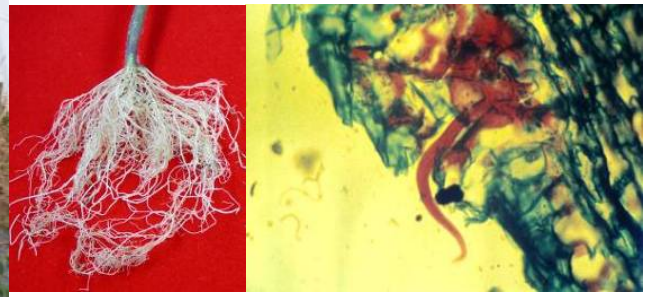
Session S20 : Plant-parasitic nematodes in temperate crops; new issues

Experimental evidence of the efficiency of 2 *R*-genes deployment strategies - pyramiding or alternating - for sustainable management of root-knot nematodes

Susceptible plant



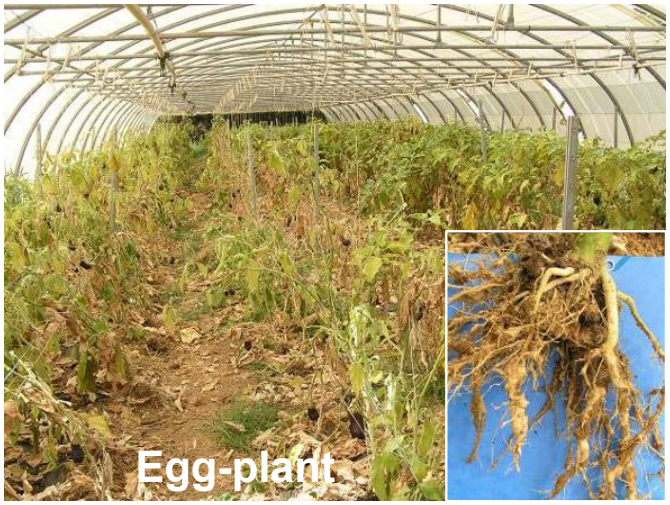
Resistant plant

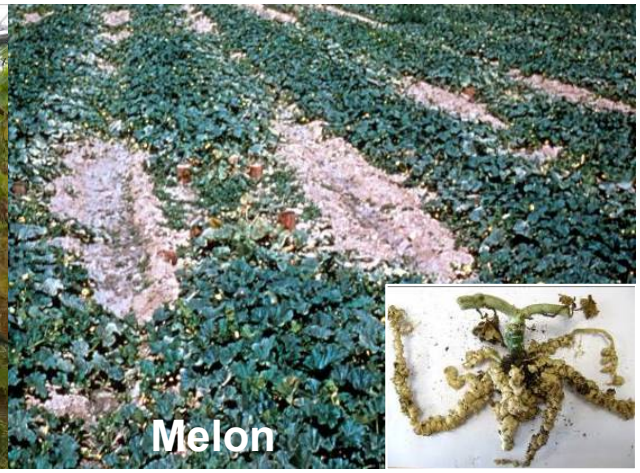
INRA FRANCE
Plant Nematodes Interaction team
Institut Sophia Agrobiotech

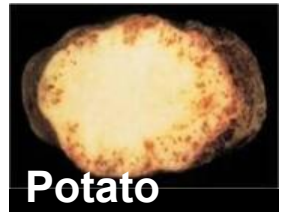
Djian-Caporalino C., Fazari A., Marteu N., Sage-Palloix A.M.,
Risso S., Lanza R., Palloix A., Castagnone-Sereno P.

Root-knot nematodes *Meloidogyne* spp.

An increasing problem on vegetable crops in all Mediterranean regions







- **A survey conducted from 2007 to 2010* : a big threat for > 40% of farms producing vegetables in SE France**
- **Crop rotations with resistant plants : economically efficient and environmentally safe but resistance can be overcome**

*Djian-Caporalino, *Phytoma November 2010 & EPPO Bulletin April 2012*

Limitation of the RKN-resistance

In controlled conditions with high pressure of RKN

- *Mi-1* in tomato and *Me3* in pepper are overcome

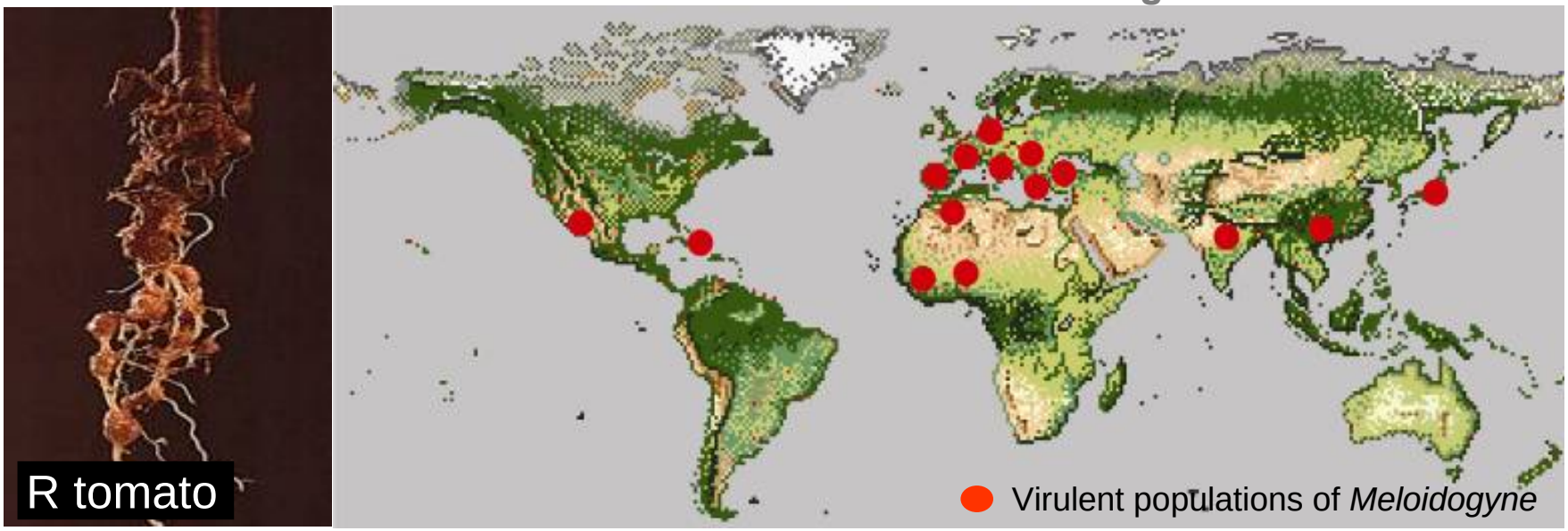
  e.g. Jarquin-Barberena *et al. 1991;* Castagnone-Sereno *et al. 1994, 1996, 2001;* Meher *et al. 2009;* Djian-Caporalino *et al., 2011*

In natural conditions

- *Mi-1* in tomato and *N* in pepper cultivars, used for 60 years, are overcome

  e.g., Tzortzakakis *et al. 2005, 2008;* Verdejo-Lucas *et al. 2009;* Devran and Söğüt *2010 ;* Thies *2012*

Worlwide occurrence of *Meloidogyne* spp. populations able to overcome the tomato *Mi-1* R-gene



Develop new « robust » *R*-lines

Manage *R*-genes to increase their durability

Model to study the durability of resistance to RKN

Capsicum annuum

Me1 to Me7, Mech1, Mech2, N

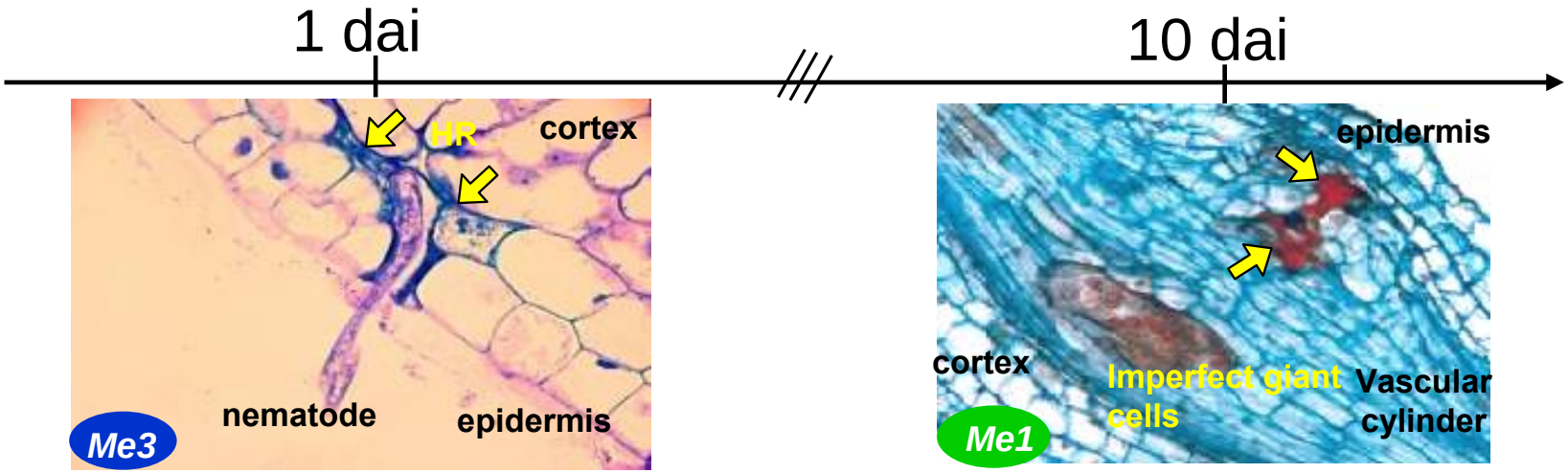
M. incognita

M. arenaria

M. javanica

R stable at high T°

Hendy *et al, Nematologica 1985 ;* Hare, *Phytopathology 1956 ;*
Thies & Fery, *J Amer Soc Hort Sci 1998 & 2000 ;* Thies & Ariss, *EJPP 2009;*
Djian-Caporalino *et al., Theor Appl Genet 1999, 2001, 2007*



Early necrosis

Later necrosis

Gene overcome

Selection of virulent nematodes

Difficult to overcome the *Me1* gene

Castagnone *et al, Plant Breeding 2001 ;* Djian-Caporalino *et al., EJPP 2011*

Experimental approach

Climate controlled room experiments

. **Strength of the genes** (in several genetic context & with several RKN pop.)

. **Varietal effect** (genetic background)

. **Combination of genes** (pyramiding)


INRA Sophia (SE France)

3-years greenhouse and field experiments

. **Validation** facing natural nematode populations

. **Deployment strategies of *R*-plants lowering the risk of emergence of virulent nematodes :**

i) alternance of *R*-genes in rotation,
ii) mixture of different *R*-genotypes in the same plot
iii) pyramiding of 2 *R*-genes in one genotype.


INRA Sophia (SE France)


Nice (SE France)


Aubagne (SE France)

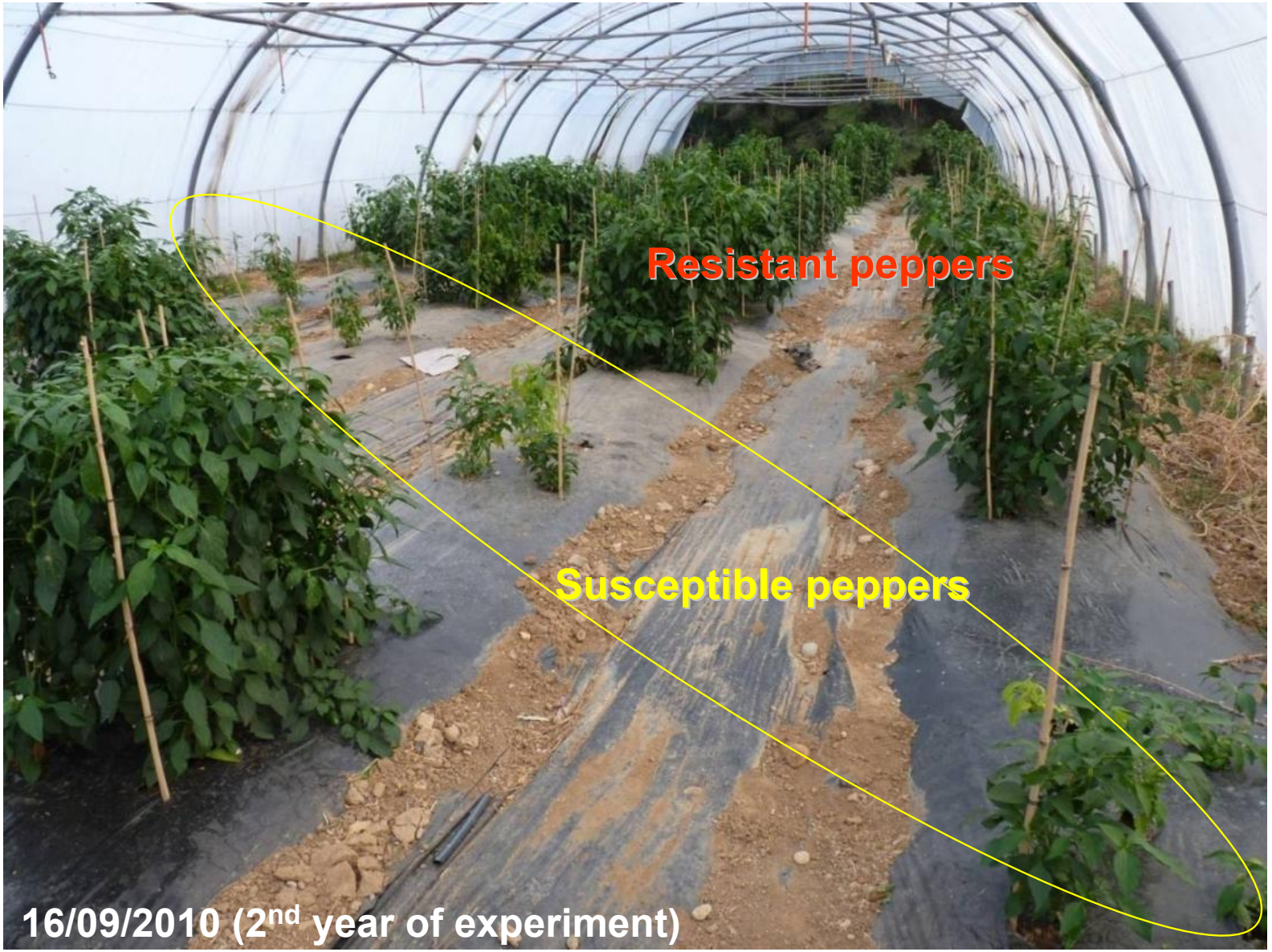
Agadir (Maroc)

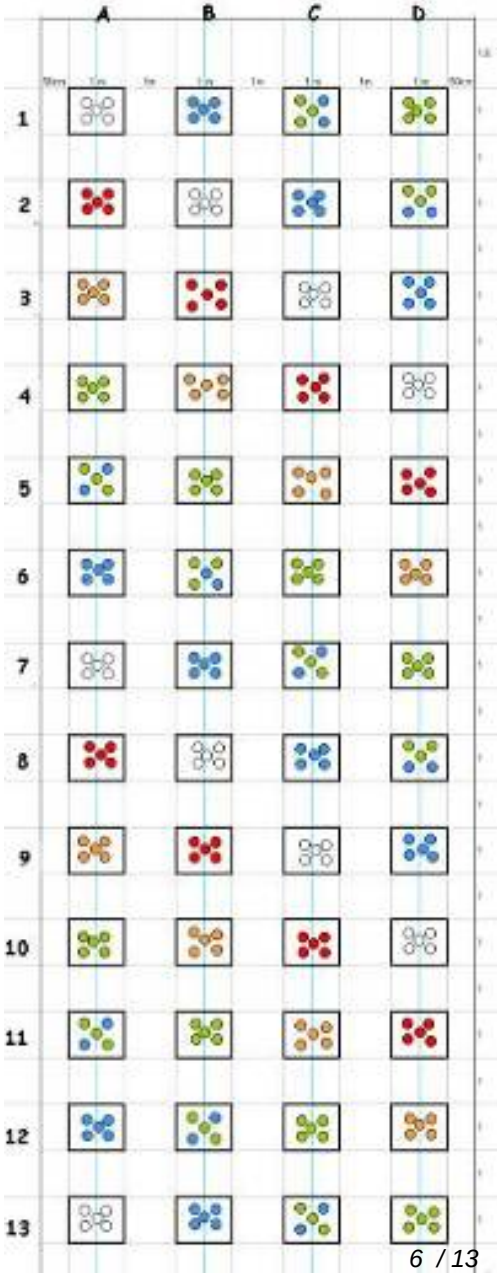
Example of an experiment in natural condition

Nice, SE France

250 m², 52 plots, 5 plants/µplot

Plastic tunnel 28 m x 8 m **infested by *M. incognita* + *M. arenaria***





Example of an experiment in natural condition

Nice, SE France

6 MODALITIES
8 to 9 µplots 1m²/modality
5 plants/µplot
= 40 to 45 plants/modality

Susceptible cultivar DLL (control)

R inbred line *Me1*

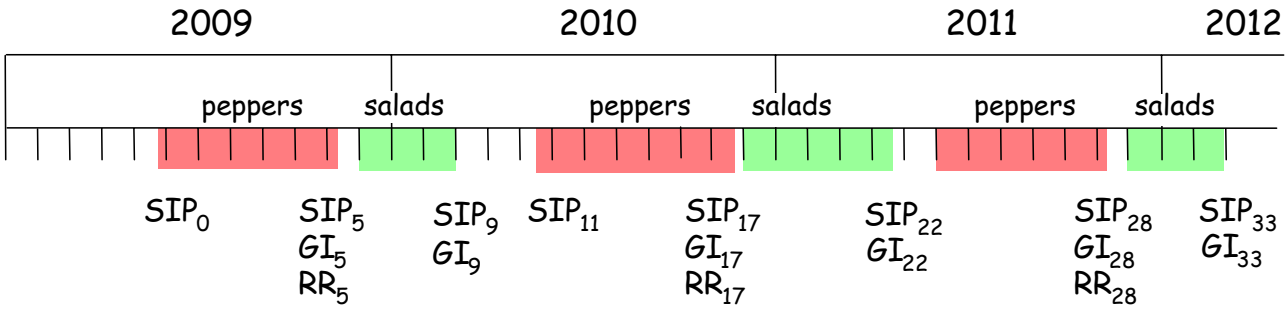
R hybrid [DLL x *Me1*]

Alternation *Me3* then *Me1*

Mixture *Me3* and *Me1*

Pyramiding *Me3* *Me1*

Schedule and Infestation parameters



SIP = soil infection potential *(number of Meloidogyne J2 /kg of soil)*

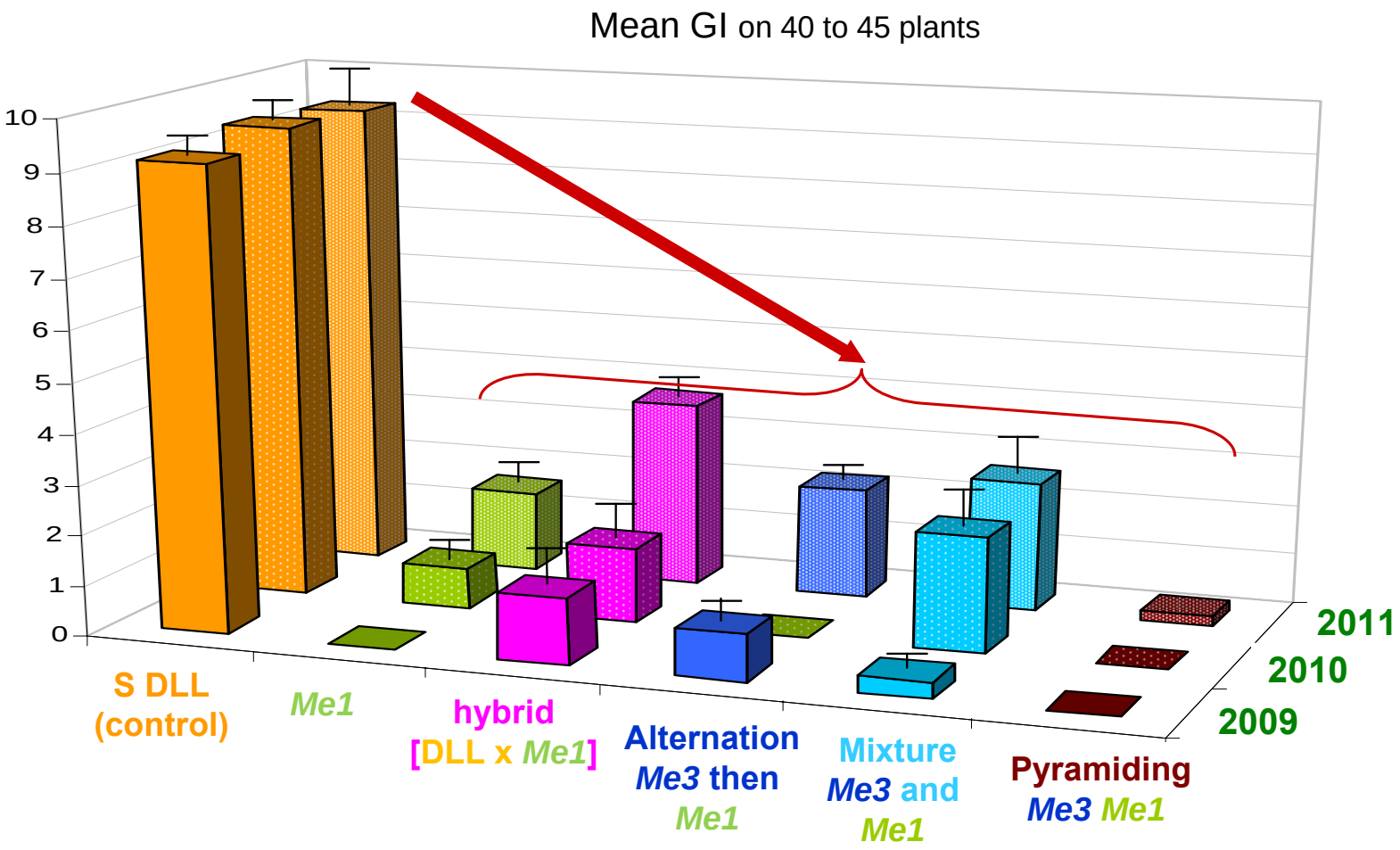
GI = gall index *(on peppers and salads)*

RR = reproduction rate of virulent nematodes

(if egg masses detected on R-peppers)

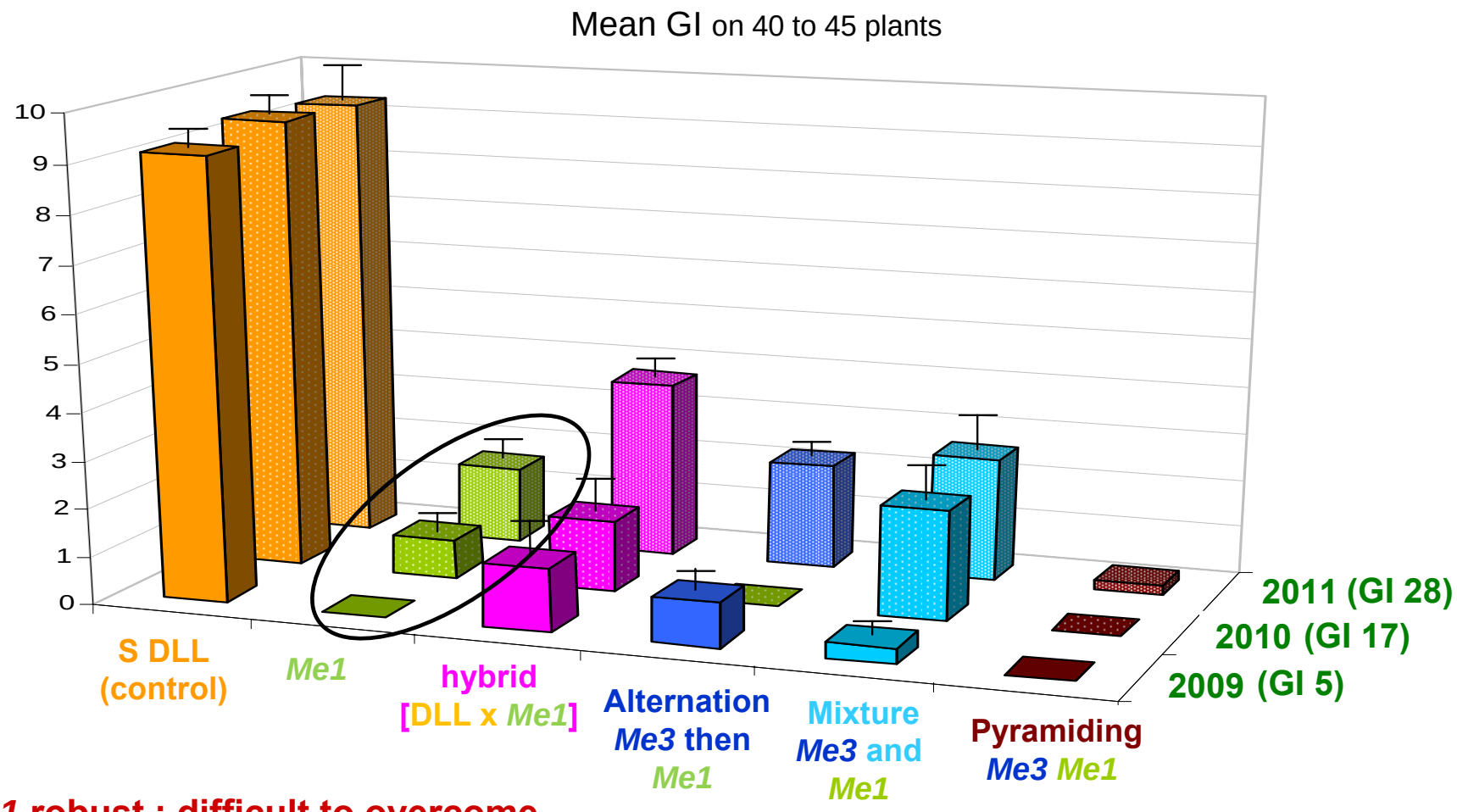
Example of an experiment in natural condition

GI = gall index on peppers *after 5 months of culture in summer*



Example of an experiment in natural condition

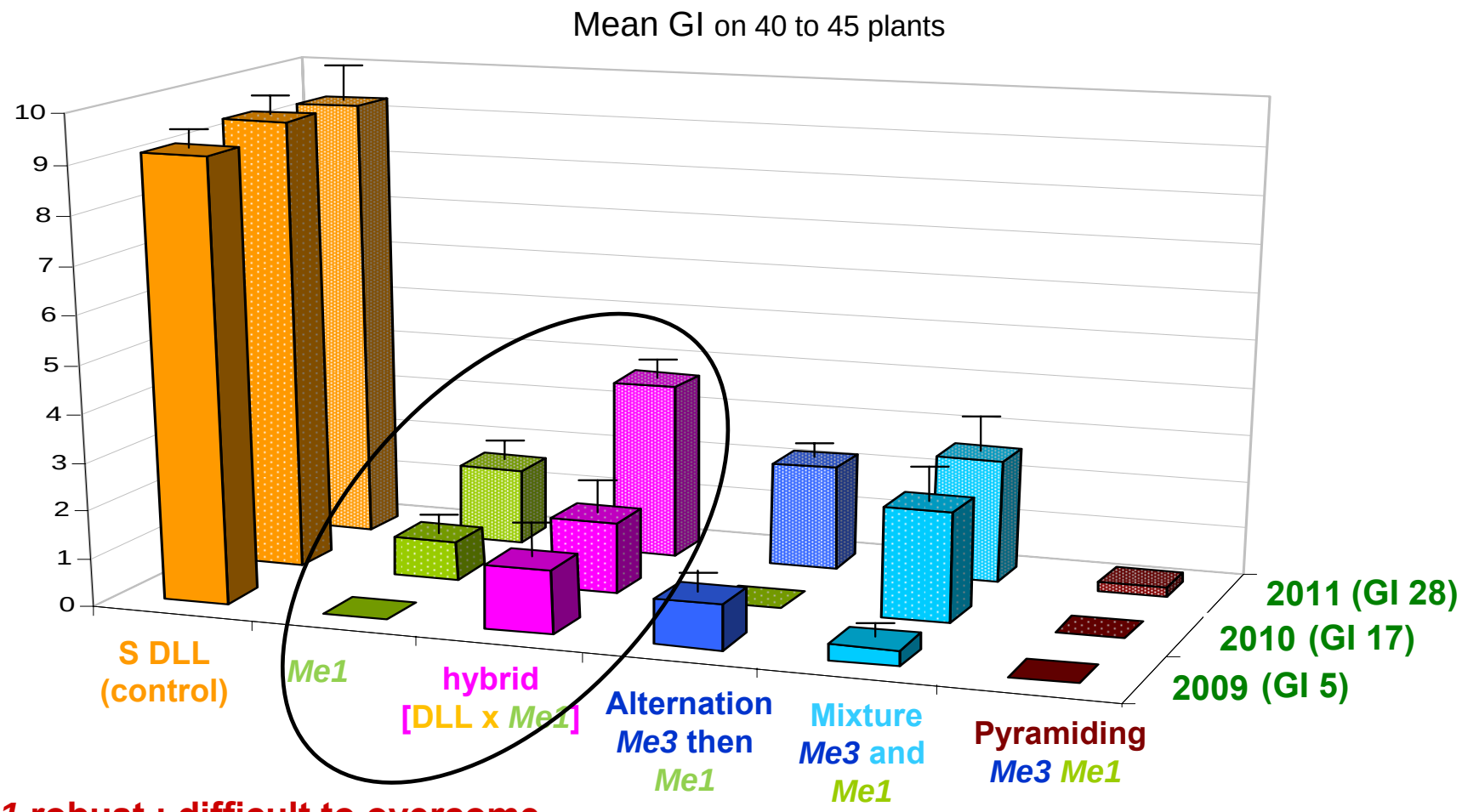
GI = gall index on peppers *after 5 months of culture in summer*



Me1 robust : difficult to overcome

Example of an experiment in natural condition

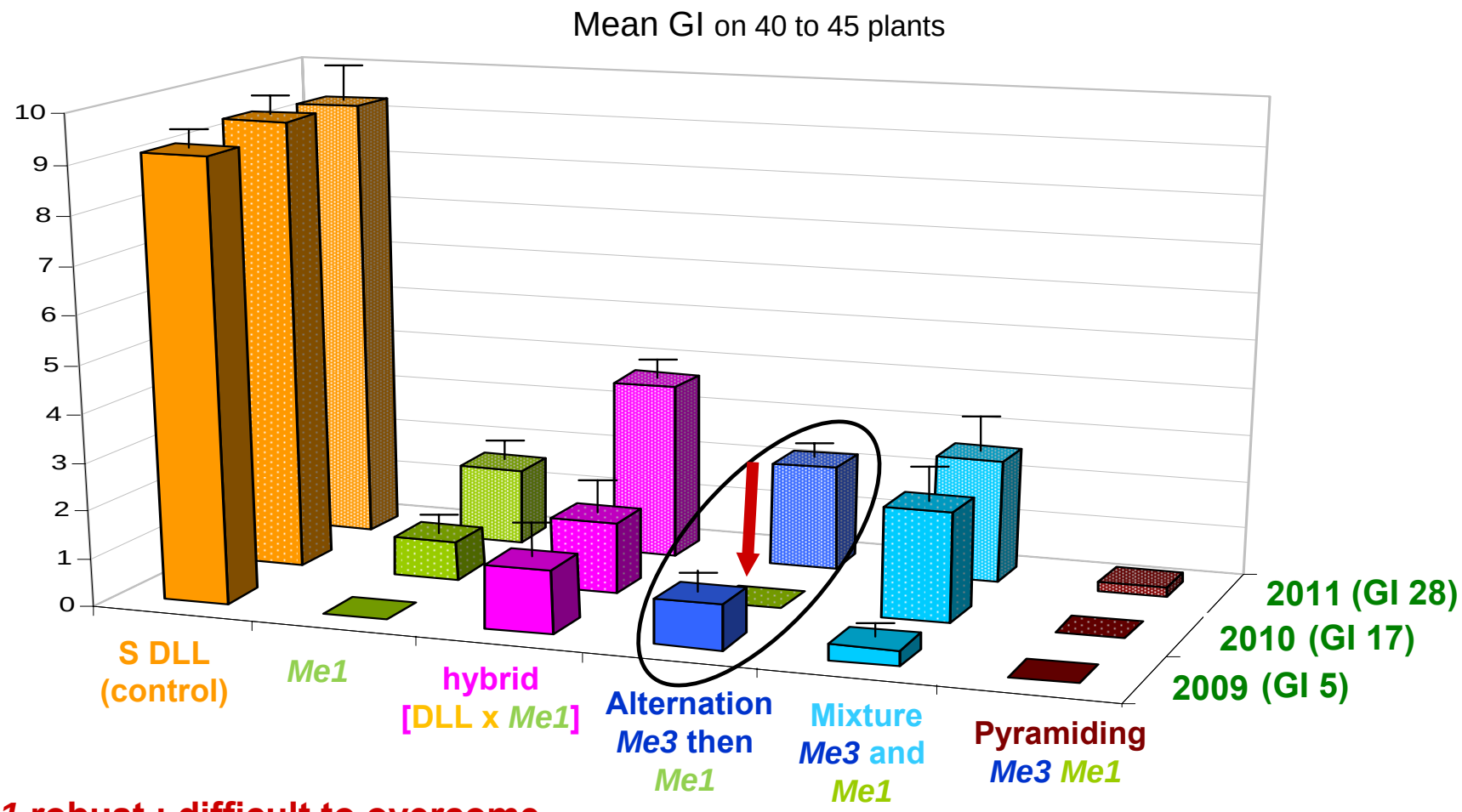
GI = gall index on peppers *after 5 months of culture in summer*



- ***Me1* robust : difficult to overcome**
- **F1 hybrids (*Me1* in S background) less R than *Me1 R*-parent**

Example of an experiment in natural condition

GI = gall index on peppers *after 5 months of culture in summer*

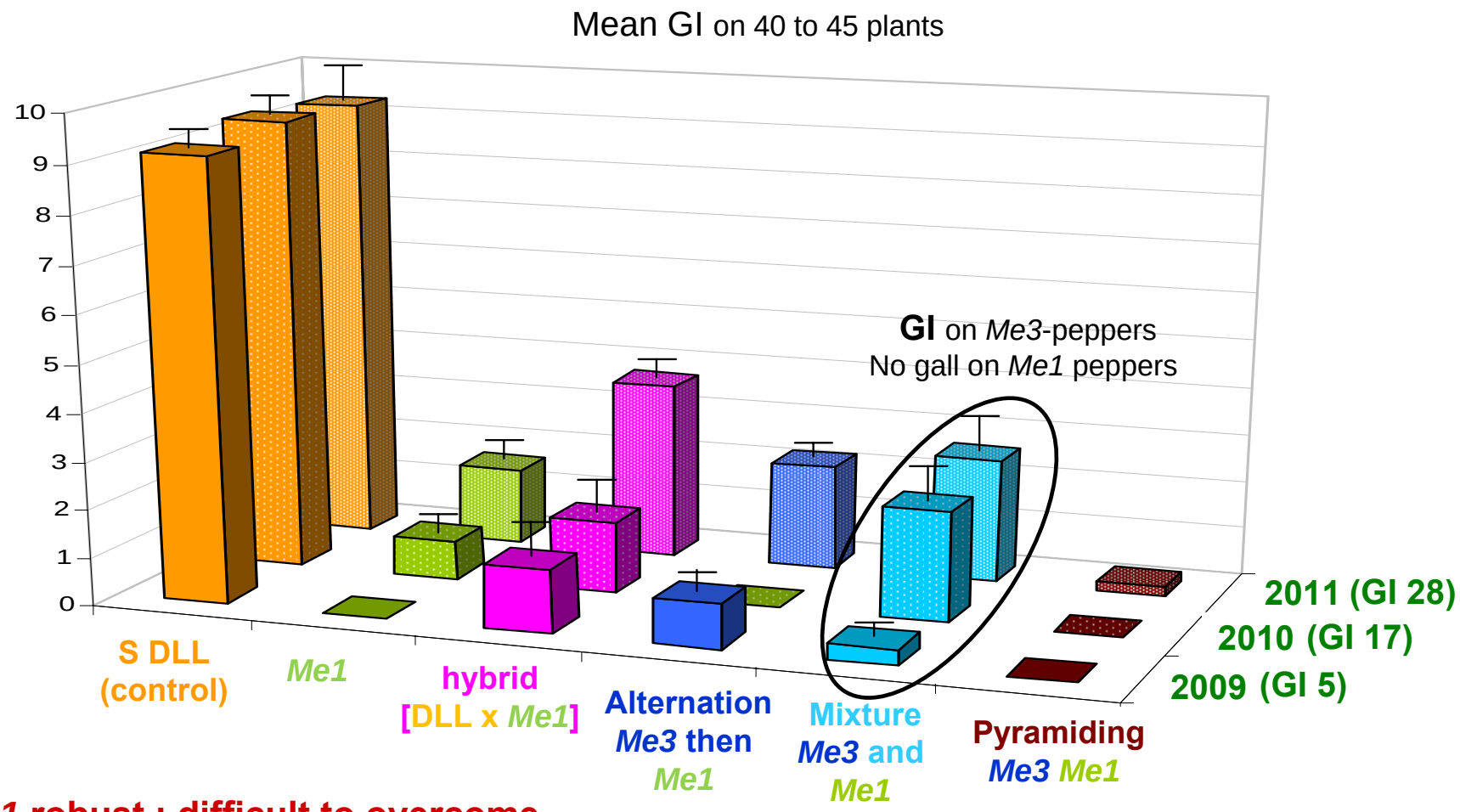


- *Me1* robust : difficult to overcome
- F1 hybrids (*Me1* in S background) less R than *Me1 R*-parent
- *Me3* overcome but specificity of virulence confirmed : alternation with *Me1* interesting

Djian-Caporalino *et al., EJPP 2011*

Example of an experiment in natural condition

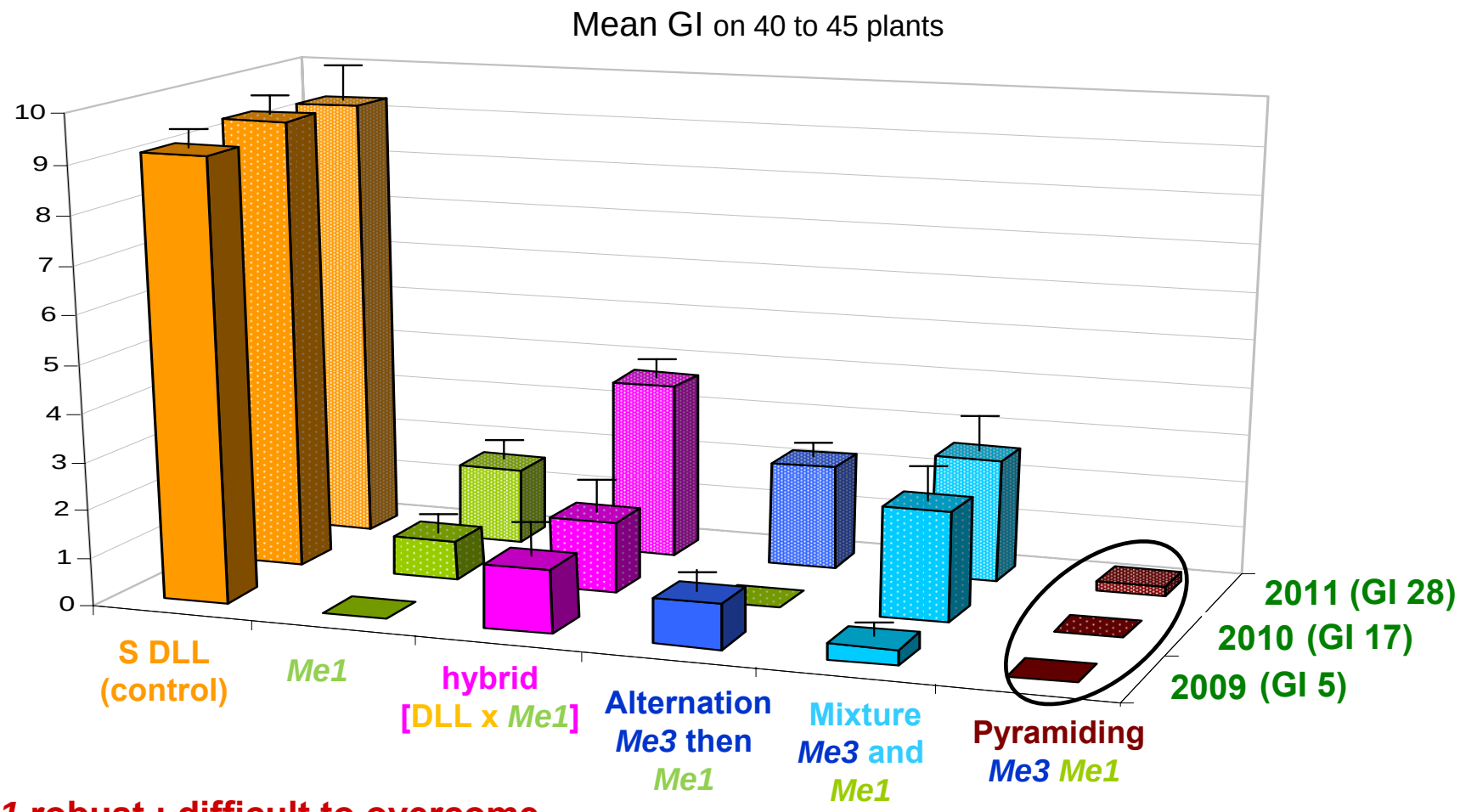
GI = gall index on peppers *after 5 months of culture in summer*



- *Me1* robust : difficult to overcome
- F1 hybrids (*Me1* in S background) less R than *Me1 R*-parent
- *Me3* overcome but specificity of virulence confirmed : alternation with *Me1* interesting
- *Me3 R*-peppers seem protected by *Me1 R*-peppers

Example of an experiment in natural condition

GI = gall index on peppers *after 5 months of culture in summer*

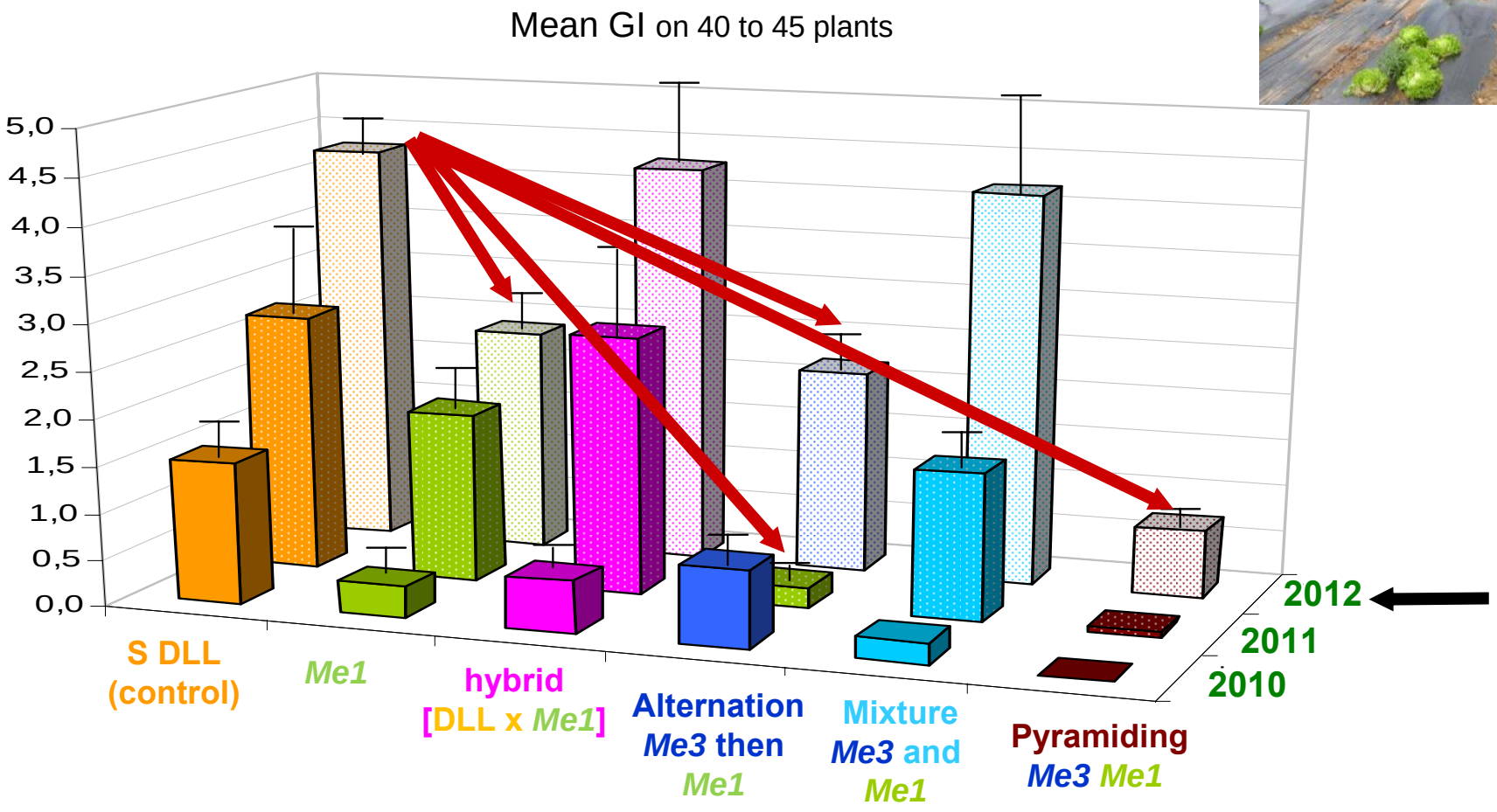


- *Me1* robust : difficult to overcome
- F1 hybrids (*Me1* in S background) less R than *Me1 R*-parent
- *Me3* overcome but specificity of virulence confirmed : alternation with *Me1* interesting
- *Me3 R*-peppers seem protected by *Me1 R*-peppers
- *Me3Me1 R*-peppers definitively the best modality

Example of an experiment in natural condition

GI = gall index on salads

after 3 months of culture in winter

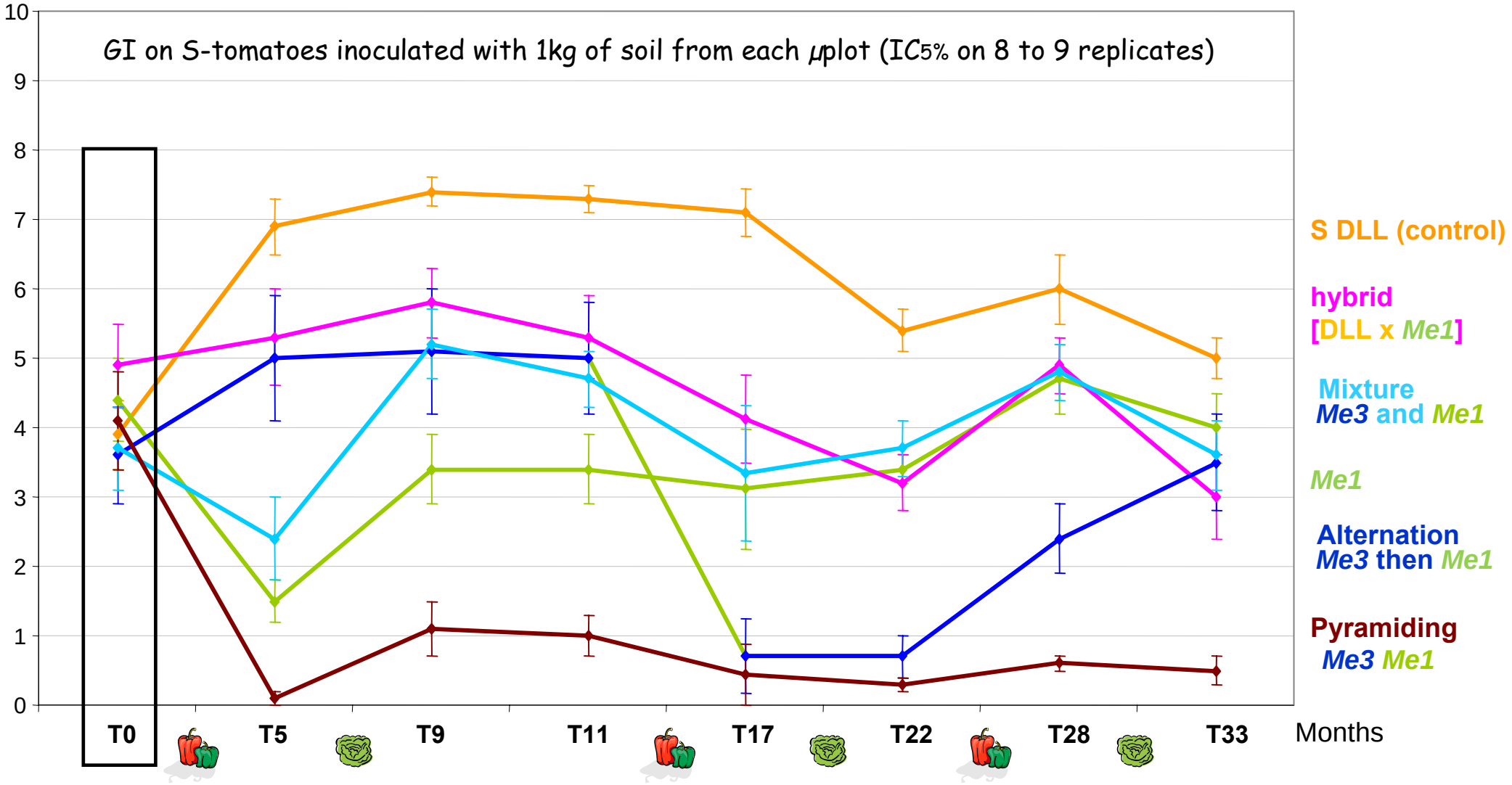


- **Some *R*-peppers modalities protected the salads, significantly**
- ***Me3Me1 R*-peppers gave the best protection to the salads in the rotation**

note : the third year, the experiment was not fertilized by the grower => the peppers were not sufficiently developped to traps nematodes

Example of an experiment in natural condition

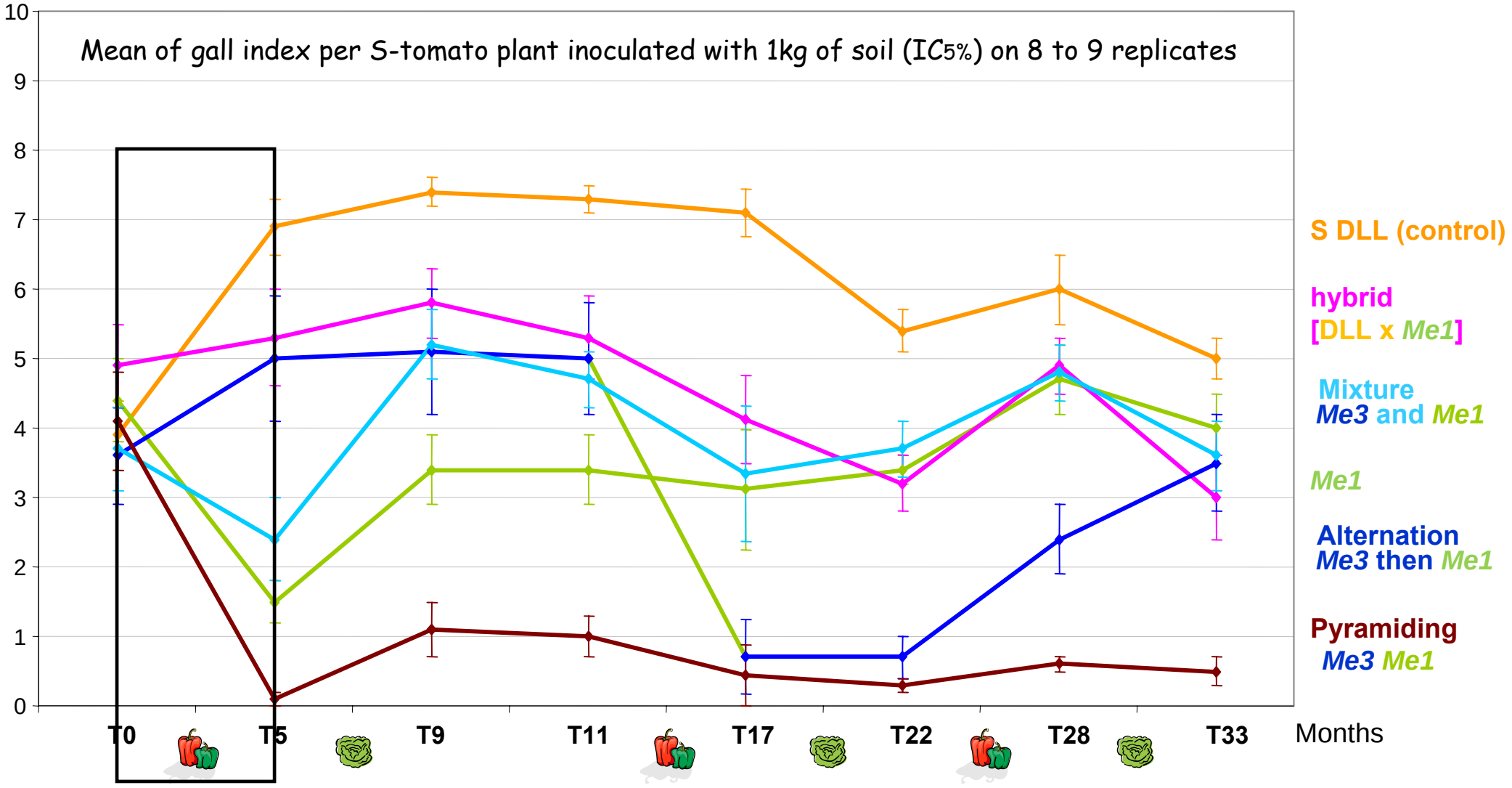
SIP = soil infection potential



Before peppers : SIP was high in each microplot (4-5)

Example of an experiment in natural condition

SIP = soil infection potential



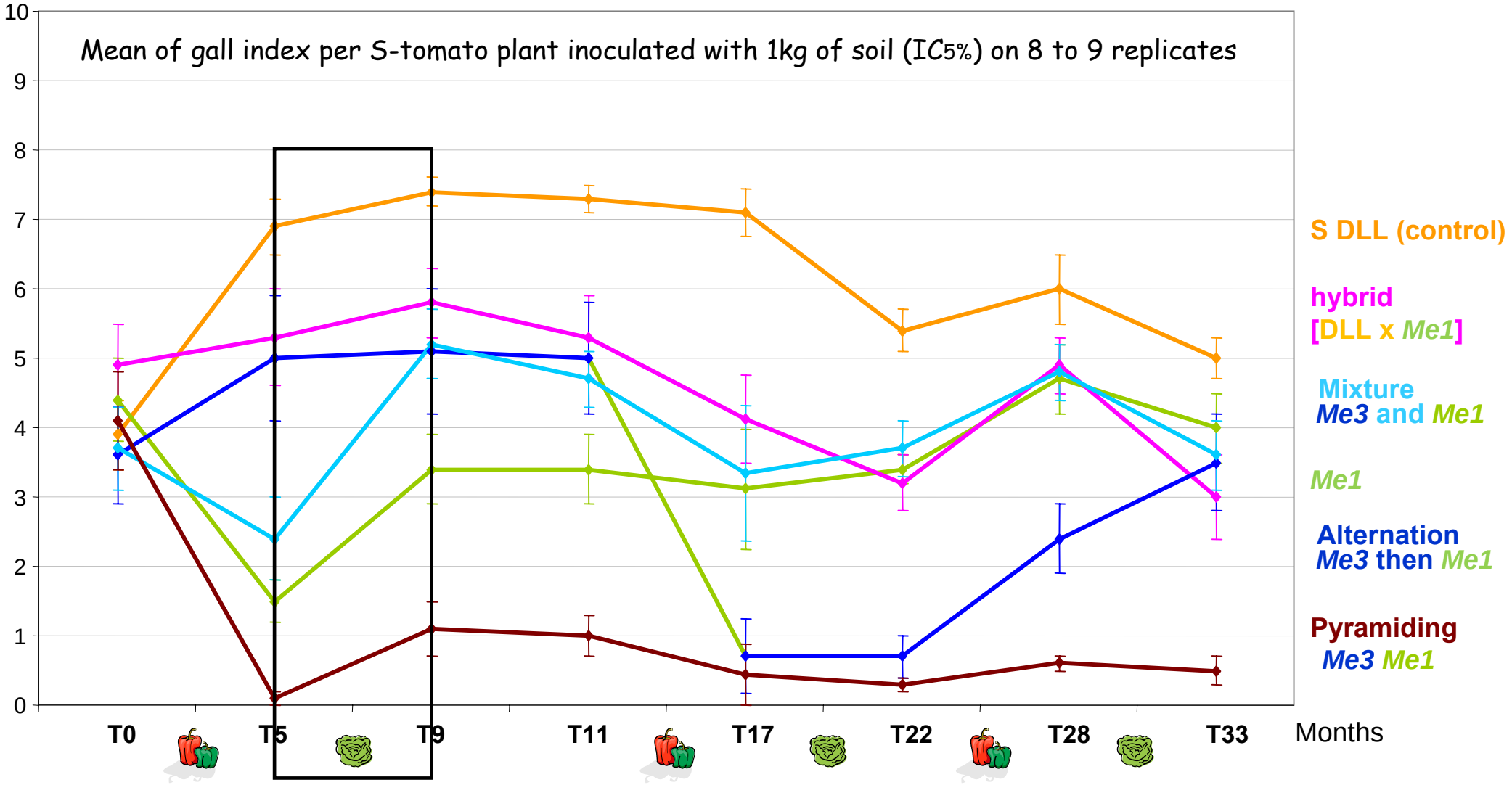
S DLL strongly increased the SIP

Mixture *Me3 and Me1* reduced the SIP

Me1 and Pyramiding *Me3Me1* strongly reduced the SIP

Example of an experiment in natural condition

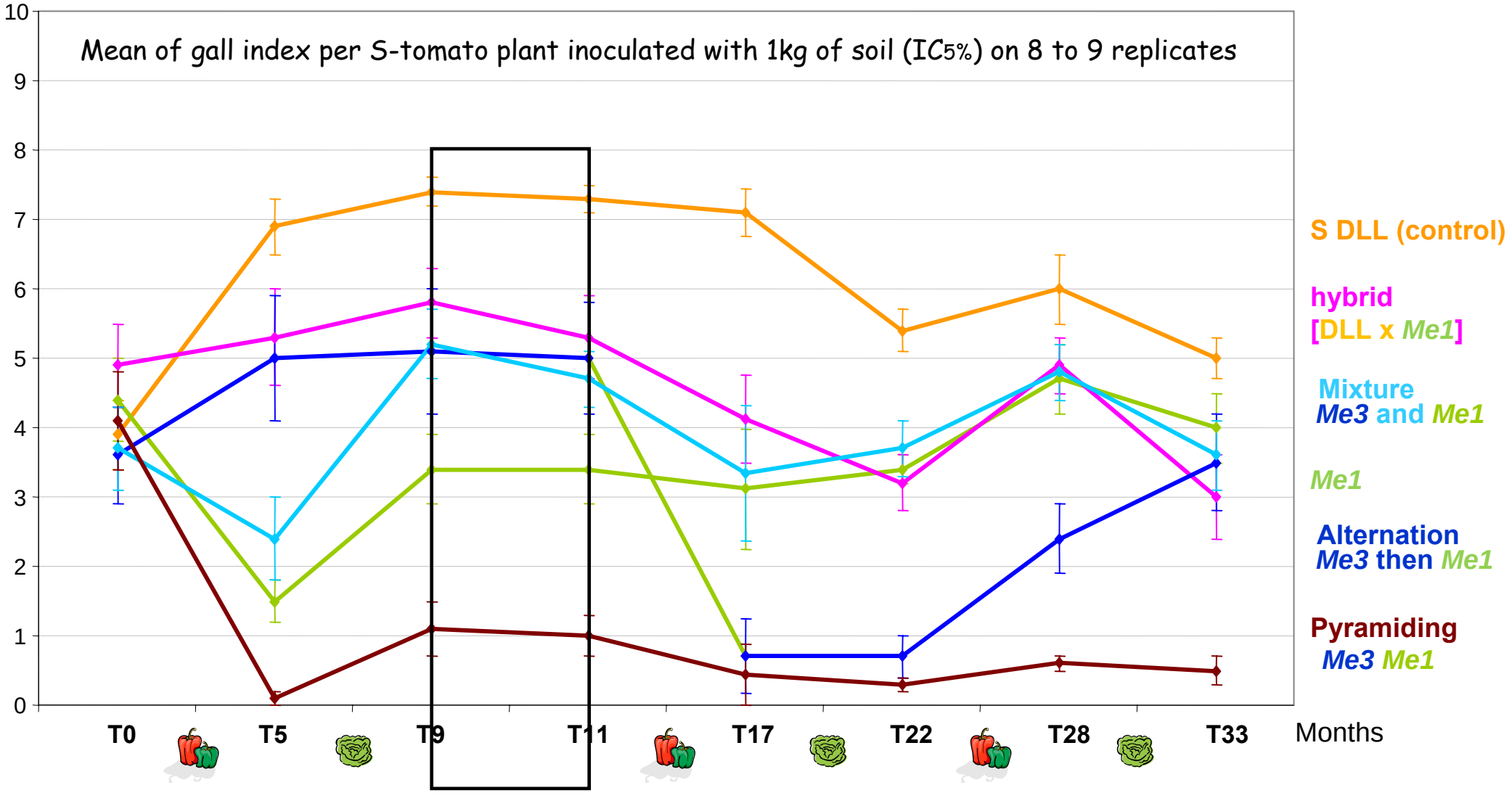
SIP = soil infection potential



S-salads allowed the multiplication of nematodes in each microplots

Example of an experiment in natural condition

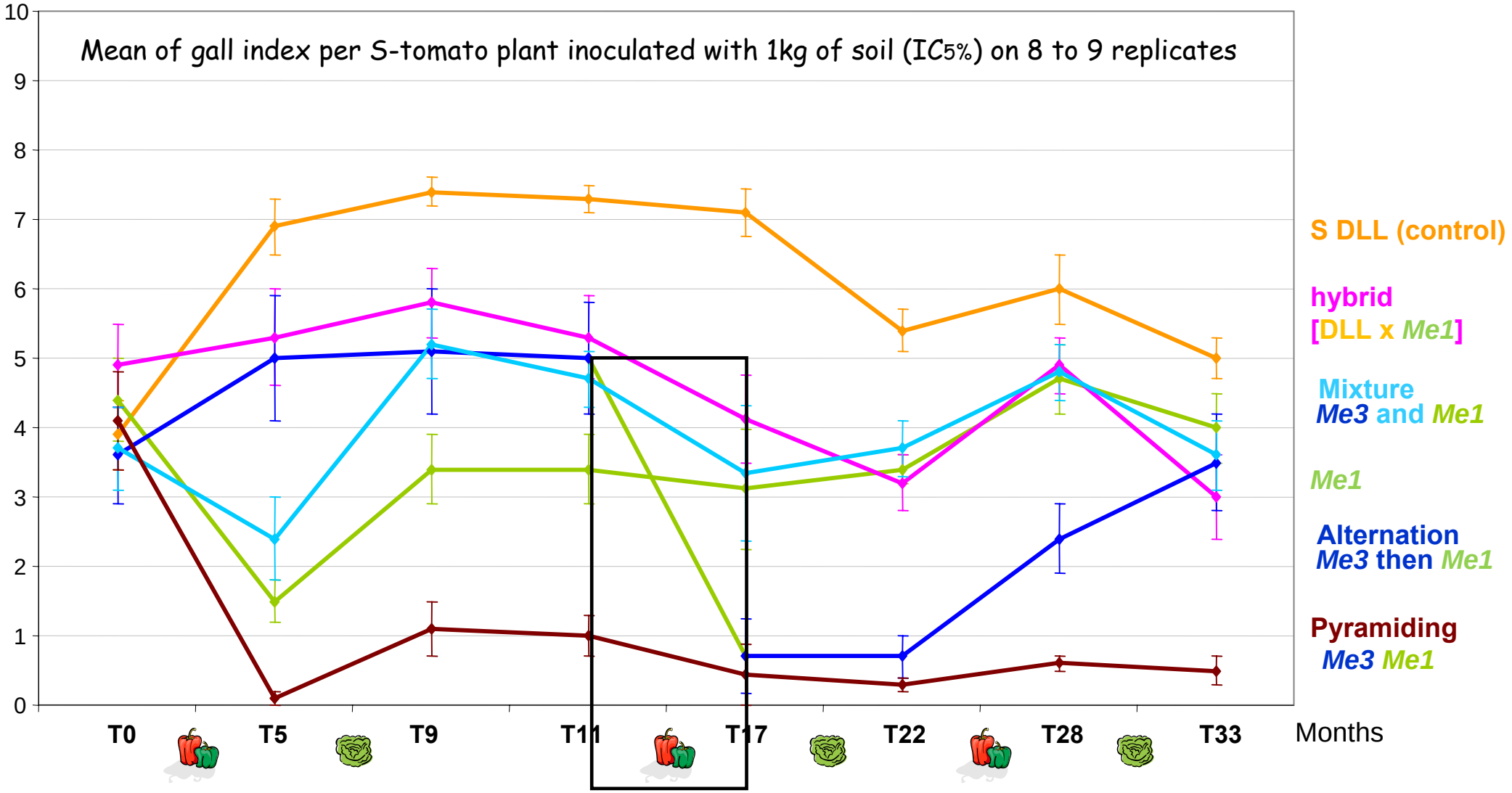
SIP = soil infection potential



After 2 months without any culture, no significant evolution of SIP

Example of an experiment in natural condition

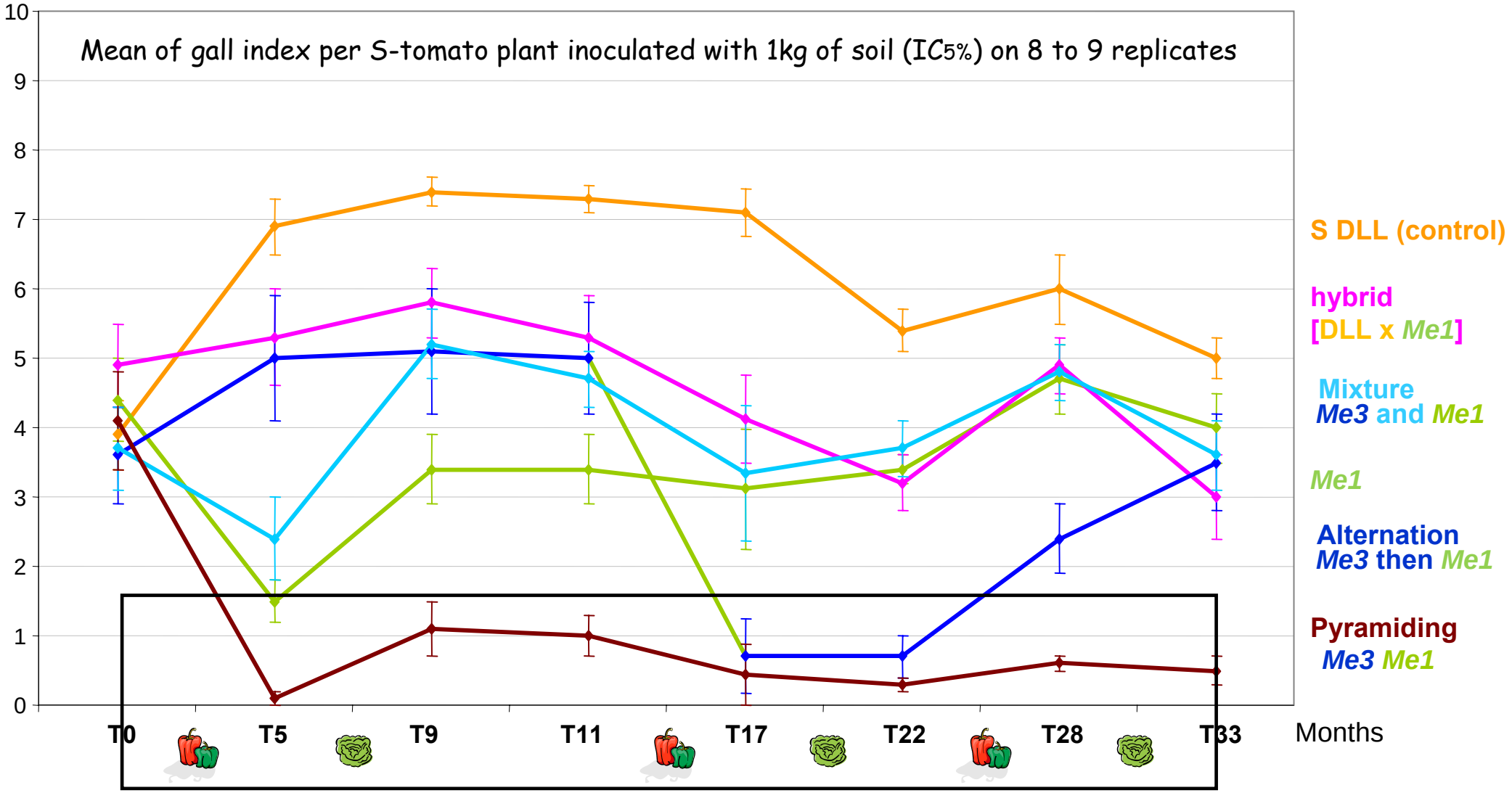
SIP = soil infection potential



Alternating *R*-genes in rotation efficient to decrease virulent populations in fields *(specificity of virulence)*

Example of an experiment in natural condition

SIP = soil infection potential



Alternating *R*-genes in rotation efficient to decrease virulent populations in fields *(specificity of virulence)*

Pyramiding R-genes in one pepper genotype : suppressed the emergence of virulent isolates, more durable, and best modality as trap crop

Conclusions

Strategies to strengthen and inscrease the *R* durability

At the plant level *(plant breeders)*

- **Choice of the *R*-genes** (the more robust, linked to the *R*-mechanism)
- **Choice of the genetic background** (in which the *R*-gene is introgressed)
- **Combinaison of *R*-genes** (pyramiding)

⇨ *To prevent the selection of virulent nematodes*

At the field and rotation level *(farmers)*

- **Diversification of *R*-plants** (alternating *R*-genes)

⇨ *To reduce the selection pressure of R-genes on the pathogens*

- **Use of a good fertilization for *R*-plants** : to increase their "trap" effect

⇨ *To decrease the amount of pathogens*

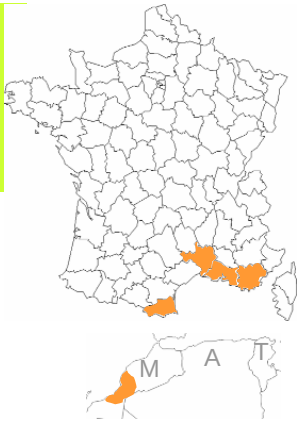
in good agreement with concepts recently developed for pepper-virus, rapeseed-fungus, rice-bacteria

Palloix *et al., New Phytol* 2009, Brun *et al., New Phytol* 2010 Yoshimura *et al. Mol Breeding* 1995 ; Hittalmani *et al. Theor Appl Genet* 2000; Singh *et al., Theor Appl Genet* 2001

Perspectives

The GEDUNEM project : Varietal and technical innovations for the sustainable and integrated management of RKN in protected vegetable cropping systems.

Combination of *R*-plants and cropping techniques : intercultural management (green manure, prophylactic treatments), biological control, multicrop rotations with bad host plants, and *R*-plants (alternance *Mi*-tomatoes, *Me3*-peppers)



INRA **metaprogramme SMaCH (Sustainable Management of Crop Health)**

Analysis of partial resistance factors (QTL, quantitative trait locus) that could explain the protective effect of the genetic background on major *R*-genes

Cifre Conventions ANRT PhD

PhD Arnaud Barbary 01/04/2011-2014

RIJK ZWAAN · GAUTIER semences · syngenta · TAKII · Vilmorin depuis 1743 · CLAUSE VEGETABLE SEEDS · SAKATA

Wed, Sept 26, Session S16

The genetic background plays an important role on durability of plant major *R*-genes to nematodes

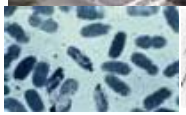
Collaborative network

INRA Sophia Antipolis (SE France)



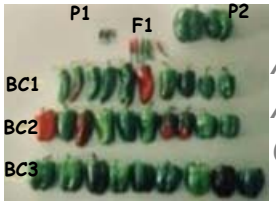







Philippe Castagnone-Sereno
Caroline Djian-Caporalino
Ariane Fazari (techn)
Nathalie Marteu (techn)
Arnaud Barbary (PhD)
Delphine Angella (CDD)

INRA Avignon and Montpellier (SE & SW France)

Alain Palloix
Anne-Marie Sage-Palloix
Ghislaine Nemouchi (techn)

Marc Tchamitchian
Mireille Navarrete
Mathilde Chapuis (student)
Amélie Lefevre
Laure Pares (techn)

IRD Montpellier (SW France)

Thierry Mateille
Johannes Tavoillot (techn)

Farmers' associations and technical centres (SE France)

CETA du Pays d'Aubagne

AGRICULTURES & TERRITOIRES CHAMBRES D'AGRICULTURE

APREL

Ctifl

Research Group in Organic Farming (SE France)

GRAB Groupe de Recherche en Agriculture Biologique

AZURA group, Maraissa company (Agadir, Morocco)

Vegetable producer and experimental station for integrated management

Azura Exigeants pour vous Exigeants pour nous

Private breeding companies (Syngenta, Vco, Gautier, Taki, Sakata, Rijkzwaan)

Cifre Conventions

Thank you for your attention

CTPS

Cifre Conventions

TAKII

GAUTIER semences

SAKATA

syngenta

RIJK ZWAAN

Vilmorin

CLAUSE

Endure

INRA

PICléo

Neoleg

ANR

Sysbiotel

alcotra

VALORI