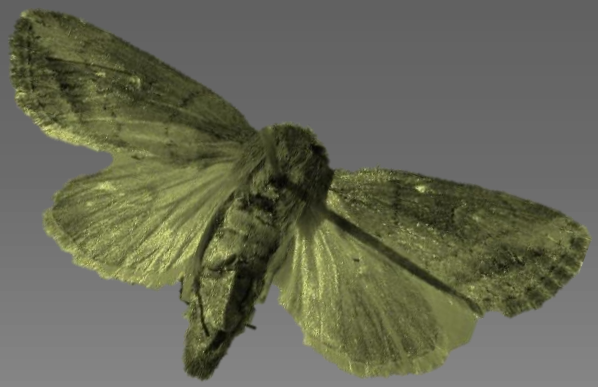
Guess or know?

How assumptions about the behaviour of lepidopteran pests affect IRM strategies and sustainability of Bt-crops.



Andri Visser

North-West University

What are Bt crops?

- Bt crops = genetically modified crops
- Contain genes from bacterium *Bacillus thuringiensis*
- Produces Cry (crystal) proteins
- Cry-proteins are effective toxins against various lepidopteran pests

Maize

Soybeans

Rice

Cotton

A Meta-Analysis of the Impacts of Genetically Modified Crops

Wilhelm Klümper, Matin Qaim*

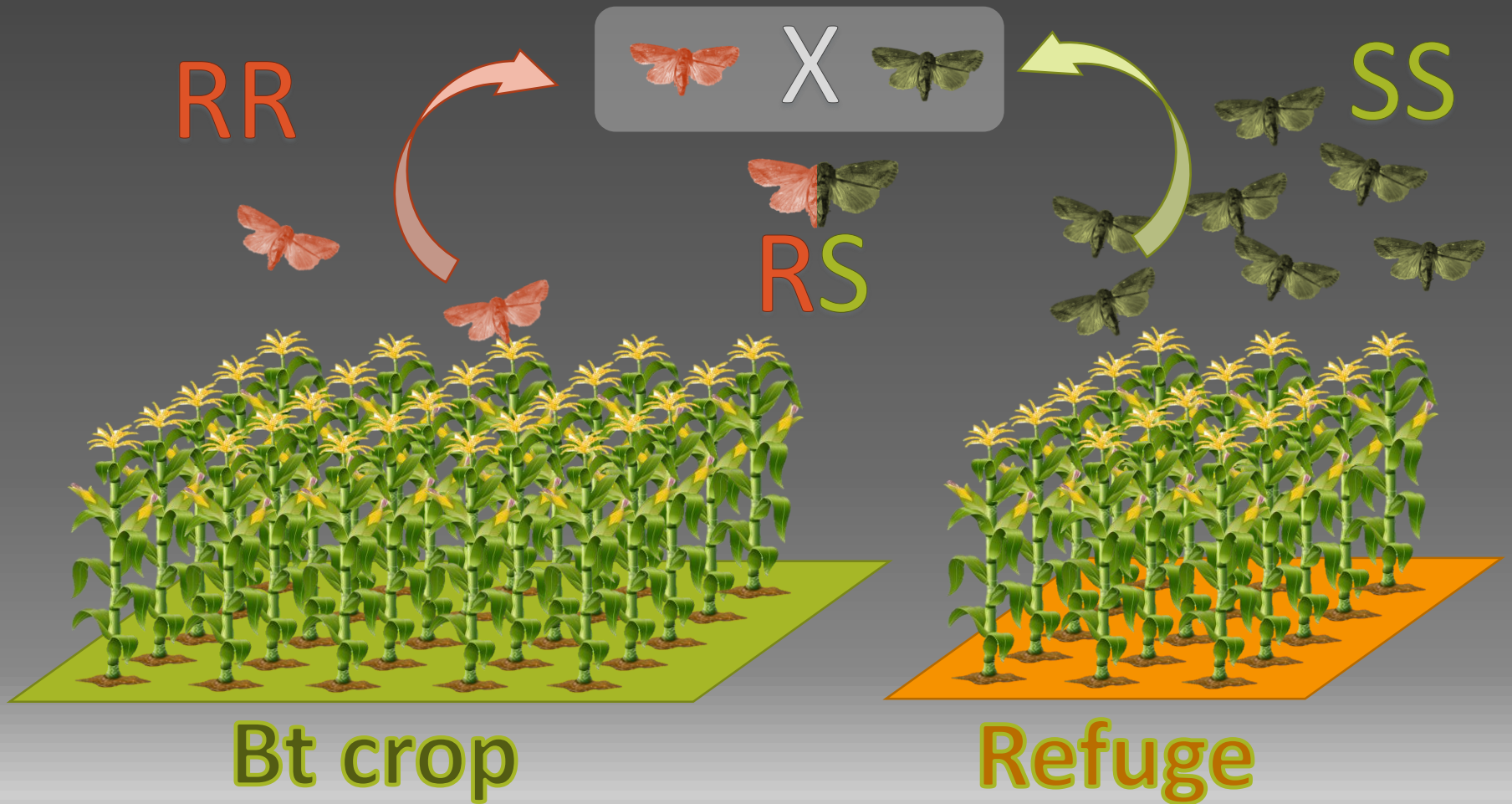
Department of Agricultural Economics and Rural Development, Georg-August-University of Goettingen, Goettingen, Germany

GM crops: global socio-economic and environmental impacts 1996-2014

Graham Brookes & Peter Barfoot

How to ensure Bt technology sustainability

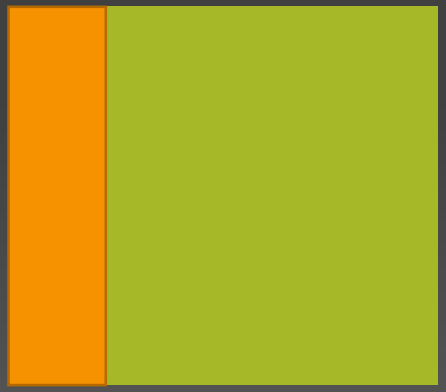
- IRM = Insect resistance management
- High-dose/refuge strategy - mandatory IRM strategy



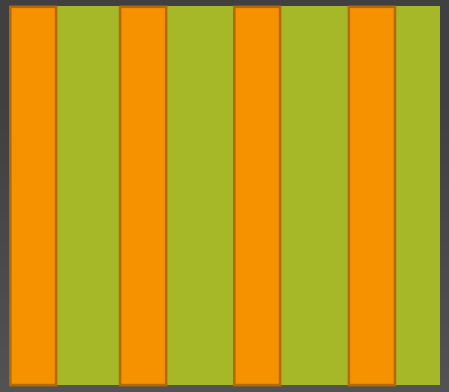
Refuge structures

Bt crop

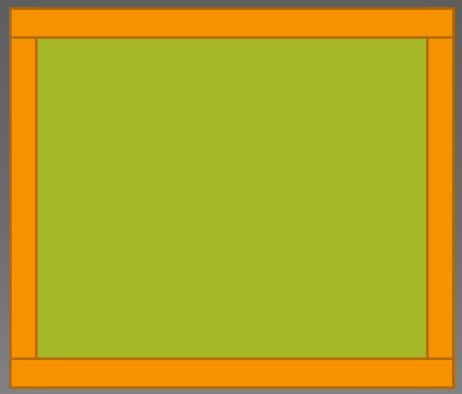
Refuge



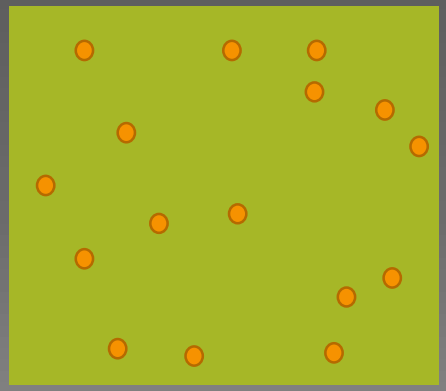
Single block refuge



Strip refuge



Perimeter refuge



Mixed seed/ refuge-in-a-bag

High-dose/refuge strategy - key assumptions

1. The resistance alleles are rare and recessive
2. Bt-toxins are expressed at a high dosage that kills heterozgotes (RS individuals)
3. The refuge produces large numbers of susceptible individuals to mate with resistant individuals

First report of field resistance by the stem borer, *Busseola fusca* (Fuller) to Bt-transgenic maize

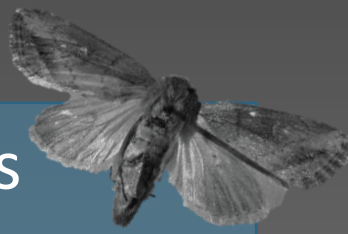
J.B.J. van Rensburg

ARC-Grain Crops Institute, Private Bag X1251, Potchefstroom, 2520 South Africa
(E-mail: koosj@arc.agric.za)

Accepted 14 June 2007

Other assumptions affecting IRM strategies

- Factors that could affect IRM are often overlooked:
  - Interaction between insect pest and Bt crop
  - Interaction between R and S individuals in pest population
- Assumptions valid for lepidopteran pests?
- Invalid assumptions = undermine IRM efforts

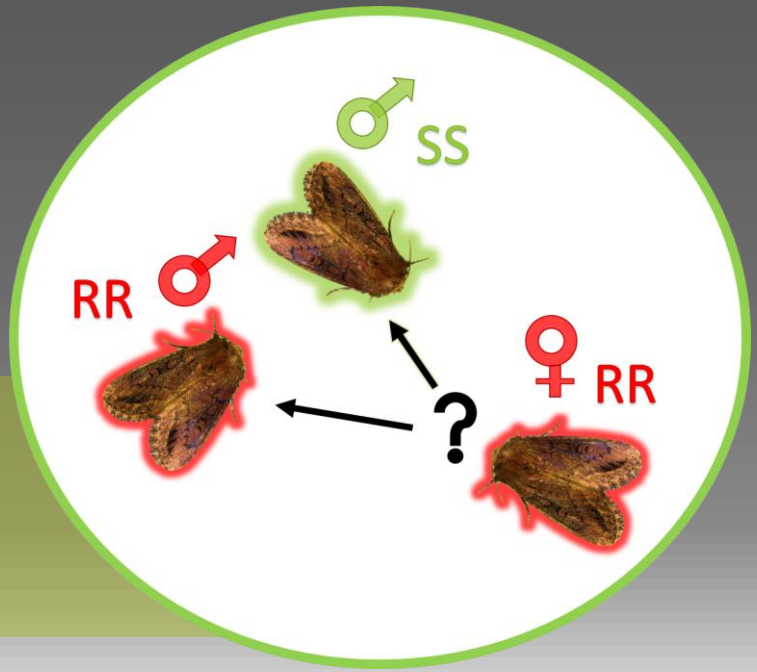


1. Random mating between R and S individuals
2. Random selection of oviposition site
3. No feeding preference and extensive migration of larvae
4. Consistently high Bt toxin expression within plants
5. Wild host plants as naturally occurring refuge

Assumption 1: Random mating

- No preferential mating between R and S moths
- Resistance evolution might affect mating behaviour
  - E.g. calling of females
- Longer development time for R individuals on Bt crop
  - Mating period or R and S moths may not overlap
  - E.g. Pink bollworm *Pectinophora gossypiella*

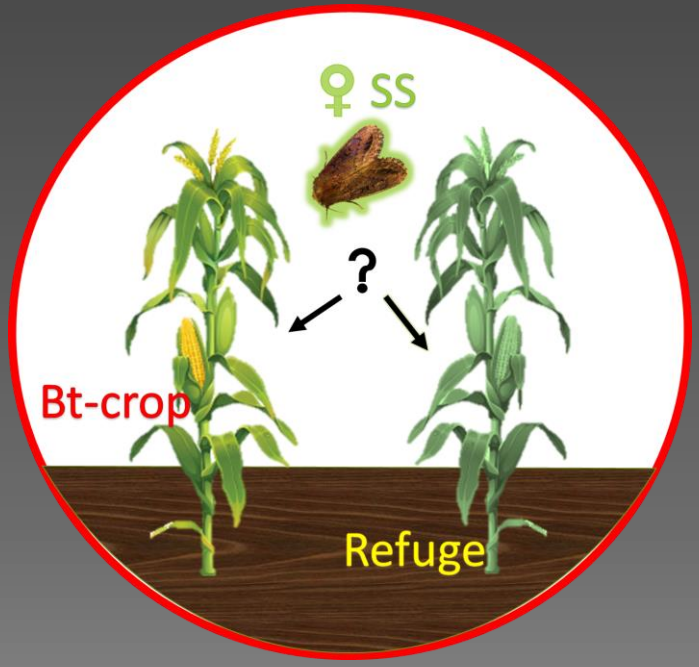
Pectinophora gossypiella



Preferential mating will
reduce likelihood of hybridization

Assumption 2: Random oviposition site selection

- Females unable to detect Bt toxins
- No preferential oviposition between Bt and non-Bt plants
- Some lepidopterans do not display oviposition preference:
  - *Ostrinia nubilalis*
  - *Chilo partellus*
  - *Sesamia calamistis*
- ...but some species DO:
  - *Spodoptera frugiperda*
  - Damage avoidance behaviour



Preference for Bt crops will accelerate resistance evolution!

Assumption 3: Feeding preference and migration

- Larvae don't display Bt avoidance behaviour
- Some lepidopterans alter feeding and migration behaviour:
  - *Ostrinia nubilalis*
  - *Sesamia nongrioides*
- ….but some species DON'T:
  - *Helicoverpa zea*
  - *Helicoverpa armigera*
- Feeding and migration behaviour will affect choice of refuge structure

Mixed seed refuges are NOT suitable for migrating pests

Assumption 4: High-dose expression of Bt toxin

- Bt-toxin expression is not uniform:
  - across plant parts
  - throughout the growing season
- Pest larvae feed on less toxic plant parts
  - E.g. *Helicoverpa armigera*
  - Prefer feeding on less toxic cotton flowers
  - Silks of Bt maize

Greater survival of RS individuals...
…rapid evolution of resistance!

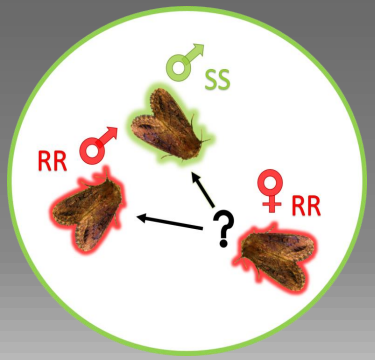
Assumption 5: Wild host plants as refuge

- Refuge plants must:
  - allow high percentage of larval survival
  - produce good quality adults
  - be abundant in areas of Bt crops
- Diverse border fields = naturally occurring refuge
- Not an option for many species
  - Oviposition preference for crop
  - Not enough surviving larvae
  - Mating period not synchronised

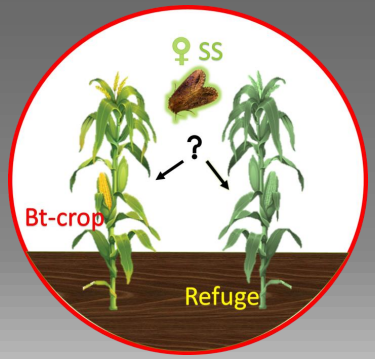
Wild host plants could act as dead-end-trap plants!

Conclusion

- IRM strategies are based on assumptions
  - Violations of these assumptions = evolution of resistance in target pest populations
- Assumptions are not all valid for each pest species
  - IRM should be tailored to each pest species
- Urgent need for studies on the behaviour of agricultural pests
  - Laboratory, semi-field and field based investigations
  - Behavioural changes → physiological changes





Final thoughts

- IRM strategies should be tailored to
  - target pest species
  - environmental conditions
  - scale of production
- Better IRM = sustainable Bt crops = improved food security

This is agriculture in Africa…

…but so is this!

Thank you!

Questions?