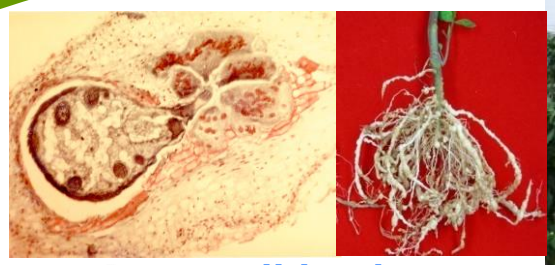
XV Meeting on Genetics and Breeding of Capsicum and Eggplant EUCARPIA
2 – 4 September 2013
Torino, Italy

XVth EUCARPIA Meeting on Genetics and Breeding of Capsicum & Eggplant

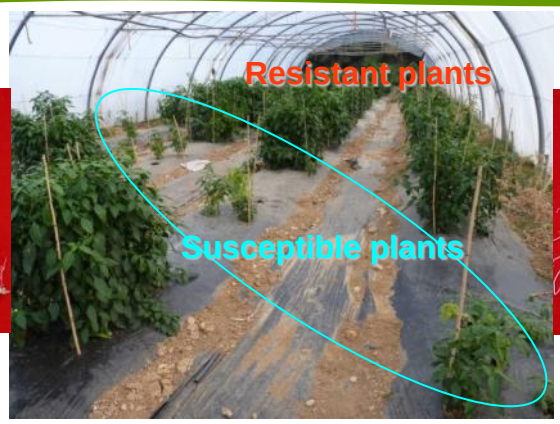
Torino, Italy 2 – 4 September, 2013

Session I: Evaluation and release of breeding material/cultivars, and seed production

Evaluation of resistance genes deployment strategies in the pepper *Capsicum annuum* for the durable management of root-knot nematodes



Susceptible plant



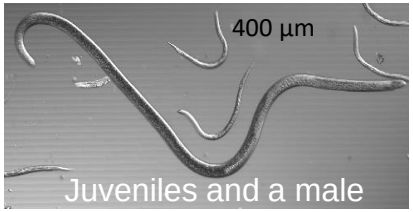
Resistant plant

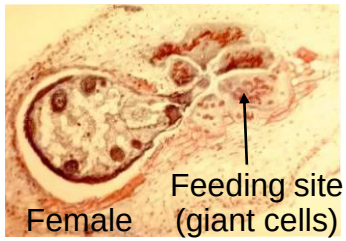
INRA PACA
Plant Nematodes Interaction team
Institut Sophia Agrobiotech

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

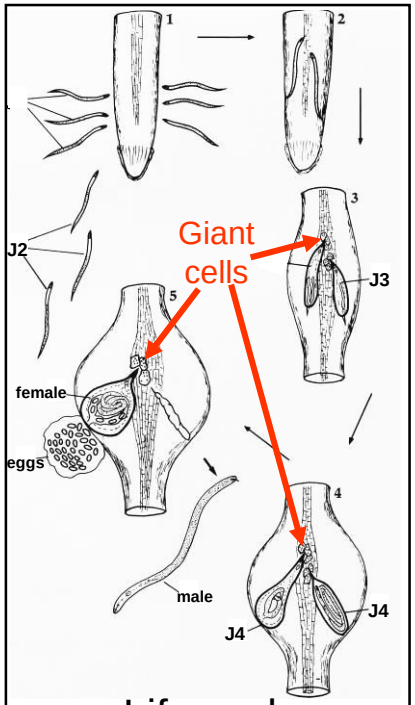
Root-knot nematodes *Meloidogyne* spp.

- Microscopic soil borne roundworms (0,2 to 2 mm), obligate sedentary endoparasites





- Symptoms : galls on roots (thus, sharp decrease in the aerial part ⋯-> death)



Life cycle
(3 weeks to 3 months)
Main species
parthenogenetic

- Extremely polyphagous (> 5,500 host plants)

- ~10% of crop losses worldwide *Trudgill & Blok, Annual Review of Phytopathology, 2001*
  = billions of euros lost / year *Sasser & Freckman, 1987*

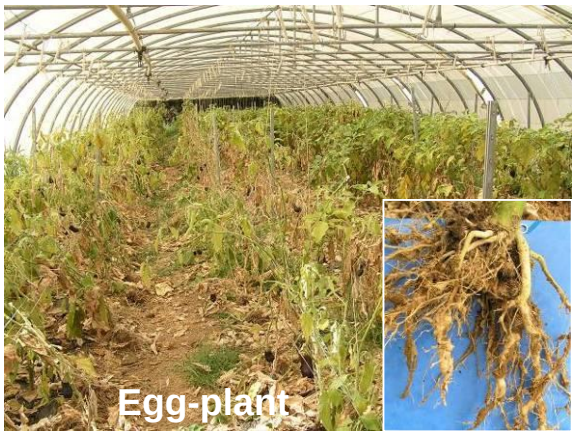
- Chemical nematicides *prohibited or restricted* *(Ecophyto plan 2018)*

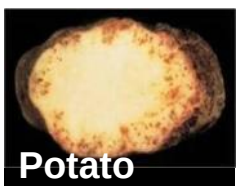
Fumigants : methyl bromide, dichloropropene

Systemics : e.g. aldicarbe LD_{50}=1ppm

Root-knot nematodes *Meloidogyne* spp.

An increasing problem on vegetable crops in Europe* and all Mediterranean regions





A survey conducted from 2007 to 2010** : > 40% of farms producing vegetables are infested in SE France

Crop rotations with resistant plants : economically efficient and environmentally safe, but resistance can be overcome

*Wesemael *et al., Nematology 2011* **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

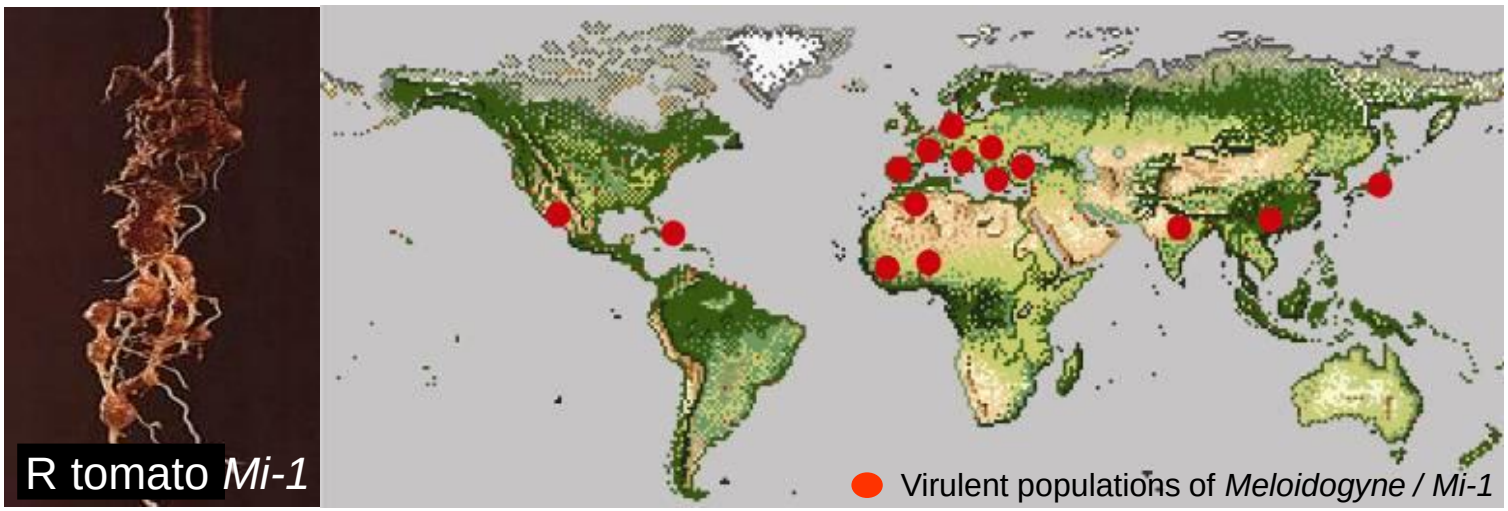
e.g. Jarquin-Barberena *et al. 1991;* Castagnone-Sereno *et al. 1994, 1996, 2001;* Meher *et al. 2009;* Djian-Caporalino *et al., 2011*

In natural conditions

- *Mi-1* in tomato and *N* in pepper cultivars, 60 years of use, 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

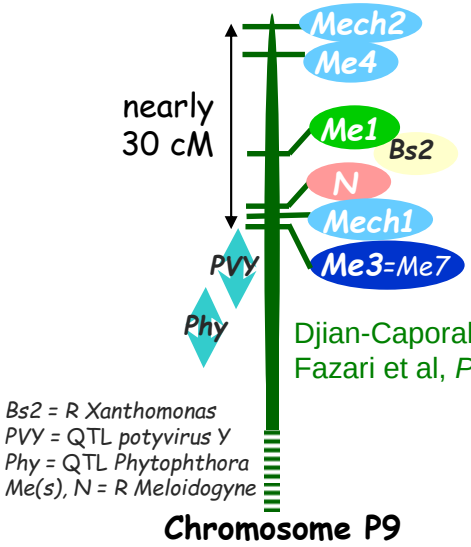


Development of new « robust » *R*-lines

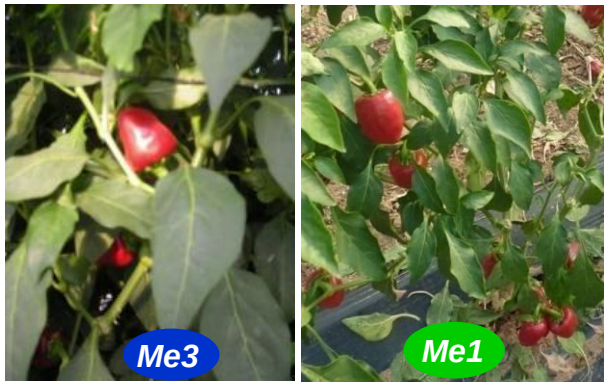
Management of *R*-genes to increase their durability

Model to study the durability of resistance to RKN

Capsicum annuum



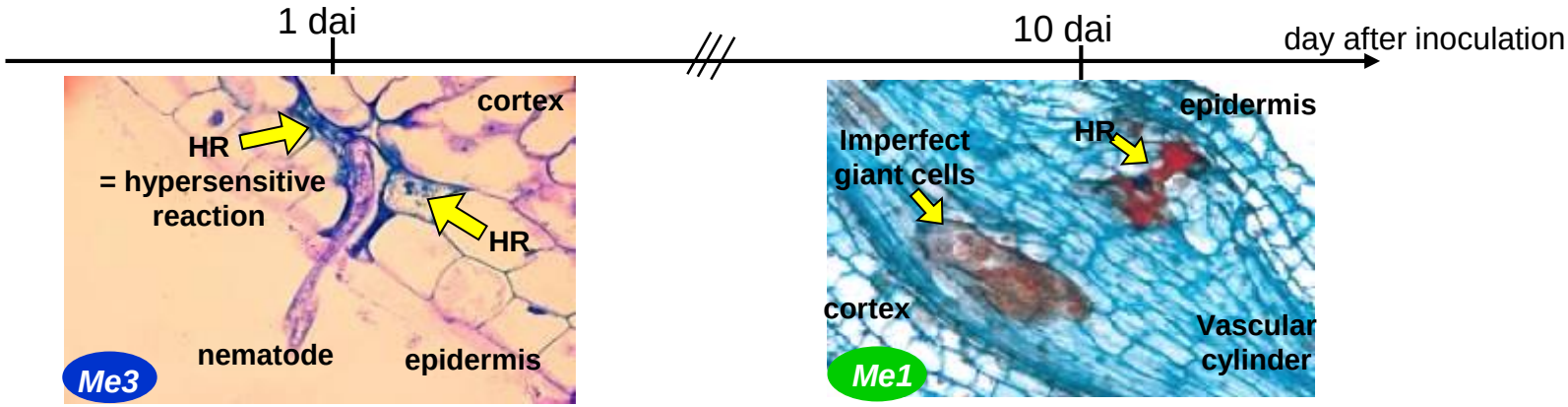
Djian-Caporalino et al, *TAG 2001, 2007*,
Fazari et al, *Plant Breeding 2012*



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

Laboratory experiments:

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 *R*-genes** (pyramiding)

3-years greenhouse and field experiments

. **Validation of results** with natural nematode populations

. **Determination of *R*-genes deployment strategies lowering the risk of emergence of virulent nematodes :**

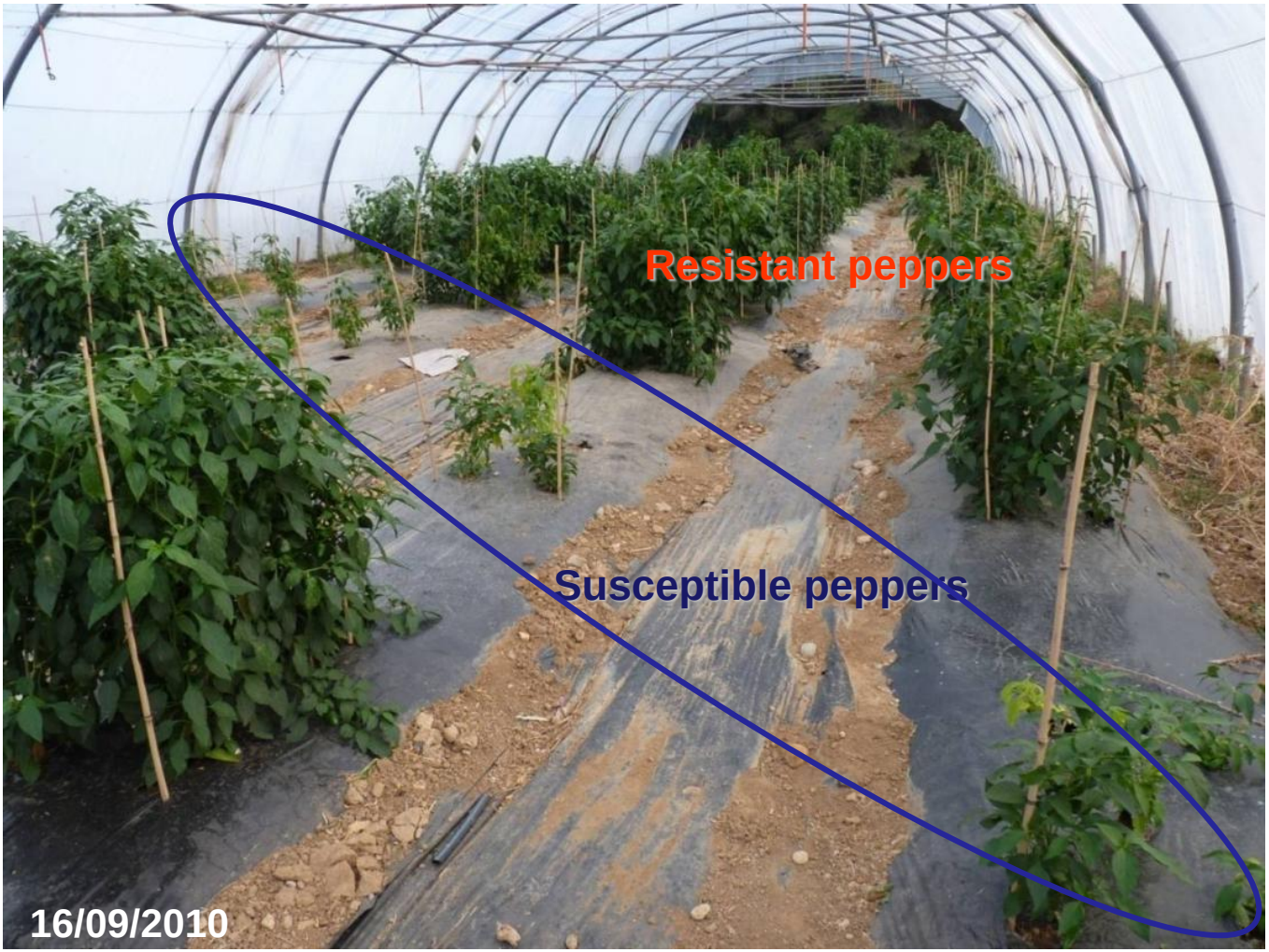
i) alternance of *R*-genes in rotation,
ii) mixture of different *R*-genotypes in the same plot
iii) pyramiding of 2 *R*-genes in one genotype.

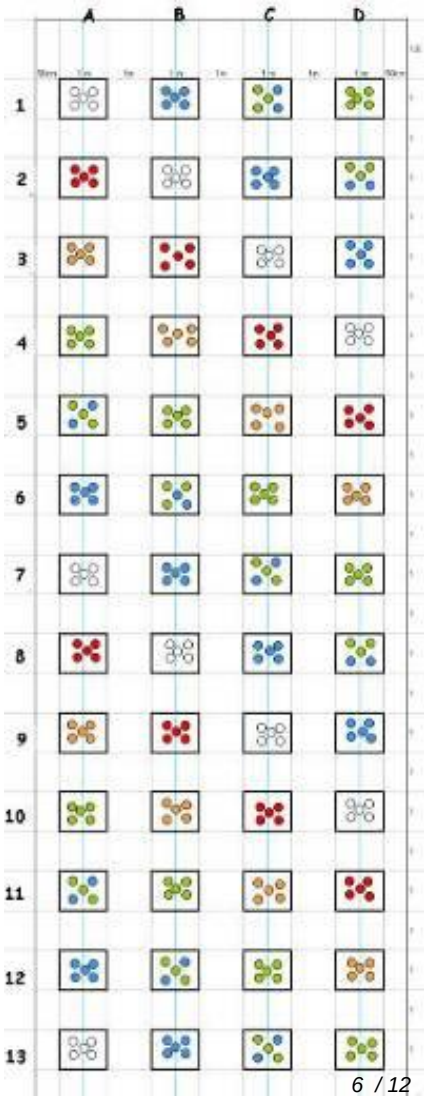
Example of an experiment in natural condition

Nice, SE France

224 m², 52 µplots, 5 plants/µplot

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





Material and methods

6 MODALITIES

8 to 9 µplots/modality

x 5 plants/µplot

= 40 to 45 plants/modality

Susceptible cultivar DLL (control)

R inbred line *Me1*

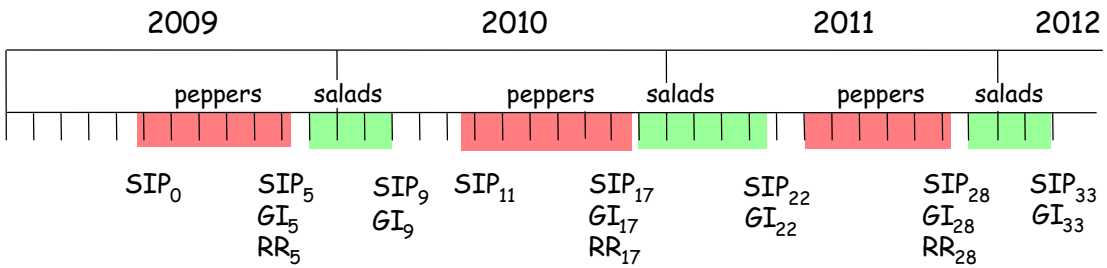
R hybrid [DLL x *Me1*]

Alternation *Me3* then *Me1*

Mixture *Me3* and *Me1*

Pyramiding *Me3* *Me1*

Schedule



Infestation parameters

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

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

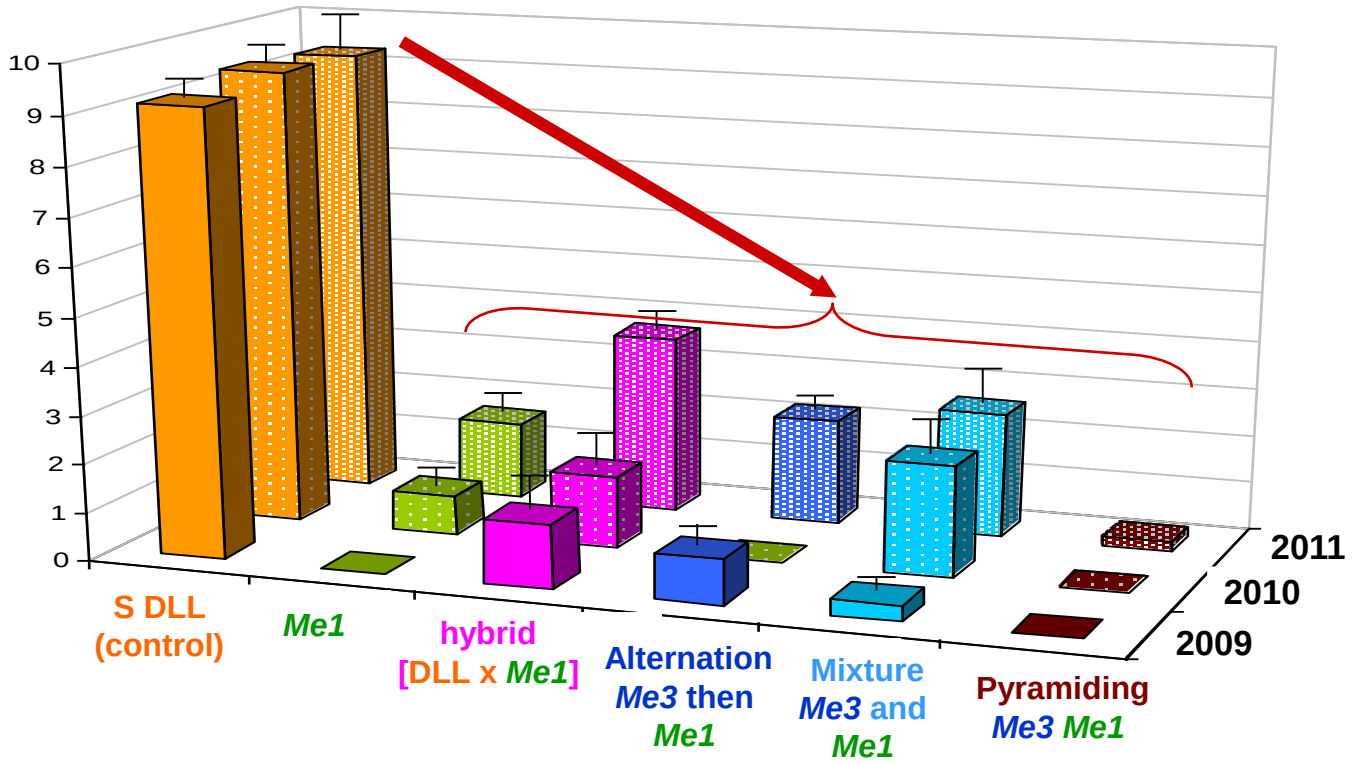
RR = reproduction rate of virulent nematodes if egg masses detected on *R*-peppers

(number of eggs produced /J2 inoculated on R-peppers in controlled conditions)

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)

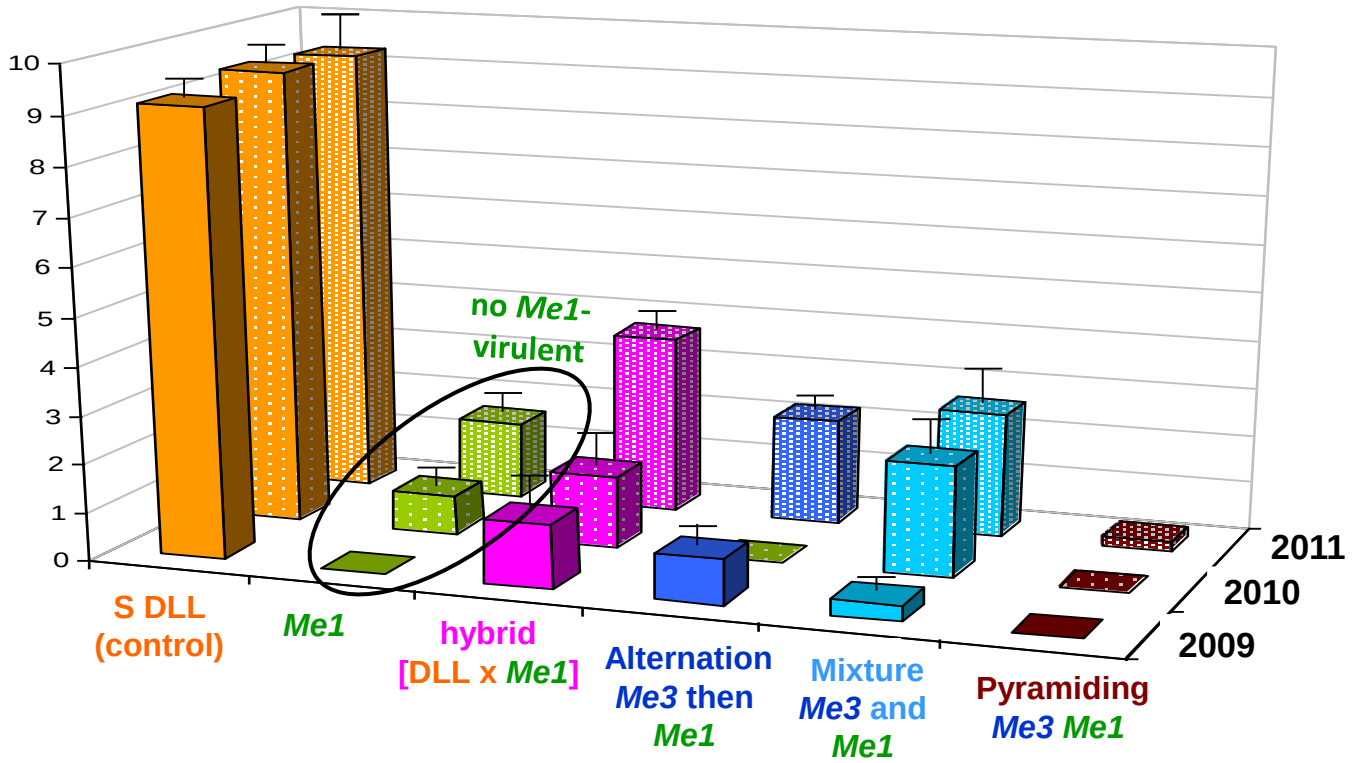


GI on *S*-peppers nearly maximum and very high compared to the *R*-peppers

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)

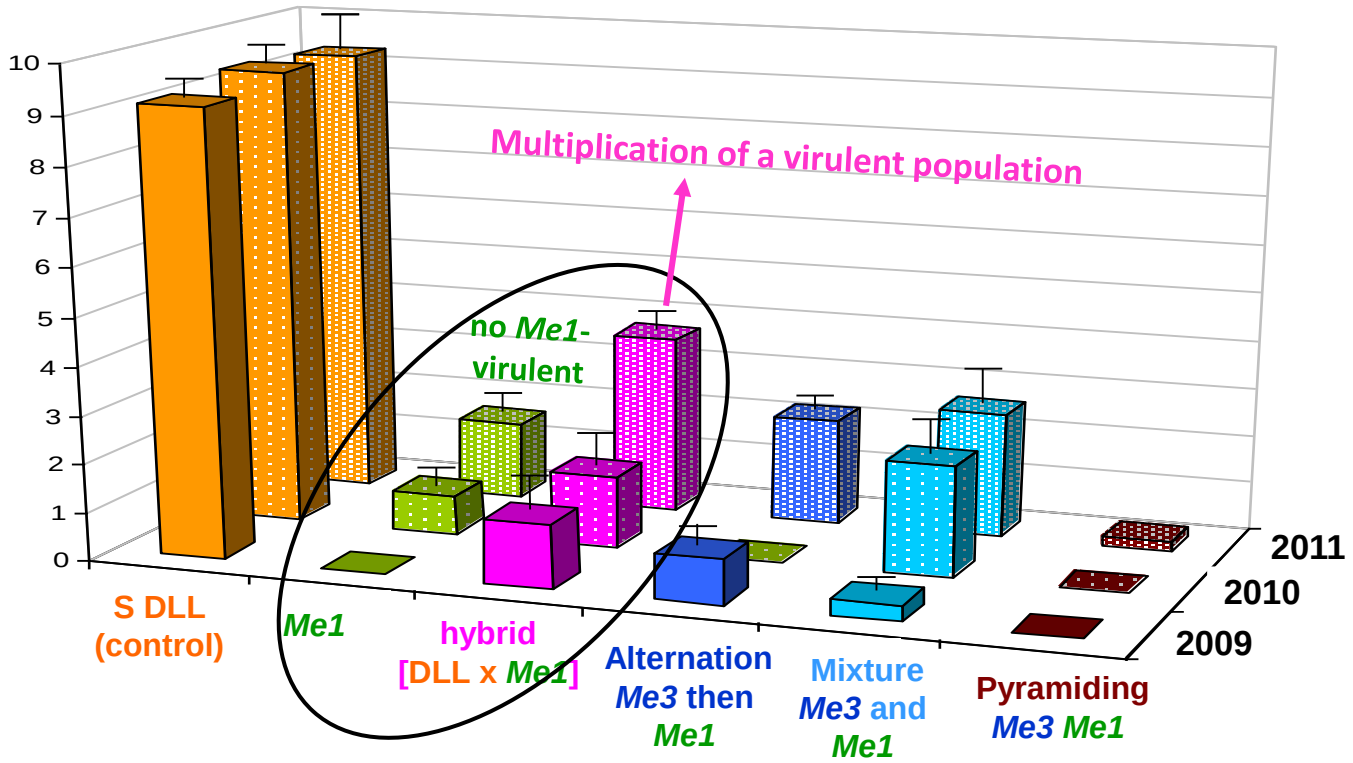


***Me1* robust : difficult to overcome even in natural conditions**

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)

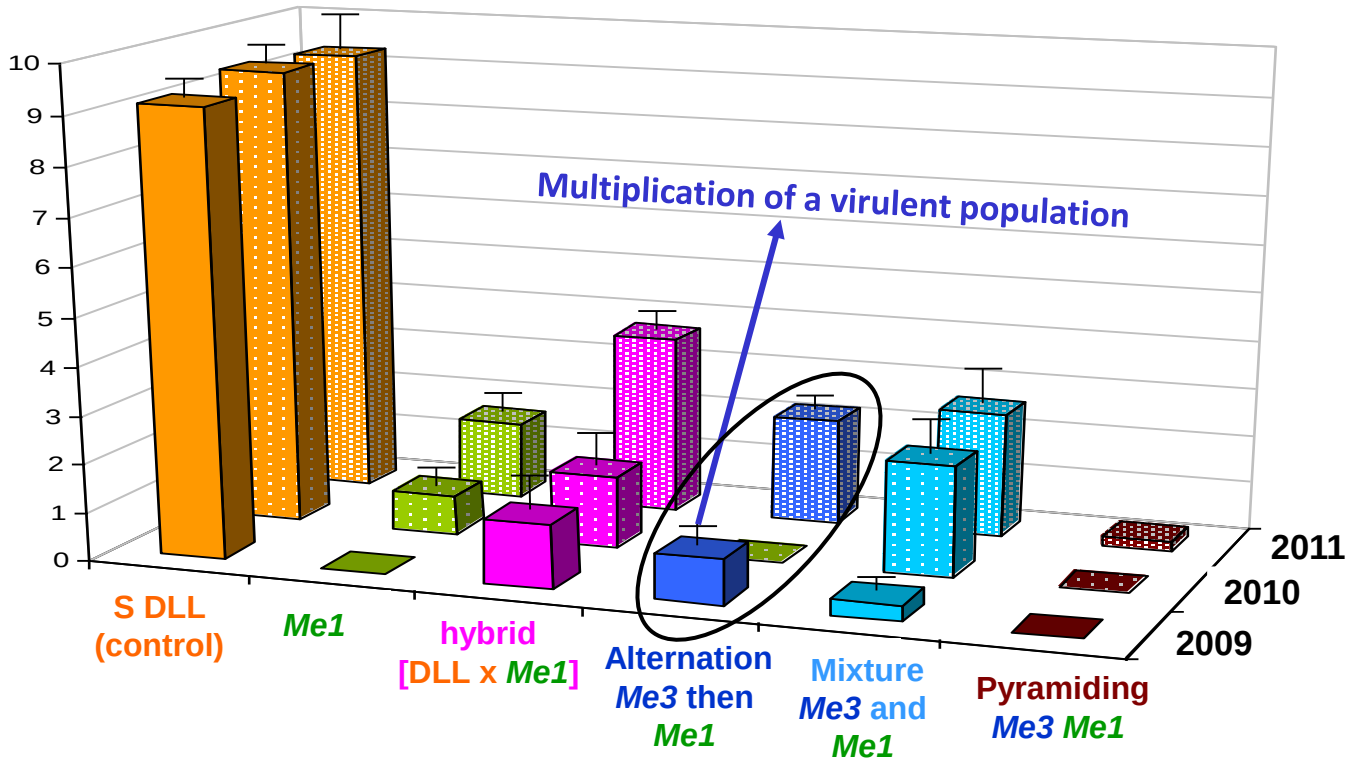


F1 hybrid (*Me1* in S background) less R than *Me1 R*-parent

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)

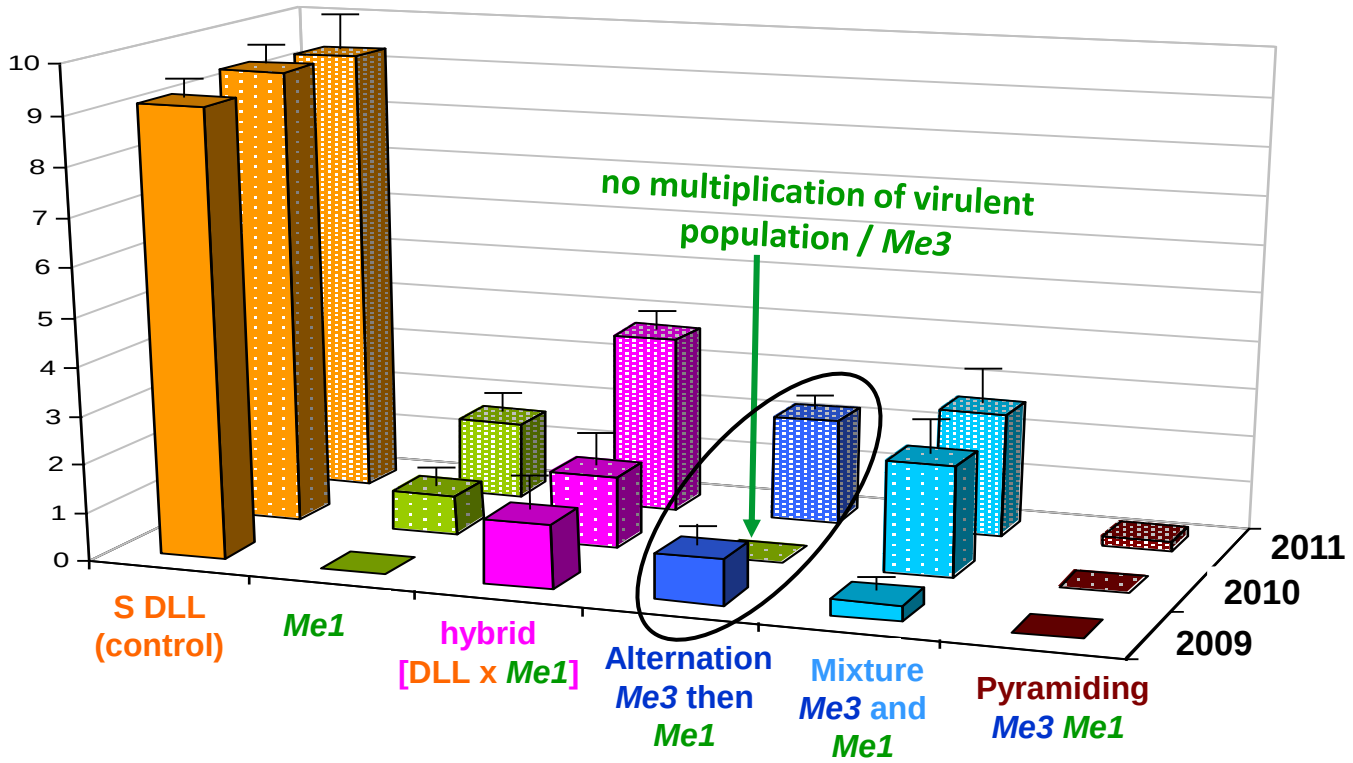


***Me3* overcome the first year**

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)



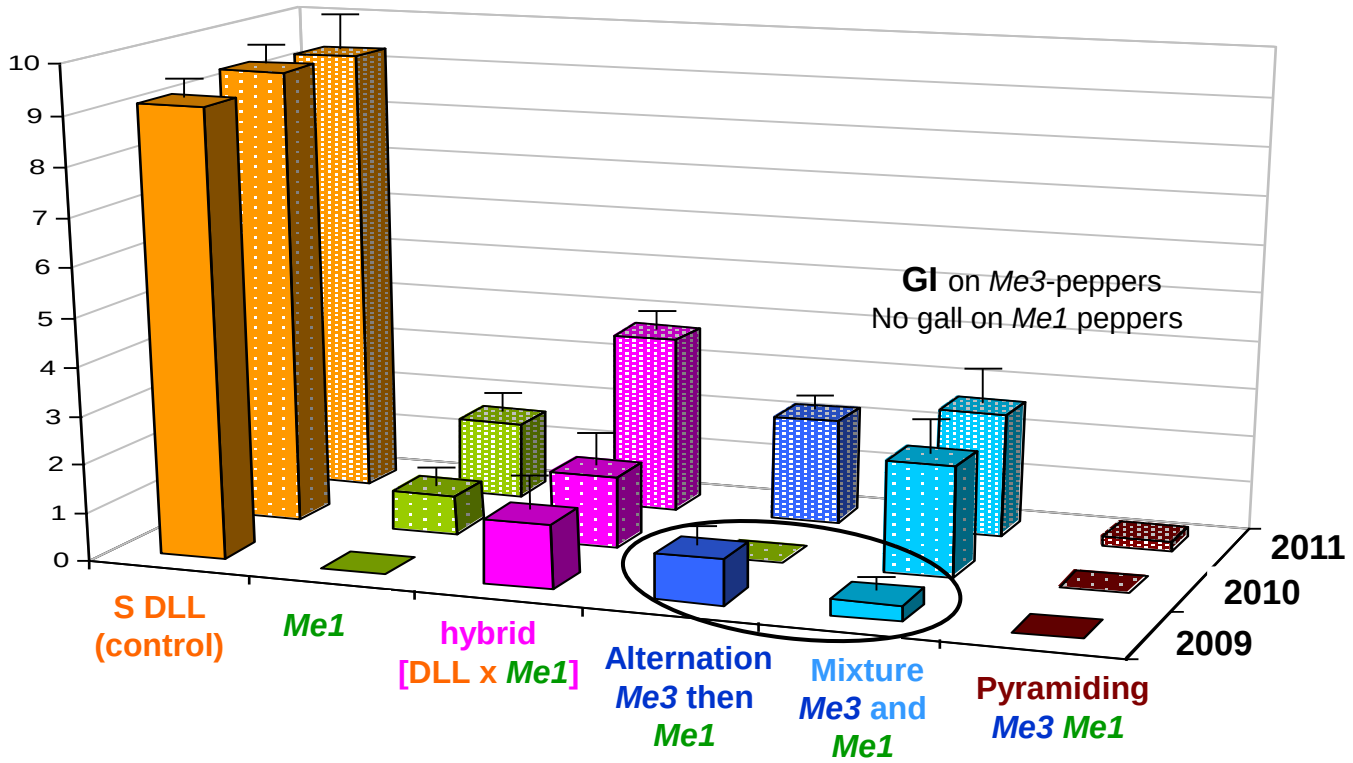
***Me3* overcome the first year but specificity of virulence confirmed**

Djian-Caporalino *et al., EJPP 2011* **=> alternation *Me3* with *Me1* interesting to stop *Me3* virulent population (recycling an ineffective *R*-gene)**

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)



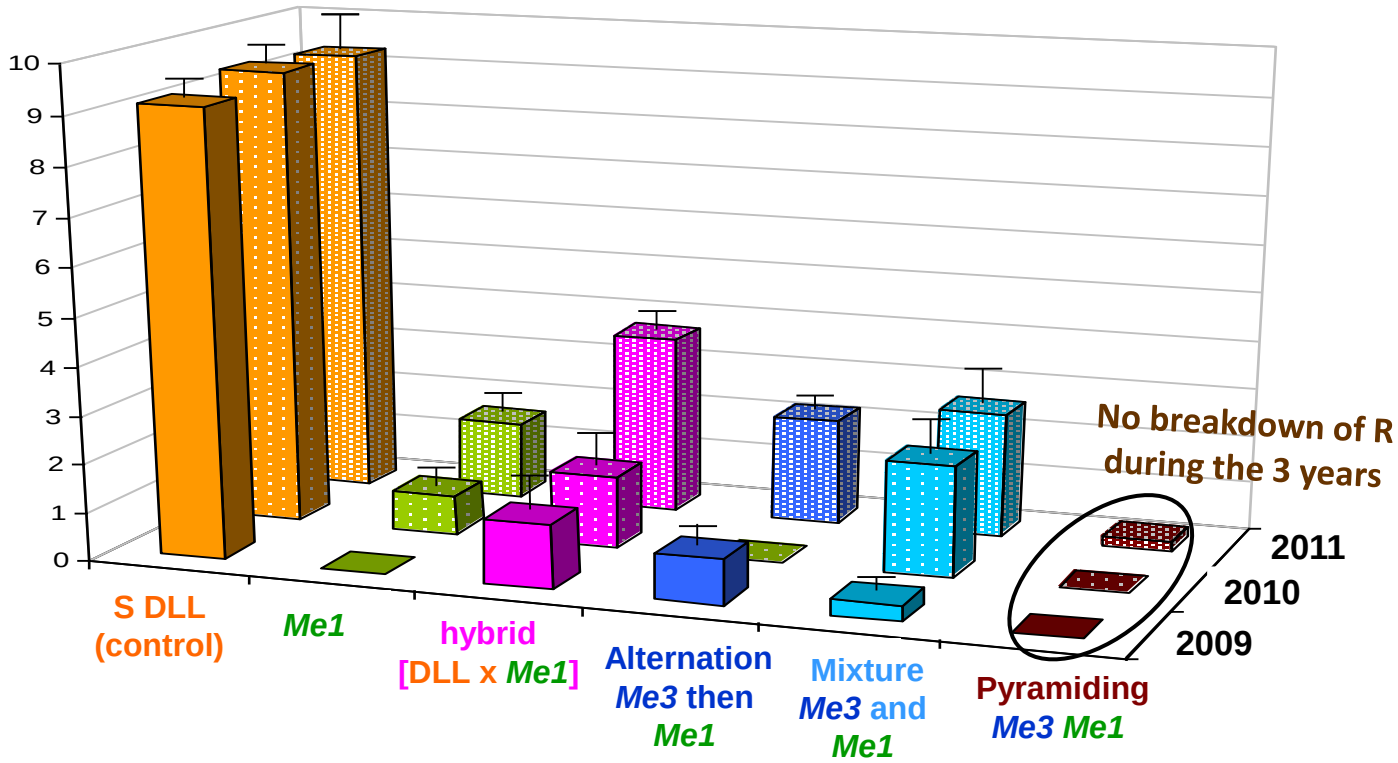
***Me3 R*-peppers seem protected by *Me1 R*-peppers**

Organic amendment the first year => the roots were well developped and intercrossed between *Me1* and *Me3* peppers the first year

Results

Strength and durability of resistances

Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)



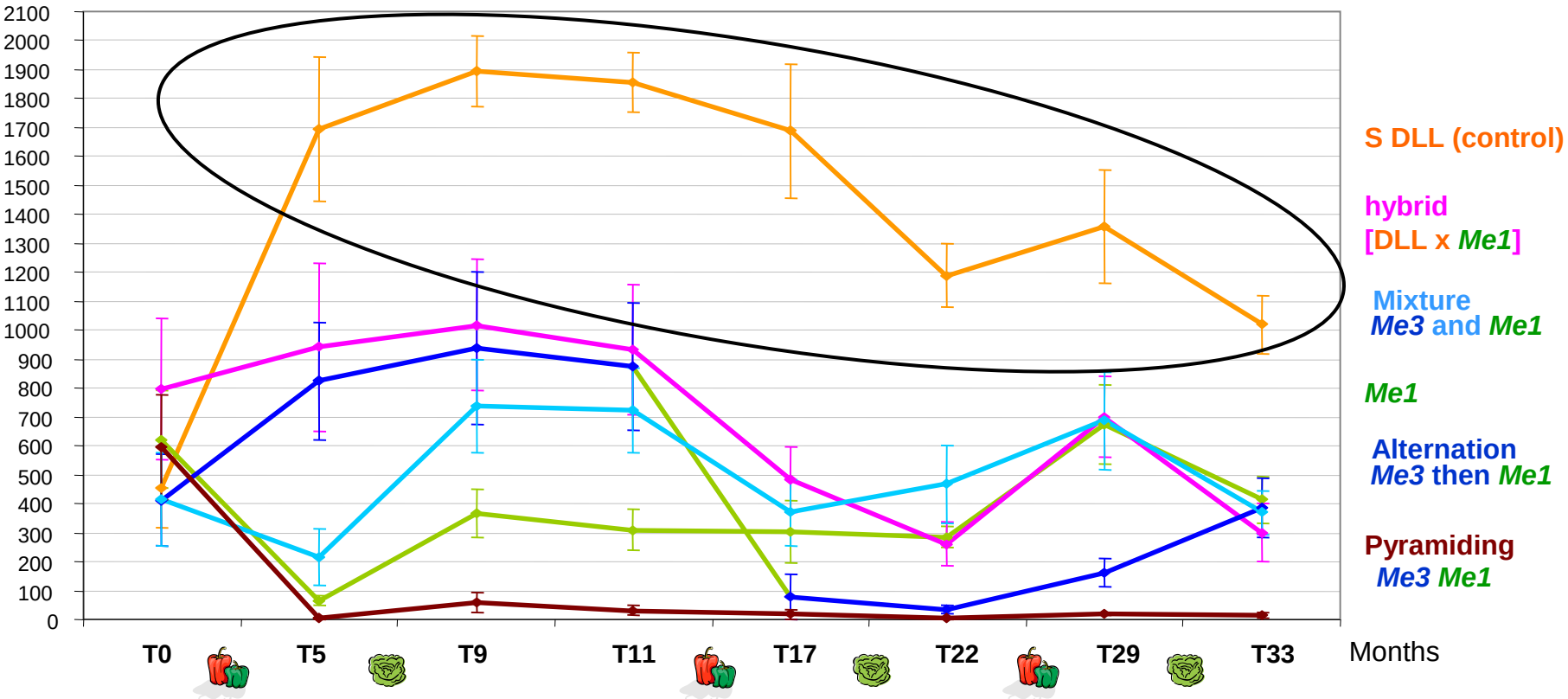
***Me3Me1 R*-peppers never infested : the best modality of deploying the *R*-genes**

Djian-Caporalino *et al., submit*

Results

Reduction of the soil infection potential (“trap” effect)

Egg-masses on S-tomatoes inoculated with 1kg of soil extracted from each µplot (IC5% on 8 to 9 replicates)

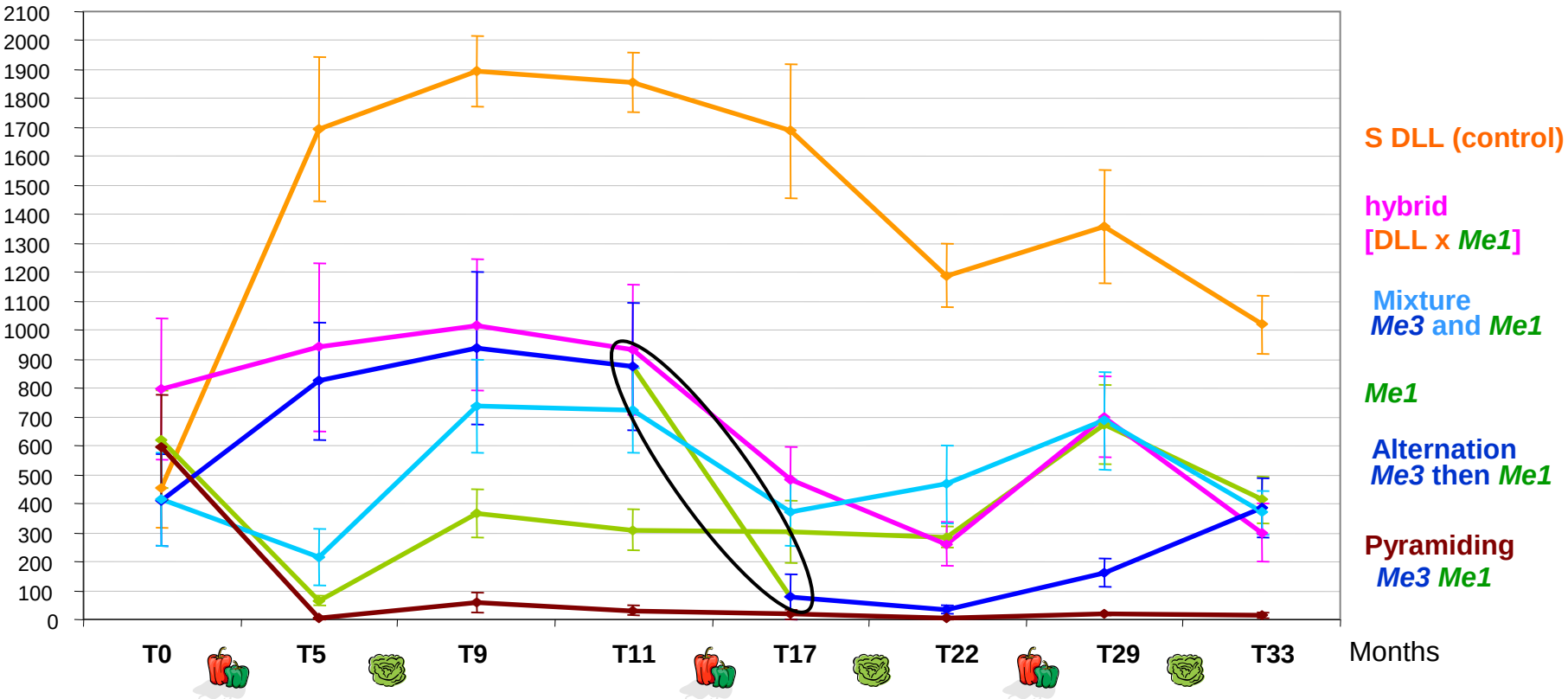


Only the S-peppers multiplied significantly the nematodes in the soil

Results

Reduction of the soil infection potential ("trap" effect)

Egg-masses on S-tomatoes inoculated with 1kg of soil from each µplot ($IC_{5\%}$ on 8 to 9 replicates)

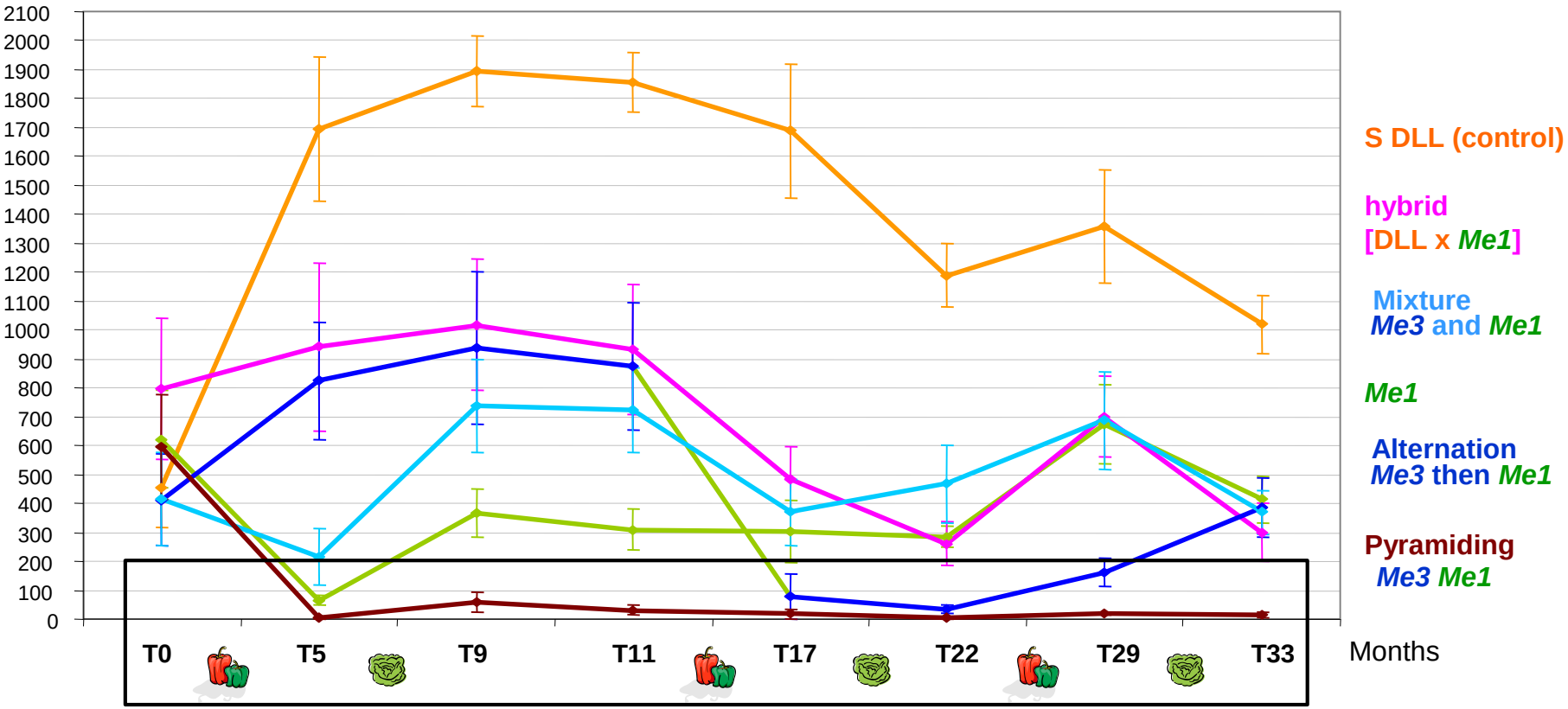


Alternating *R*-genes in rotation : efficient to decrease virulent populations in the field ***(specificity of virulence)***

Results

Reduction of the soil infection potential ("trap" effect)

Egg-masses on S-tomatoes inoculated with 1kg of soil from each µplot ($IC_{5\%}$ on 8 to 9 replicates)



Pyramiding *R*-genes in one pepper genotype : best modality as trap crop and to suppress the emergence of virulent isolates

Djian-Caporalino *et al., submit*

Strategies to strengthen and increase the resistance 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)
- **Combination of *R*-genes** (pyramiding)

⇨ *To prevent the selection of virulent nematodes*

At the field and rotation level *(farmers)*

- **Pyramyding > Alternating > Mixture > Sequential use of a single *R*-gene introgressed in a susceptible background**

⇨ *To reduce the selection pressure of R-genes on the pathogens ; To 'recycle' broken R-genes ; To decrease the amount of pathogens in the soil*

in good agreement with concepts recently developed for pepper-virus, rapeseed-fungus, rice-bacteria, adaptation of xenobiotic to drugs and pesticides…

Palloix *et al., New Phytol* 2009; Brun *et al., New Phytol* 2010; Yoshimura *et al. Mol Breeding* 1995 ; Hittalmani *et al. TAG* 2000; Singh *et al., TAG* 2001; REX Consortium, *Trends Ecol Evol* 2012.

Perspectives

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

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

labelled by

PEIFL PIClég

07/2011 *09/2012*

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

Action PRESUME (Plant REsistance SUstainable ManagEment) **02/2012-02/2016**


1 experimental station and 4 farms to evaluate consequences of such systems from agronomical, pathological, ecological and socioeconomical points of view

Analysis of partial resistance factors (QTL, quantitative trait locus) that could explain the 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

Wednesday 4 September 2013 "Session IV: Breeding strategies"

Towards the deciphering of the genetic factors involved in durability of plant major resistance genes to RKN in pepper

Collaborative network

INRA

- **Centre PACA** { UMR ISA **Sophia Antipolis** / UR GAFL, UR EcoDev, UR PaVe **Avignon** }
- **Centre Montpellier** UE DEAR **Alénya Roussillon**
- **Centre Dijon** UMR MSE
- **Centre Rennes** UMR Bio3P

IRD **Montpellier** UMR CBGP

Farmers associations and technical institutes

- **APREL** (Association for vegetable research and experimentation) **St Rémy de Provence**
- **Chambres d'agriculture** **CA 06 & CA83**
- **CTIFL** (Interprofessional technical center for fruits and vegetables) **Balandran**
- **GRAB** (Research Group in Organic Farming) **Avignon**

Private breeding companies

Vegetable producers (France & Morocco) **La Baronne-Nice (06), Six-Fours (83), Lambesc (13), Marguerittes (30)**

Thank you for your attention








Financial support

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