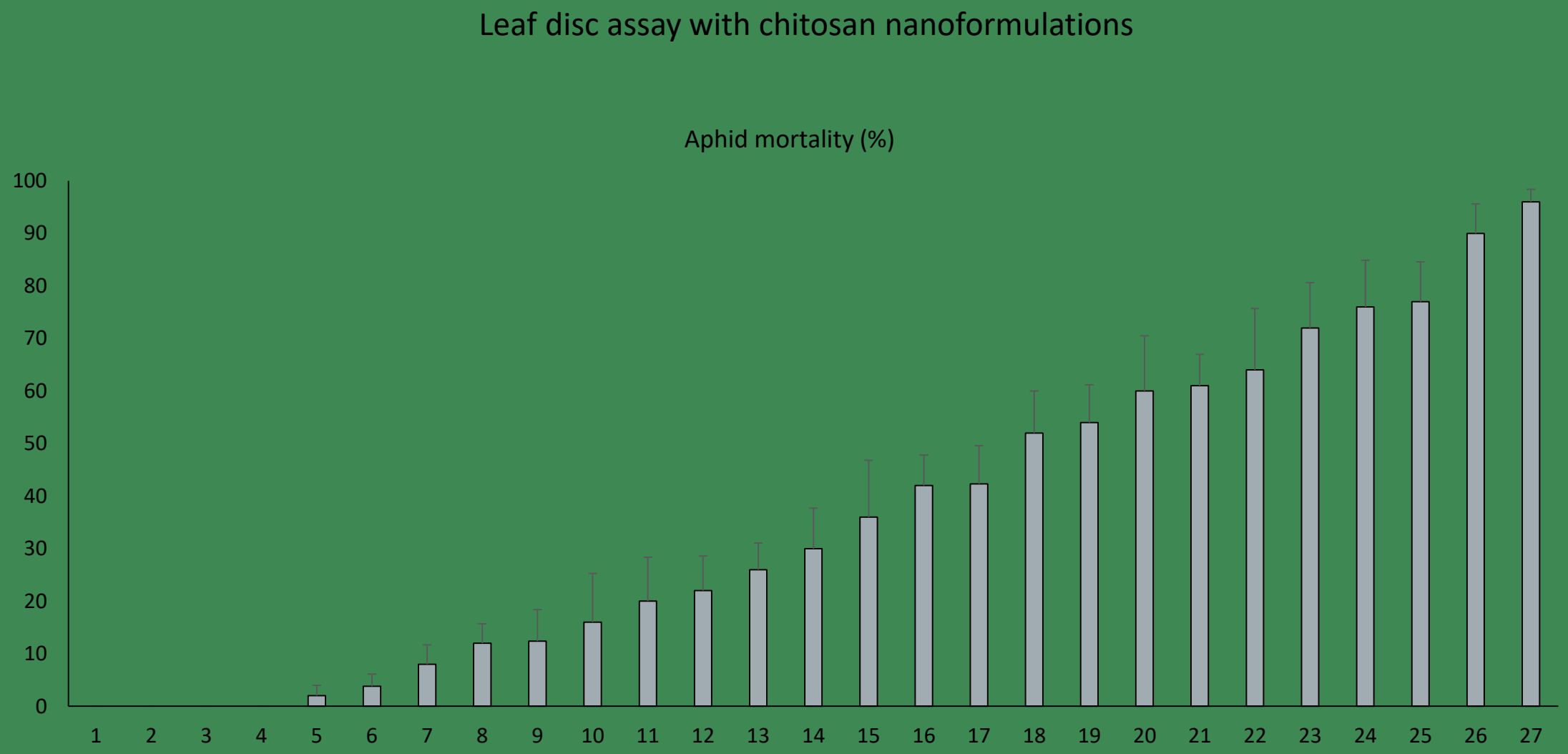
Aphid mortality with different phytochemical treatments



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CULTIVATED
(***Solanum tuberosum***
cv. 'Desiree')

WILD
(***Solanum stoloniferum*** **–**
selected lines)

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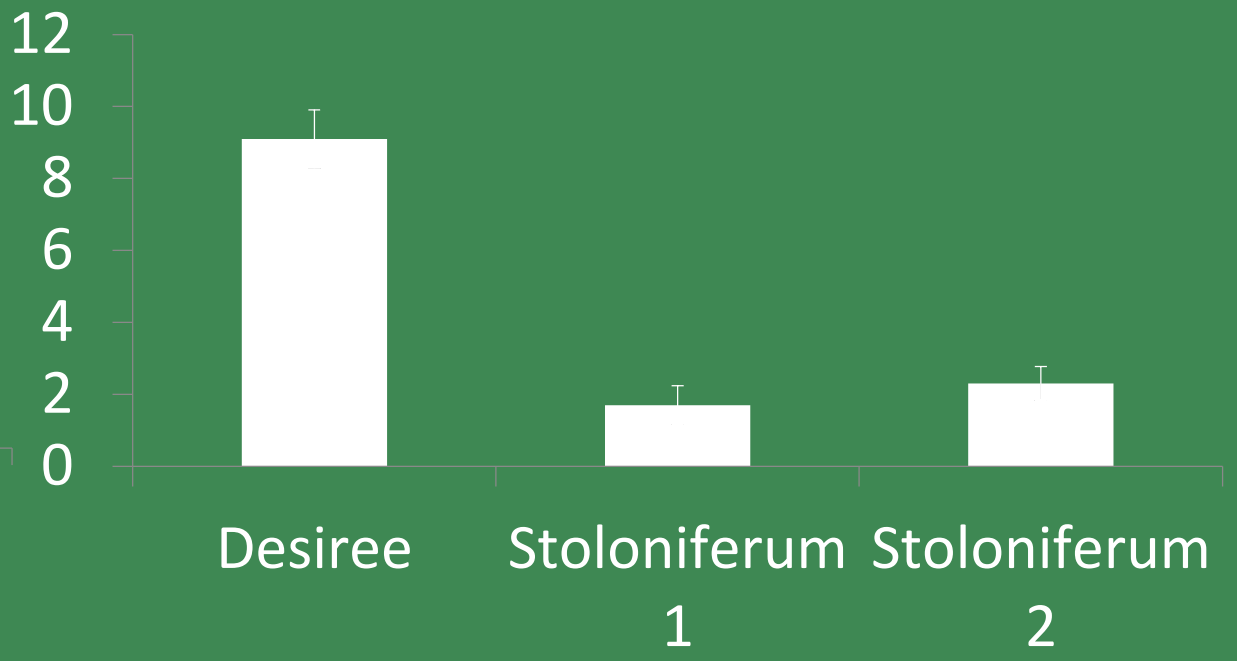
Adults settled – 24h

Nymphs produced - 24h



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% Nymph survival - 7 days
100
80
60
40
20
0
Desiree
Stoloniferum 1
Stoloniferum 2

Stemborers: 15 - 80% yield losses to maize Africa

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Striga: 30-100% yield losses to maize, up to 80% yield losses to sorghum in Africa

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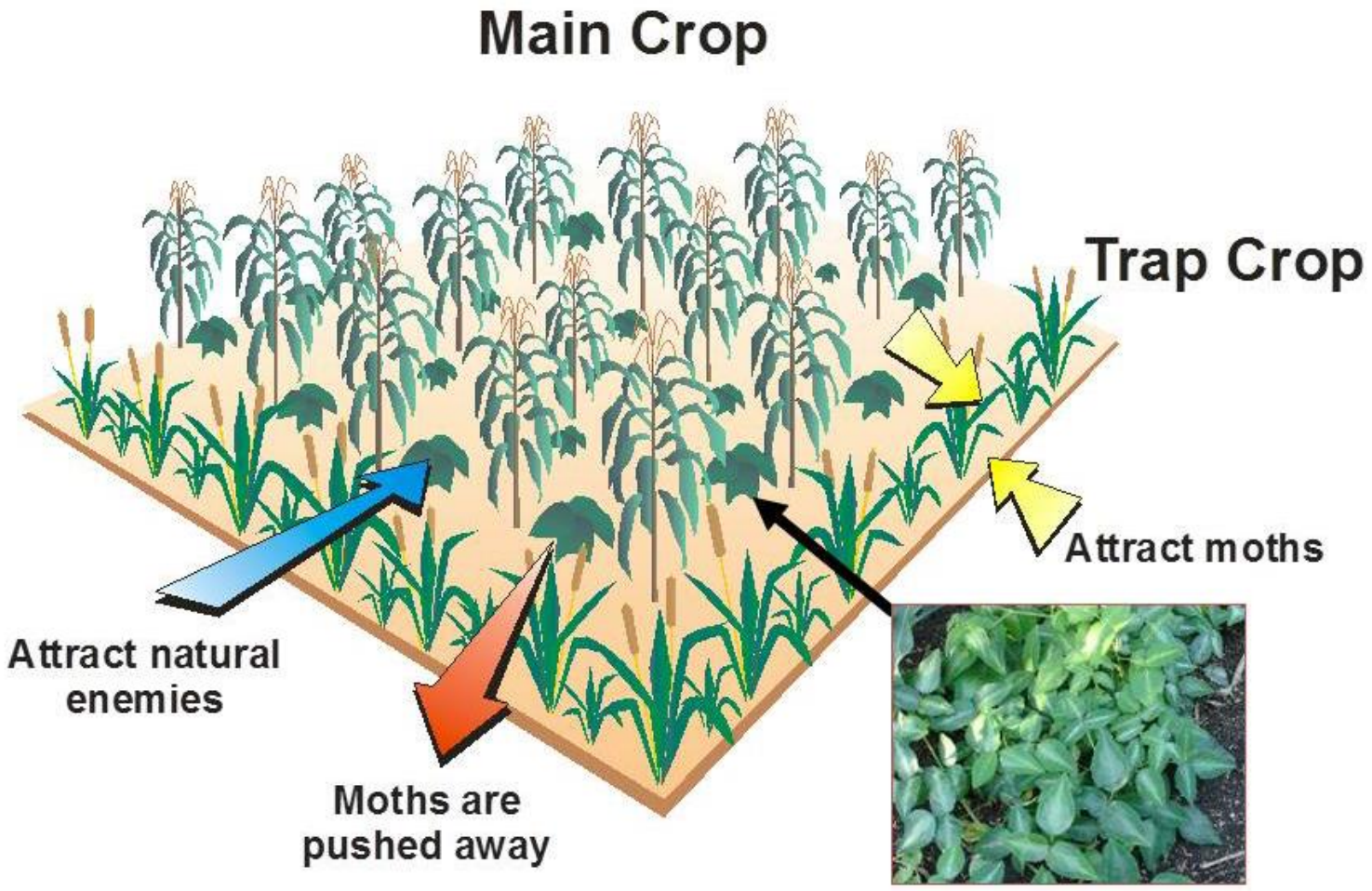
Plants that influence insect behaviour:

- **Stemborers**
  - attracted to trap plants (pull)
  - driven away from the main crop by repellent intercrop (push).
- **Parasitic wasps**
  - Attracted to intercrop



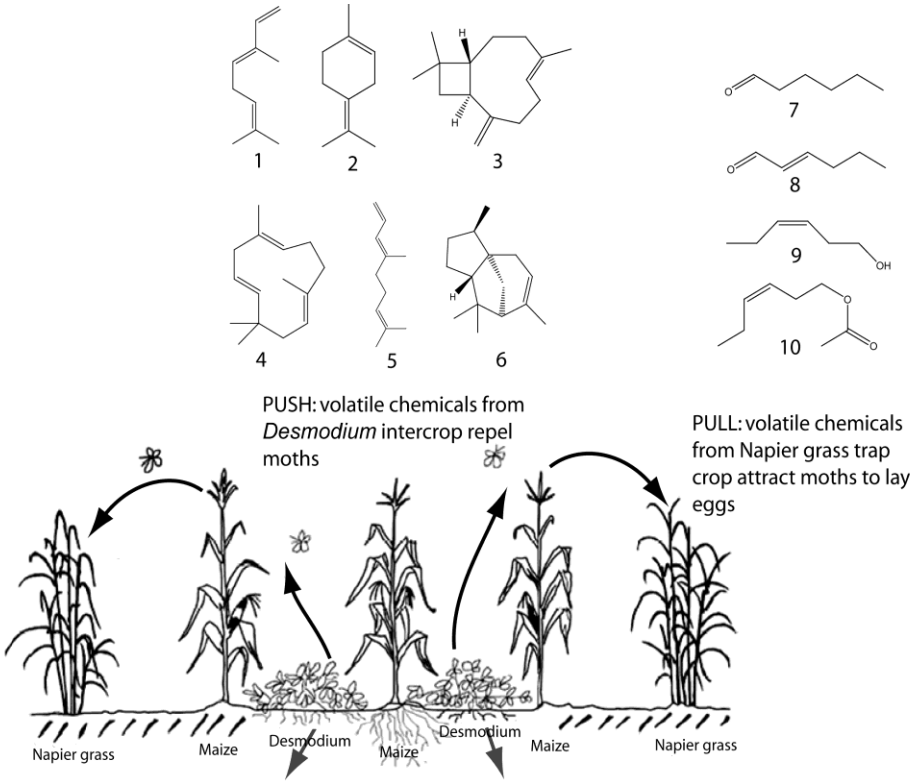
Khan et al. (2010) *J. Exp. Bot.* 61: 4185

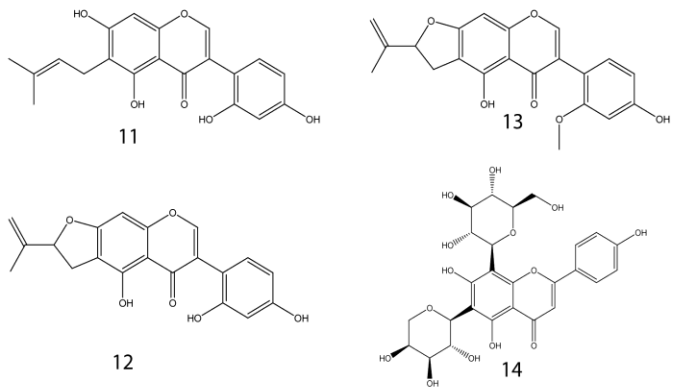
“Push-Pull”

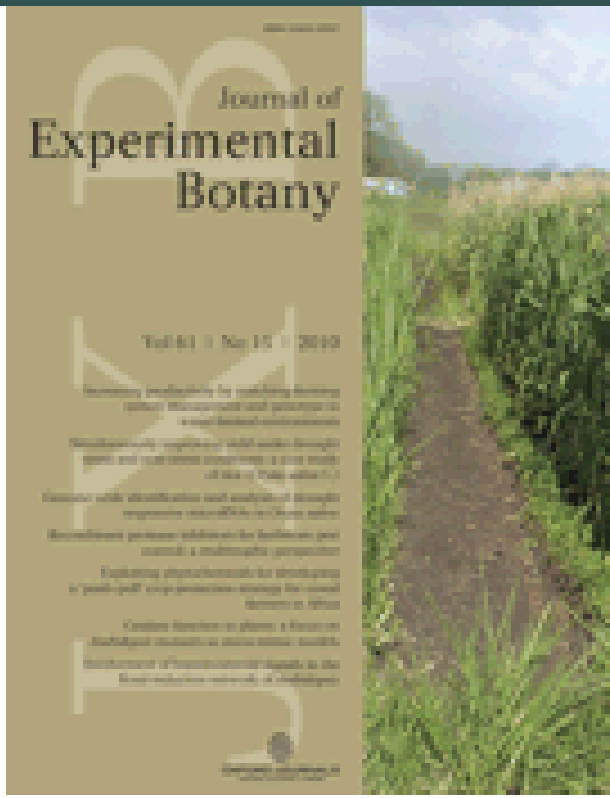
- **maize yields up from 1 t/ha up to 3.5 t/ha**
- achieved with minimal inputs
- adopted by > 100,000 small farmers in E. Africa

“Push-Pull”

1= (*E*)-ß-ocimene;
2= *α*-terpinolene;
3= *ß*-caryophyllene;
4= humulene;
5= (*E*)-4,8-dimethyl-1,3,7-nonatriene;
6= *α*-cedrene;
7= hexanal;
8= (*E*)-2-hexenal;
9= (*Z*)-3-hexen-1-ol;
10= (*Z*)-3-hexen-1-yl acetate ;
11= 5,7,2′,4′-tetrahydroxy-6-(3-methylbut-2-enyl)isoflavanone (uncinanone A);
12= 4′′,5′′-dihydro-5,2′,4′-trihydroxy-5′′-isopropenylfurano-(2′′,3′′;7,6)-isoflavanone (uncinanone B);
13= 4′′,5′′-dihydro-2′-methoxy-5,4′-dihydroxy-5′′-isopropenylfurano-(2′′,3′′;7,6)-isoflavanone (uncinanone C), and
14= di-*C*-glycosylflavone 6-*C*-α-L-arabinopyranosyl-8-*C*-*ß*-D-glucopyranosylapigenin.







Khan et al. (1997) *Nature* 388: 631-632
Khan et al. (2010) *J. Exp. Bot.* 61: 4185

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African Insect Science for Food and Health

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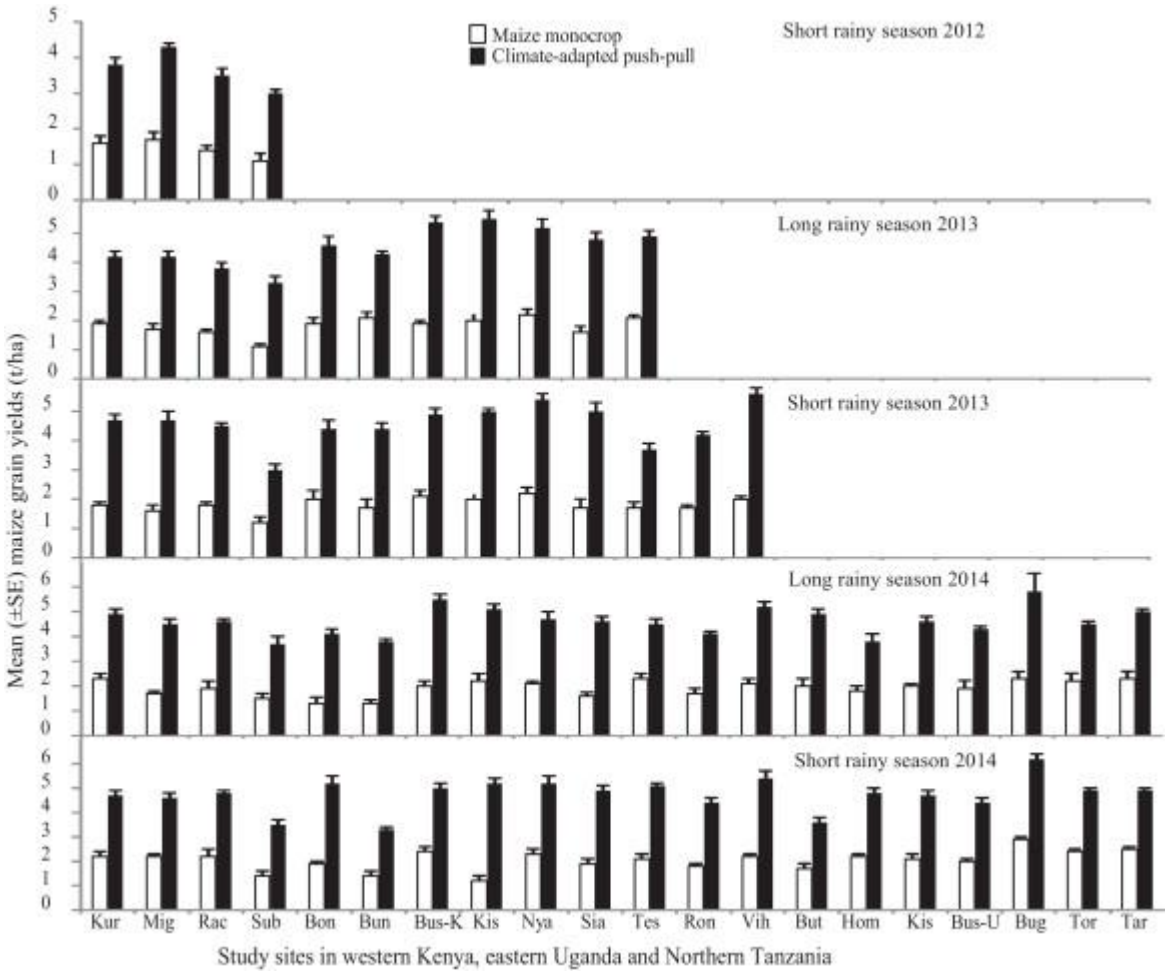
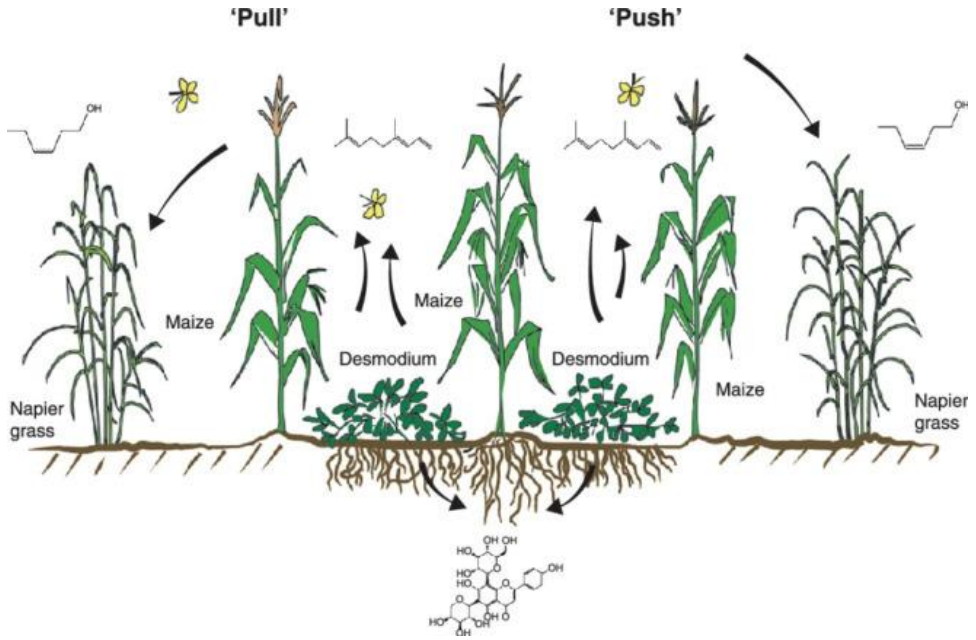
Companion cropping (Push-Pull)





2-3 x yield increase on farmers fields

Khan et al. (2011) *JXB* 61: 4185-4196
Midega et al. (2015) *Field Crops Research* 180: 118 - 125

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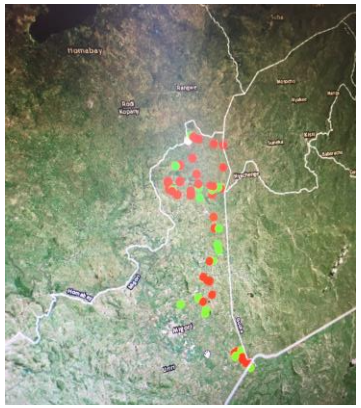
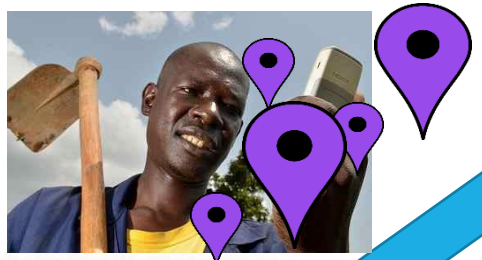
Mapping and Managing Striga weed



GIS

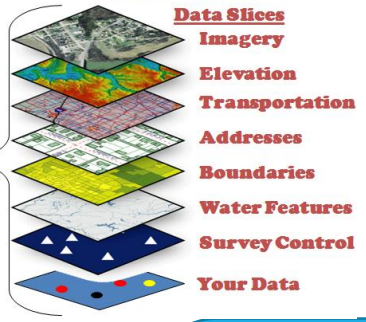
-> Striga risk map

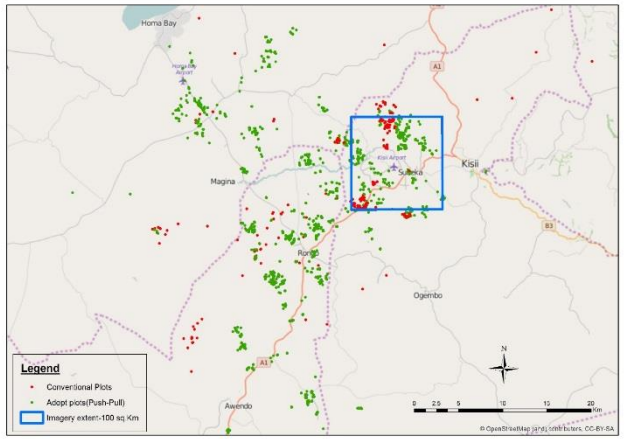
-> Identify hotspot areas



The Real World

GIS World Model





Provide management recommendations to hotspot areas & ensure desmodium seed is available there

YIELD INCREASE

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Acknowledgements

Charles Midega

Zeyaur Khan

BBSRC
bioscience for the future

Research England

Expanding Excellence in England (E3) Fund ??

INSTINCT - Innovation in Science and Technology for Insect Control

Clare Hoskins

William Kirk

Islam Sobhy

David Buss

Joseph Roberts

The deadline for submitting your full bid is 21 January 2019. Only institutions who have been notified that their EOI has been shortlisted are invited to apply at this stage.

icipe INTERNATIONAL CENTRE OF INSECT PHYSIOLOGY AND ECOLOGY

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