Genetically Modified Cotton in Africa: A South African Experience

CIRAD: J-L HOFS, M. VAISSAYRE, B. HAU, C. PANNETIER

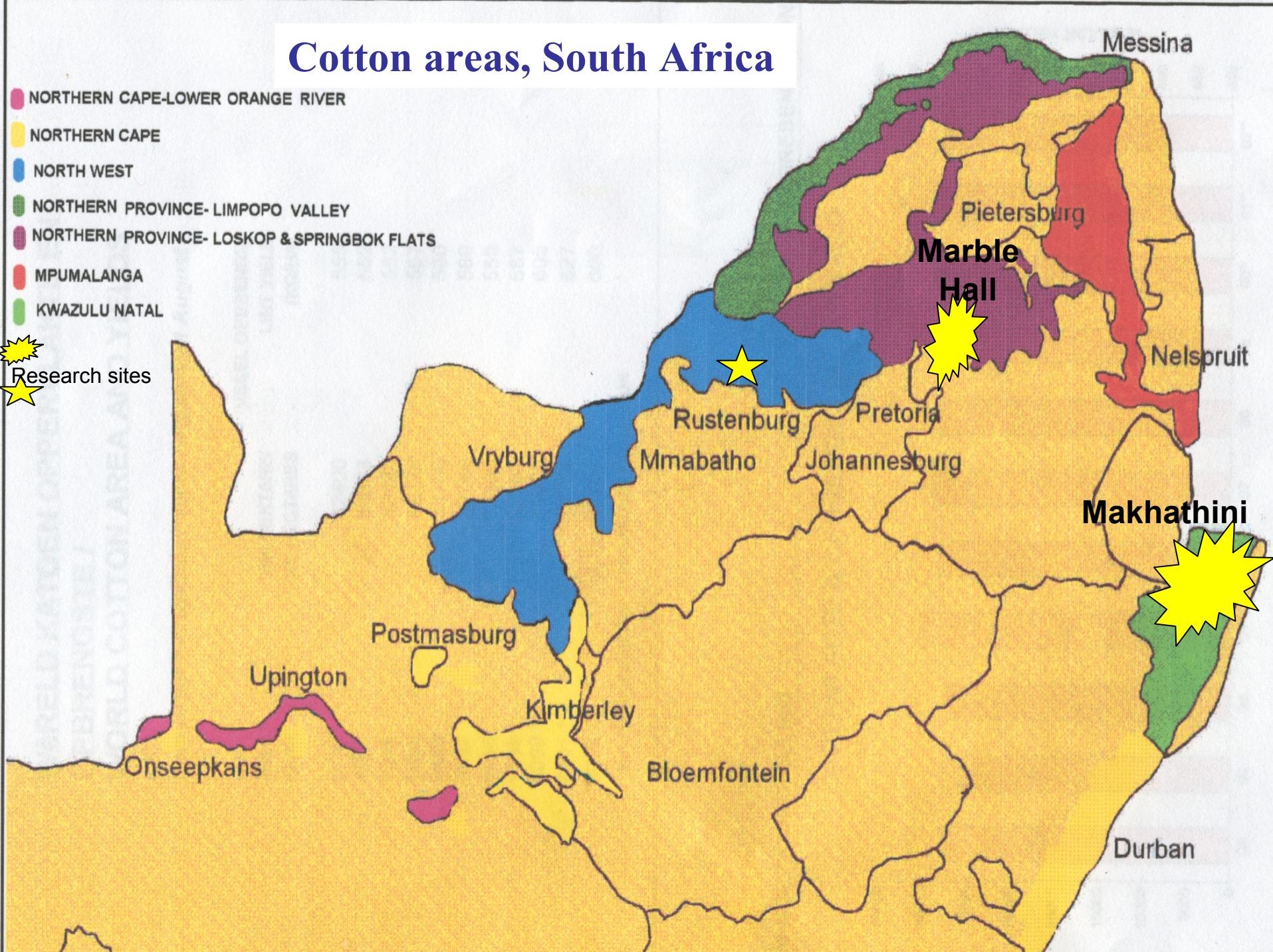
U.P. : D. MARAIS, K. KUNERT

MAIN TOPICS

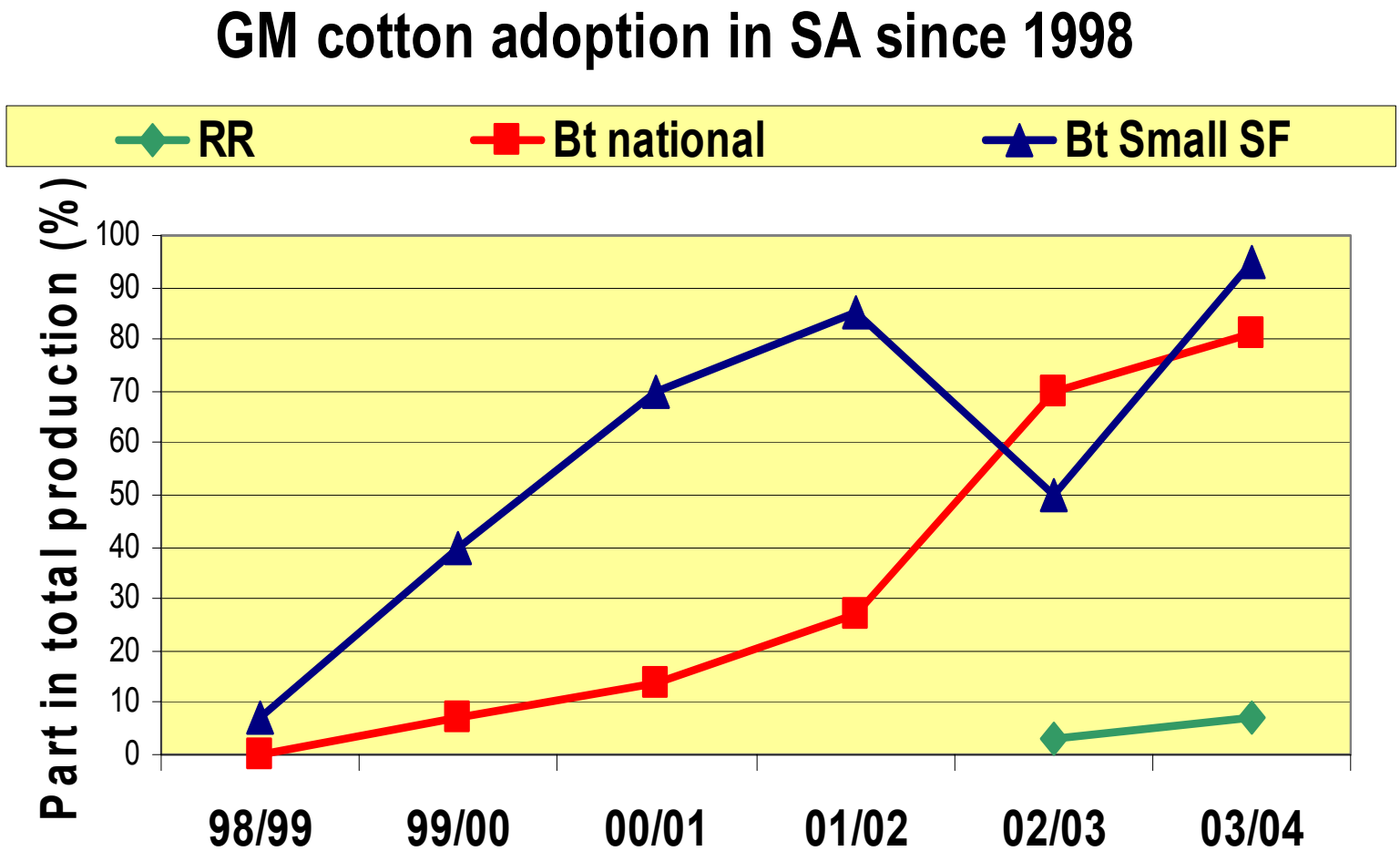
- Background: Bt introduction, adoption and performances
- Impact studies:
  - → Plant production
  - → Gene expression
  - → Gene flow
  - → *Agro-economics (not presented)*

- GM Cotton: another green revolution ?

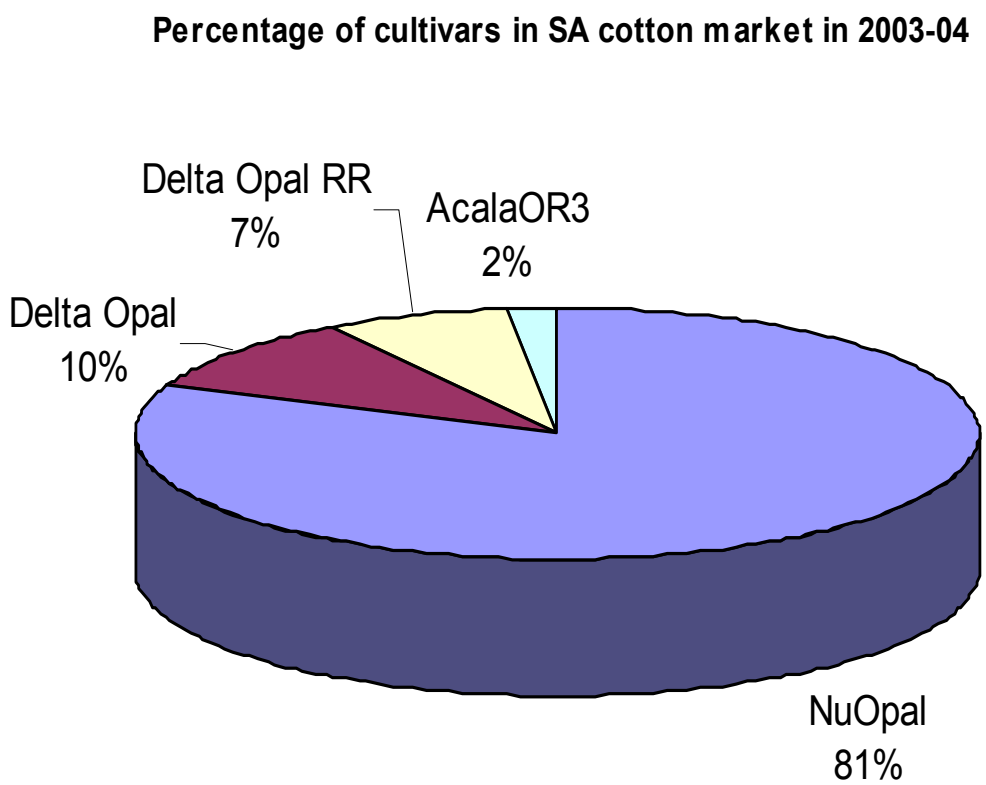
Cotton areas, South Africa



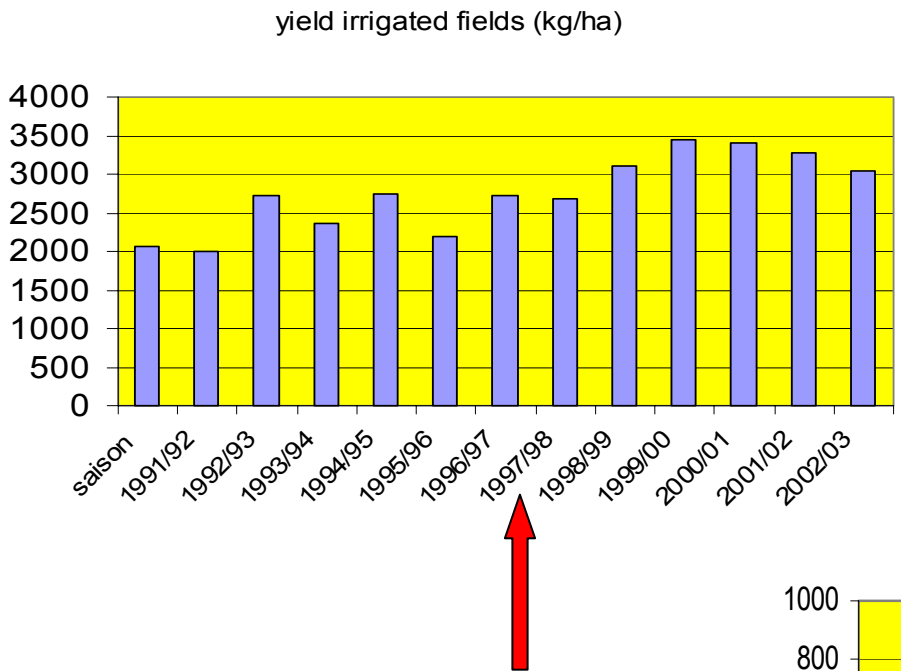
Evolution of GM cotton adoption

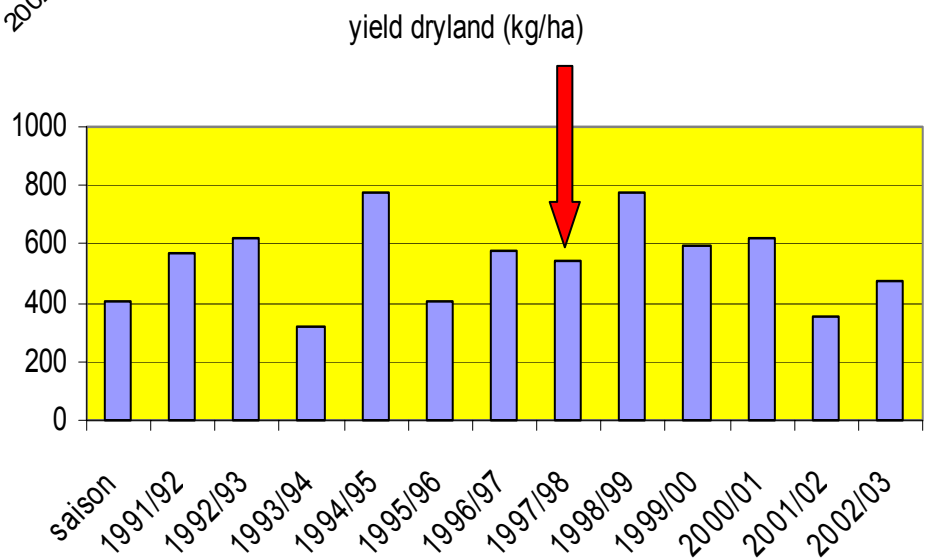


CGM: the beginning of a seed monopoly?



Yield performances and Bt introduction





IMPACT STUDY
Plant production and agro-physiology

- How Bt cotton elaborates (out-) yields?
- Is Bt Cotton profitable at all levels (for all farmers) ?
- If not, in which conditions?

- What is the importance of non targeted insect control for SSF production?

- Is there a need to improve other practices to get more profit from Bt?

Plant production and agro-physiology

Controlled trials:

Plot: 40 m^2 , 6 replicates, threshold insect control for non Bt or Bt or absence of insect control. Optimal agronomic management.

On farm trials:

LSF : > 1 ha fields with 3-4 subplots (40 m^2), Farmer's program and full insect control or/and absence of insect control.

Optimal -> good practices.

SSF: Plot: 300 m^2 .Farmer's program and full insect control. Low input.

replicates: number of farms monitored.

Material: comparison of near isogenic lines (e.g. NuOpal (Bt) and Opal)

Methods: Plant mapping and yield component analysis.

Trials Bt vs Non Bt: compare what's comparable

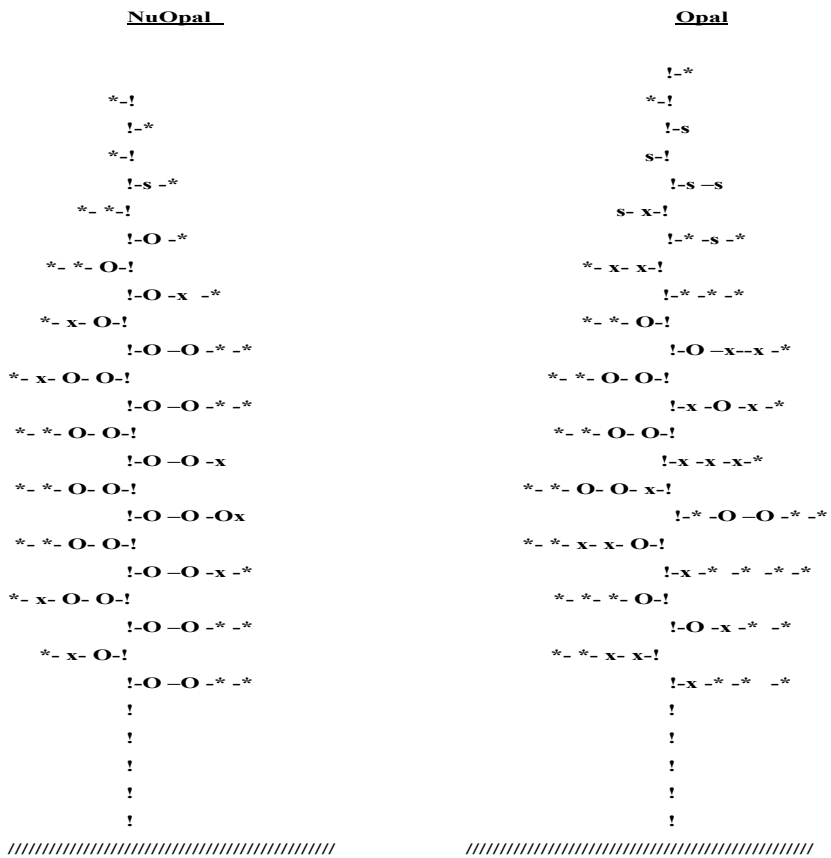
Bt cotton: NuCotn 37 B
US short season cultivar designed for mechanical picking & high input

Non-Bt: CA223 or DPL Acala 90
Late season cultivar
Less intensive management

A useful tool: the plant mapping

Explanation of Bt out-yield in LSF

Bt cotton



70 % representativity = At least 70% of the plant have a boll set at the O site; 60% with additional O .

Non-Bt Cotton

Marble Hall

2000-2001

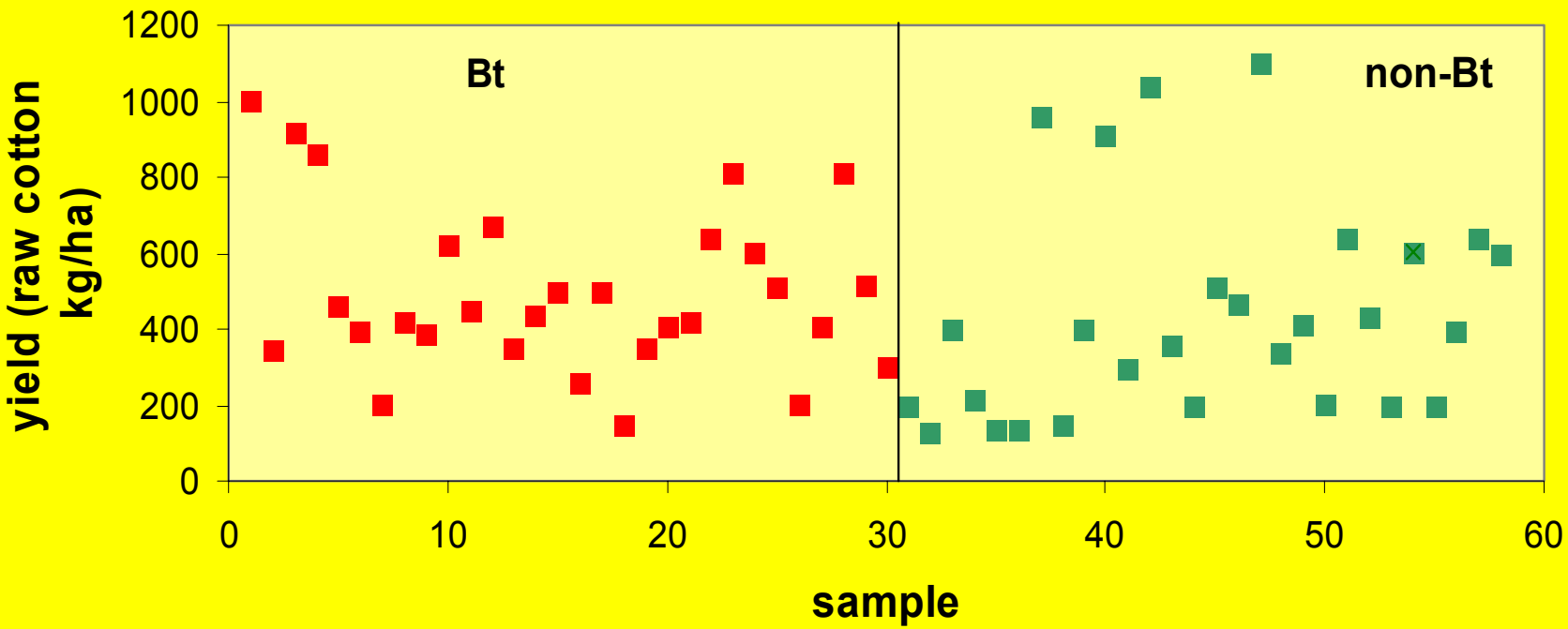
Bt yield: + 13%

In average

Bt Cotton field in the Pongola area (KZN)

Is Bt enough to boost yields in small-scale farming?

Yield variability among Bt and non-Bt cotton: Makhathini 2003



Bt Cotton in SSF (Makhathini): poor management

Bt Cotton in SSF (Makhathini) : good management

The kick that boosts Bt yields: Adapted CM

Sample: 10 farmers (rep). year: 2003-2004
In field experiments with 4 treatments

Treatment	Pest control	Fertilisation
A	> 10 sprays + Bt	NPK 4:3:4 +5g. Zn/kg Planting: 150 kg/ha 45 dap : 100 kg/ha
B	> 10 sprays + Bt	no
C	< 4 sprays + Bt	NPK 4:3:4 +5g. Zn/kg Planting: 150 kg/ha 45 dap : 100 kg/ha
D	< 4 sprays + Bt	no

Results

Kg /ha (P < 0.05)			
1642 A	1352 B	862 C	735 C

Estimate of costs and profit margin (in Rand/ha)

Costs	A	B	C	D
Seed	319	319	319	319
Insecticide	1442	1442	389	389
Fertilizer	595	0	595	0
Soil preparation	410	410	410	410
Weeding	240	240	240	240
Harvest	480	395	249	212
Income (R 3.10/kg)	5090	4191	2672	2279
Profit	1604	1385	470	709

Gene expression and Bt toxin efficacy

FACTS

Bollworm in US = Heliothis virescens (tobacco bw.)

Bollworm in the old world = Helicoverpa armigera (american bw).

Bt toxin controls a part of the pest spectrum: Helicoverpa, Pectinophora, Earias, Diparopsis..

No control on: Spodoptera, Aphids, Leafhoppers, bugs, whiteflies….

Efficacy of Bt Toxin (2)

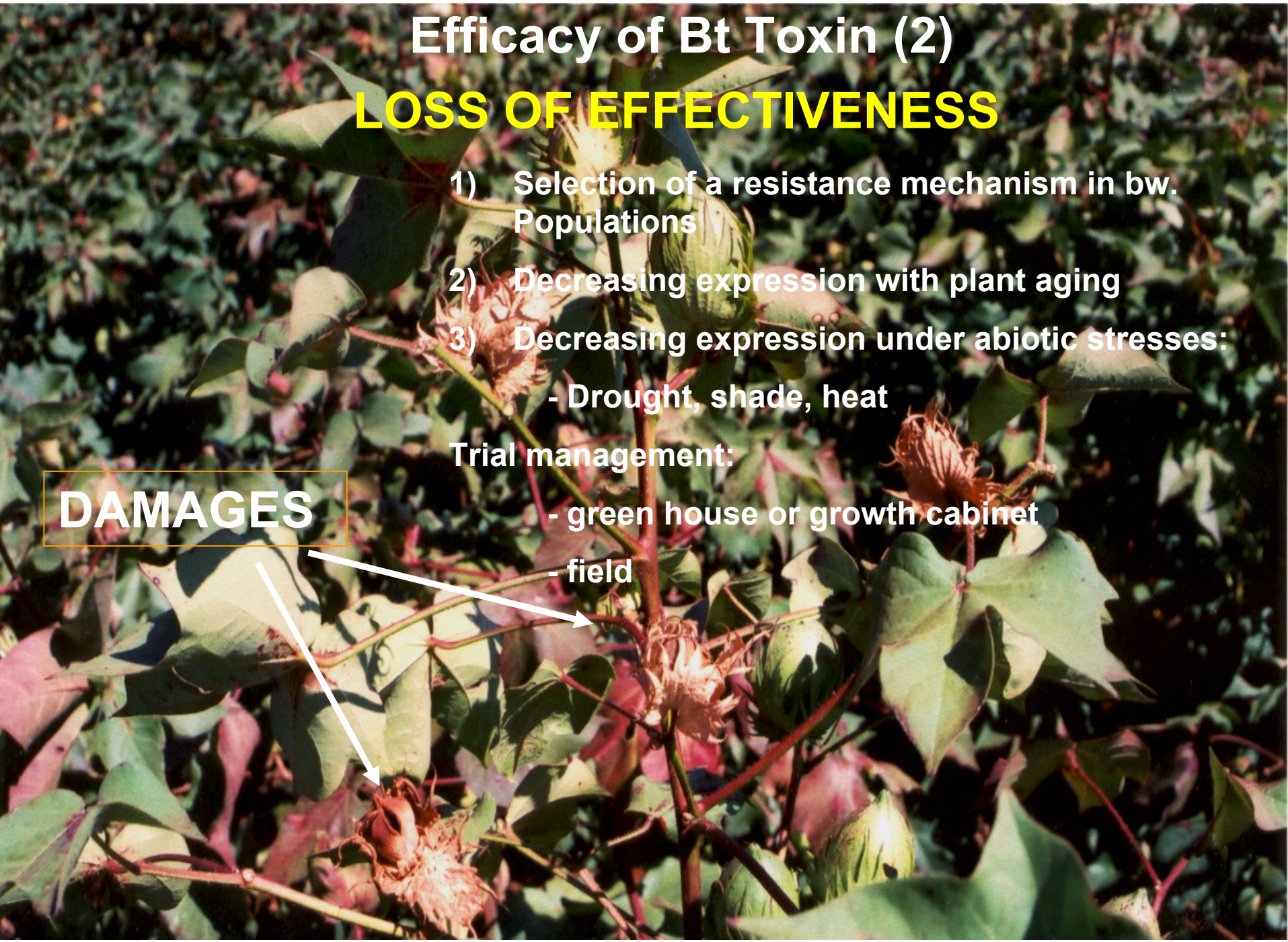
LOSS OF EFFECTIVENESS

1) Selection of a resistance mechanism in bw. Populations
2) Decreasing expression with plant aging
3) Decreasing expression under abiotic stresses:
   - Drought, shade, heat

Trial management:

- green house or growth cabinet
- field

DAMAGES



Bt Expression: Plant Protein Analysis

Methods

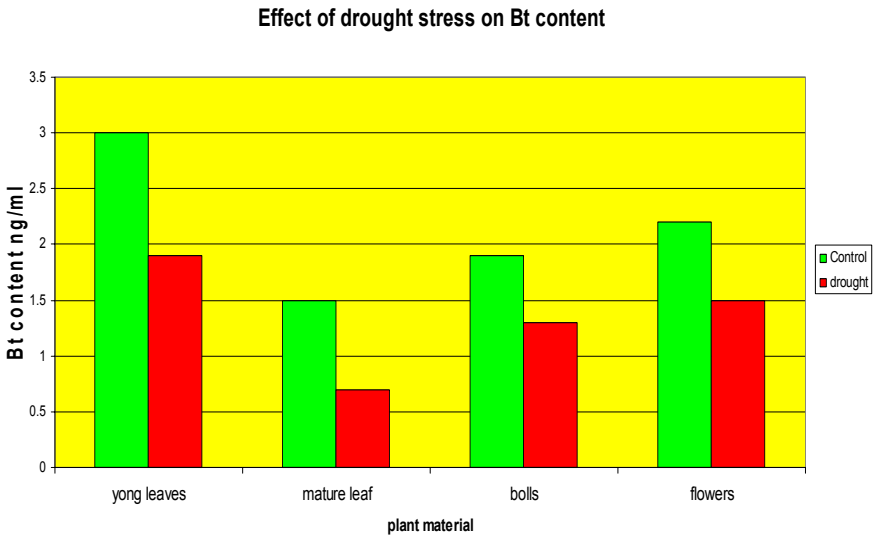
- Bt quantification in plant using ELISA
- Western Blotting (gel)

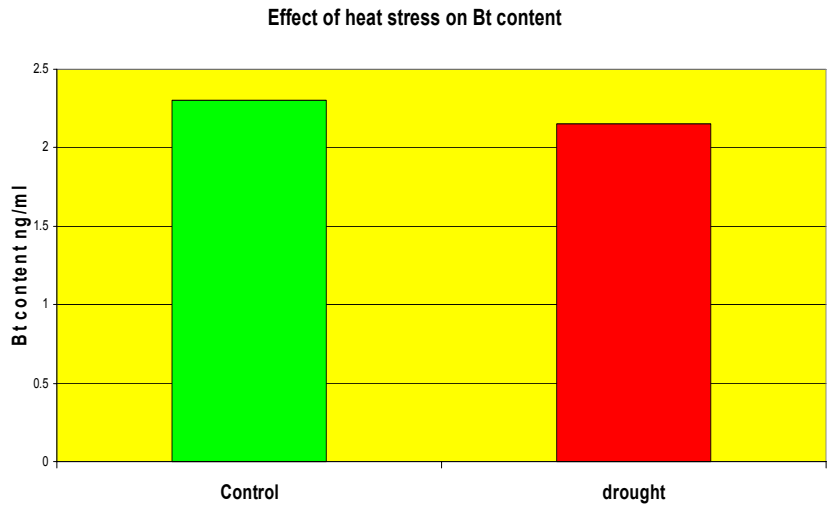
Experimental conditions

- Drought stress : 25% of field capacity
- Heat stress: 25/28°C → 32/38°C

Bt Expression : controlled environment

(from Kunert & Martins, UP/FABI)



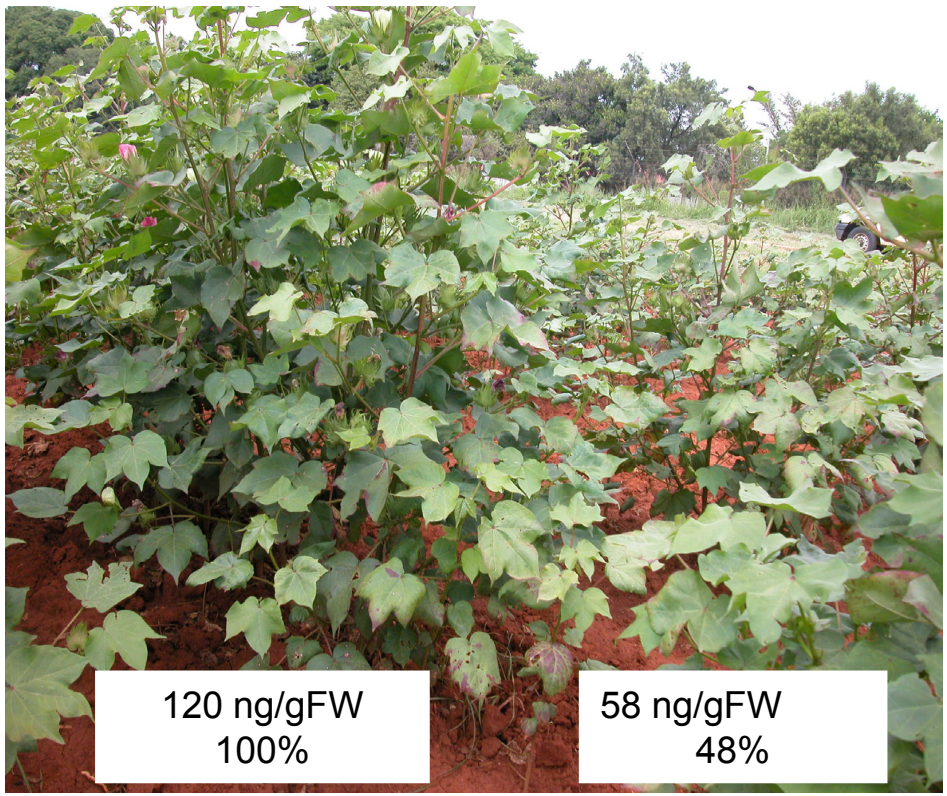


Significant differences between control and stressed

Not confirmed by bio-assay

No significant difference

Bt Expression in field



High variation of Bt content between plants

Lower content in stressed plants

Gene flow

pollen

intraspecific

interspecific

GMO

Non GMO

Related species

seeds

volunteers

Intraspecific gene flow

Pollen - 0 to 30 % allogamous

- pollen dispersal by insects

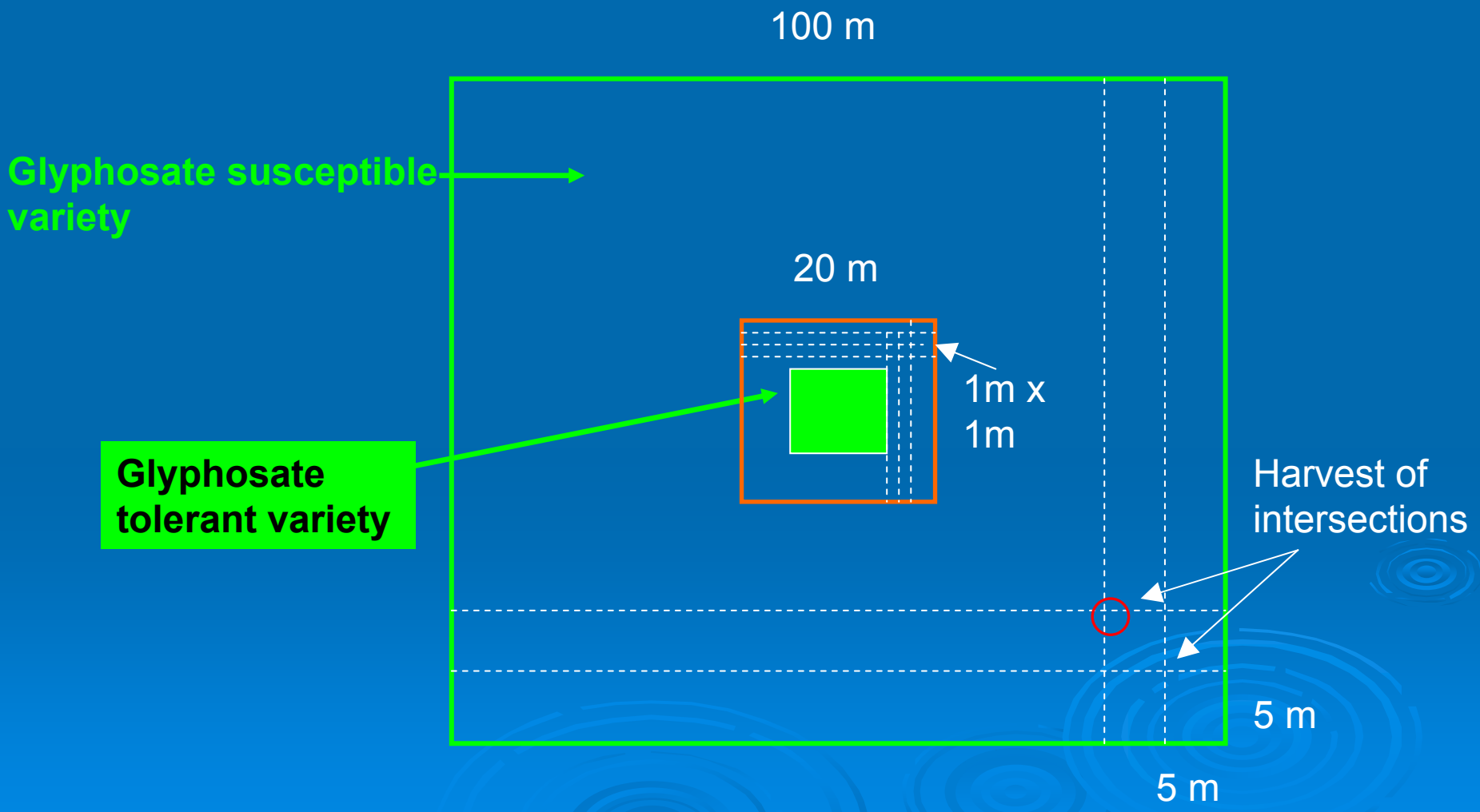
No wild populations of Upland cotton

Pollinating insect survey (sp/100 flowers)

Rate of allogamy (locally)

Pollen dispersal in a field (spatial)

Dispersal within the field



Cultivated Upland cotton

AADD , 2n = 52

Other genera within Malvaceae

Wild African cotton

AA , 2n = 26

F1 hybrids → steriles

Baranov (1930) , Gerstel (1953)

Prospective surveys

Seed collection → spontaneous hybrids

Hybridizations cultivated x wild

CONCLUSION

Not a revolution but a tool

Four years of study in S.A. shown that Bt cotton can be profitable if used under rational management in both large scale and small scale farming.

Bt cotton must be considered as an element of the IPM, which has its own limits.

Long term and adequate monitoring is necessary to evaluate the impact of the technology. Nevertheless, at this stage of the research with Bt cotton there is no evidence of serious risk on the environment in Southern Africa.

NGIYAKUBONGA

Thank You

C’est fini! Merci …pour votre patience