6th ICN
4-9 May 2014
Cape Town
South Africa

Theme 13 : Integrated Nematode Management
(Session 3, Abstract 102)

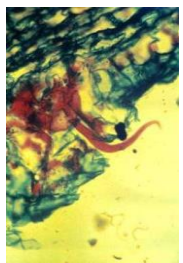
Varietal and technical innovations for the sustainable and integrated management of root-knot nematodes

Solarisation

Green manure crop

Trap crop

Non host crops



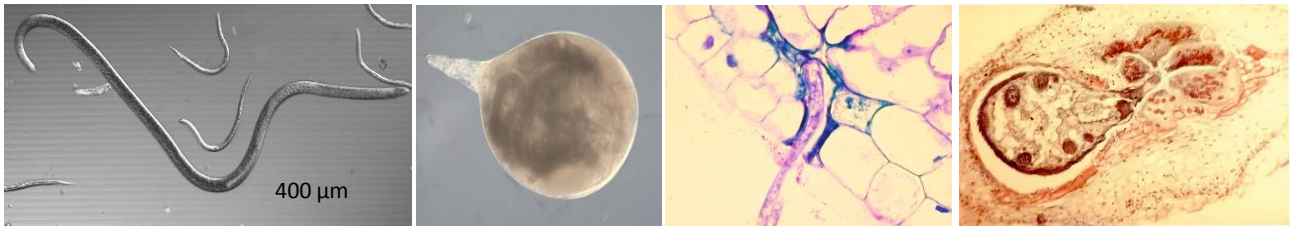
Resistant crops

INRA FRANCE
SCIENCE & IMPACT
Plant Nematodes Interaction team

Institut SOPHIA AGROBIOTECH

Djian-Caporalino C., Navarrete M., Palloix A., Mateille T., Lefevre A., Barbary A., Fazari A., Marteu N., Chapuis M., Tchamitchian M., Dufils A., Sage-Palloix A-.M., Tavoillot J., Pares L., Védie H., Goillon C., Taussig C., Risso S., Lanza R., Castagnone-Sereno P.

Context

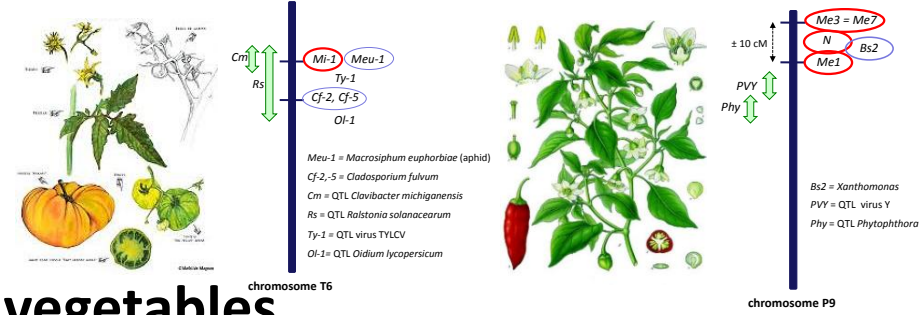


- **Root-knot nematodes (*Meloidogyne* spp.): a major problem in organic and conventional horticulture especially in warm areas and under shelters**

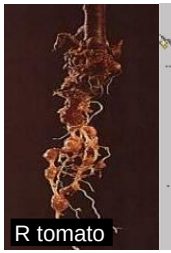
An average 10% of yield loss is frequently cited (*Raaijmakers et al., 2009*) **but much higher percentages observed under local conditions** (*Wesemael et al., 2011*)

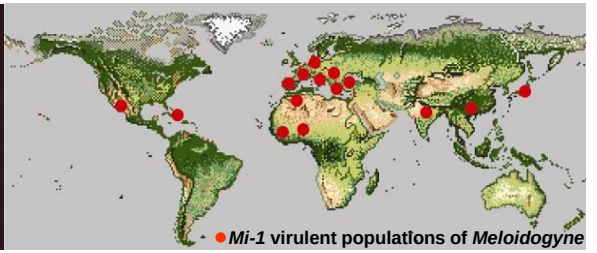
South-East France : 40% of farms experience crop losses due to RKN (*Djian-Caporalino, 2010*)

Context



- **Few RKN *R*-genes available for vegetables and fewer commercial cultivars available** *(Starr et al. 2002 ; Villeneuve & Djian-Caporalino 2013)*
  - ✓ ***Mi-1* gene on tomato** (T°<30°C)
  - ✓ ***Me(s)* and *N* genes on pepper**





- ***R*-genes can be overcome**

(Jarquin-Barberena et al. 1991; Castagnone-Sereno et al. 1994, 1996, 2001; Meher et al. 2009; Djian-Caporalino et al. 2011; Tzortzakakis et al. 2005, 2008 ; Verdejo-Lucas et al. 2009 ; Devran and Söğüt 2010 ; Thies 2012)

  - ✓ **In controlled conditions with high pressure of RKN** (*Mi-1* and *Me3*)
  - ✓ **In natural conditions** (*Mi-1* in tomato and *N* in pepper cultivars)

- **Several alternative techniques used to control RKN, but only partially efficient** *(Collange et al. 2011)*
  - ✓ **Thermal techniques (soil solarization, steam)**
  - ✓ **Nematicide cover cropping**
  - ✓ **Crop sequence combining host and non host species**

INRA SCIENCE & IMPACT

Neoleg 2008 – 2012 | Sysbiotel 2009 – 2013 | Gedunem 2012 – 2016

The main questions of our projects

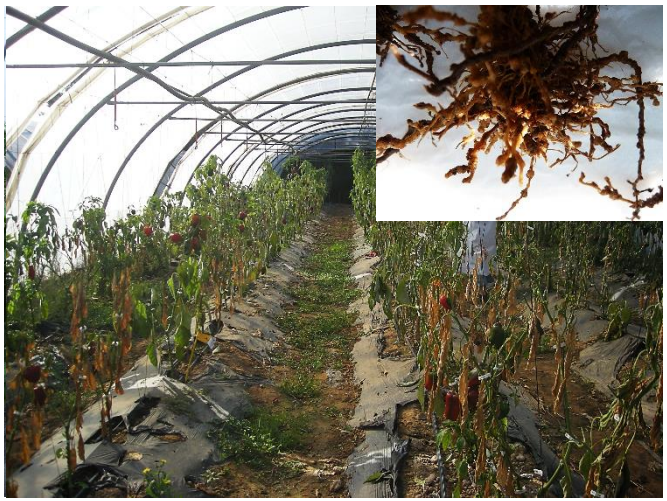
1. What **crop production system(s)** combining *R*-plants management strategie(s) and other cropping techniques (solarisation, intercropping, rotation with non host plants, etc.) to **extend resistance durability and sustainability of the protection?**
2. What **agronomic** impact (productivity, soil fertility)?
3. What impact on soil **ecology** (other nematodes and other plant pathogens)?
4. Are the proposed options **acceptable** for producers (yield, work organisation, etc.)?

Neoleg 2008 – 2012

Sysbiotel 2009 – 2013

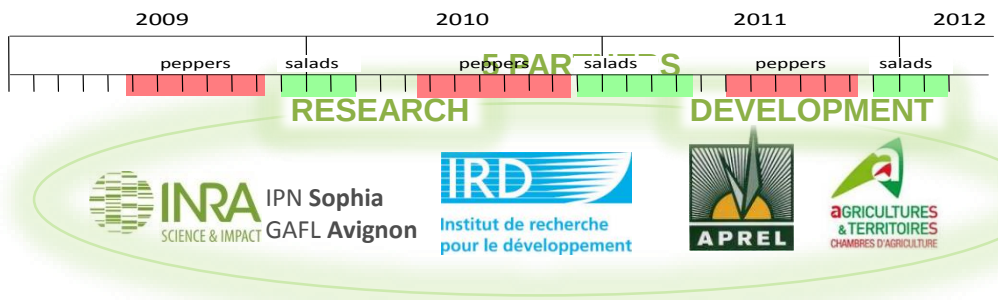
First experimental approach: a 3-year experiment in an experimental farm (SE France)

Development of *R*-plants management strategies lowering the risk of emergence of virulent nematodes :



Protected vegetable crops under mediterranean climate, soil naturally highly infested by *M. incognita* + *M. arenaria*

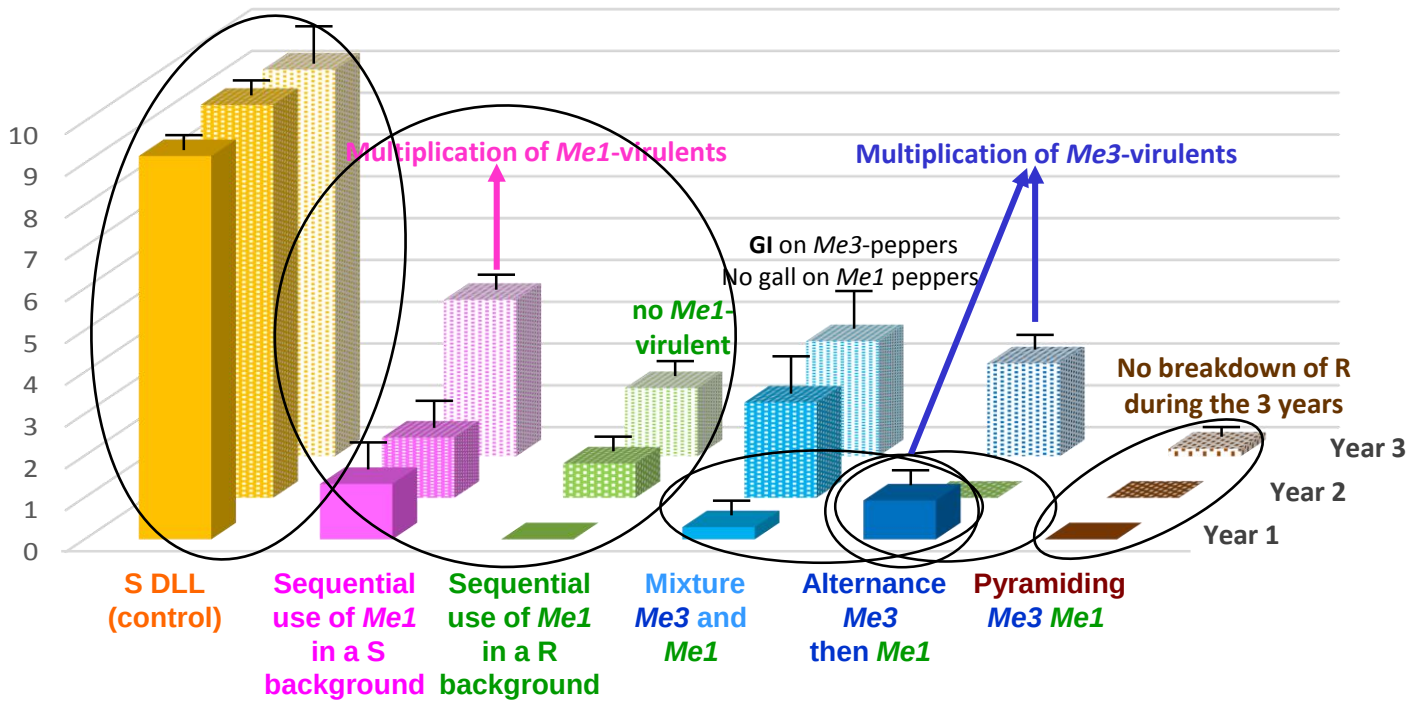
- **Sequential use of a single *R*-gene introgressed in a susceptible or in a resistant genetic background**
- **Alternance of *R*-genes in rotation**
- **Mixture of different *R*-genotypes in the same plot**
- **Pyramiding 2 *R*-genes in one genotype**



Results of the first experiment

1 ***R*-efficiency and *R*-durability : Pyramiding > Alternating >** Mixture of *R*-genes ⇔ Sequential use of a single *R*-gene introgressed in a *R* background **>>** Sequential use of a single *R*-gene introgressed in a *S* background

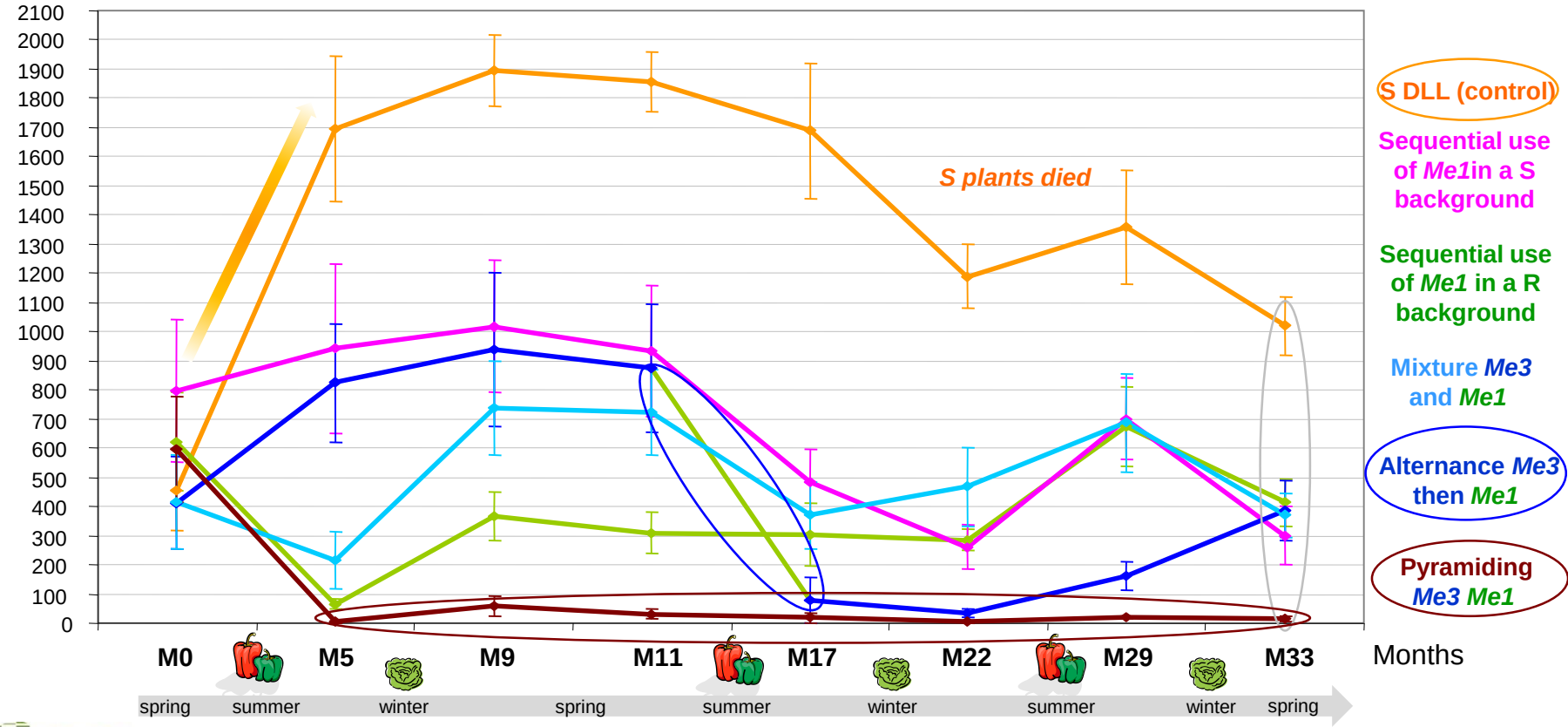
Mean GI (gall index) on 40 to 45 peppers after 5 months of culture in summer ($IC_{5\%}$)



Results of the first experiment

- 2 **Sustainability of rotating cultivation by "Trap effect" : Alternating R-genes in rotation is efficient to decrease virulent populations in the field** *(specificity of virulence)* **and Pyramiding R-genes in one pepper genotype is the best modality as trap crop**

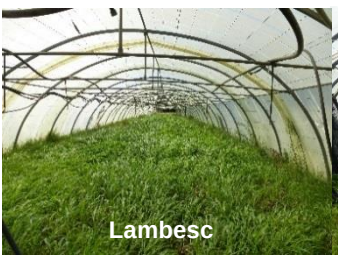
Egg-masses on S-tomatoes inoculated with 1kg of soil from each µplot /modality (IC5% on 8 to 9 replicates)



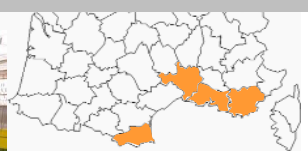
On going experimental approach: a 4-year and multi-site device in experimental stations and commercial farms

Combination of R-plants and cropping techniques for the sustainable and integrated management of RKN, extending resistance durability, with positive impact on soil ecology and good agronomic potential, acceptable for producers

5 geographical sites



4 in the South of France



1 in Morocco

12 PARTNERS

RESEARCH

INRA SCIENCE & IMPACT
IPN **Sophia**
GAFL & EcoDev **Avignon**
DEAR **Alenya Roussillon**

IRD Institut de recherche pour le développement

DEVELOPMENT

GRAB Groupe de Recherche en Agriculture Biologique

APREL

AGRICULTURES & TERRITOIRES CHAMBRES D'AGRICULTURE

PRODUCERS

farmers South of France & Morocco idyl

On going experimental approach: a 4-year and multi-site device in experimental stations and commercial farms

4 cropping systems with:

Solarisation

or

Non host crop

or

Green manure

Trap crop

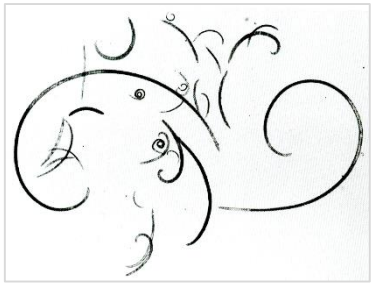
&

Resistant crops

&

Susceptible crops

A 4-year nematological, ecological, genetical, and agronomical assessment

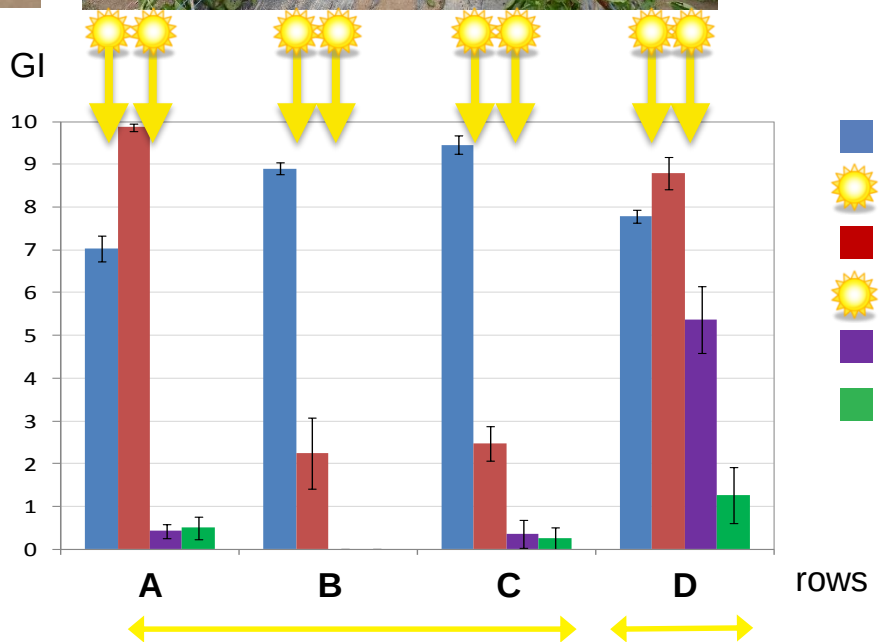


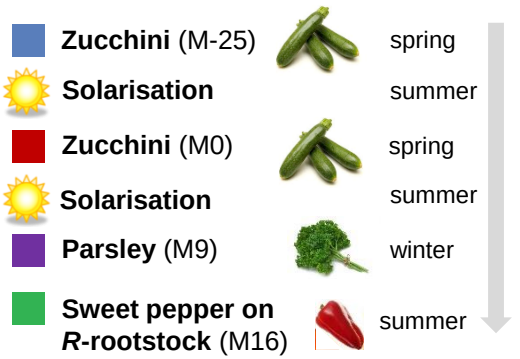
A survey of farmers' acceptability of cropping systems in 30 farms producing vegetables and with RKN problems

A few preliminary results

1 Solarisation on a highly infested plot : Efficient protection of pepper resistance and reduction of RKN damages

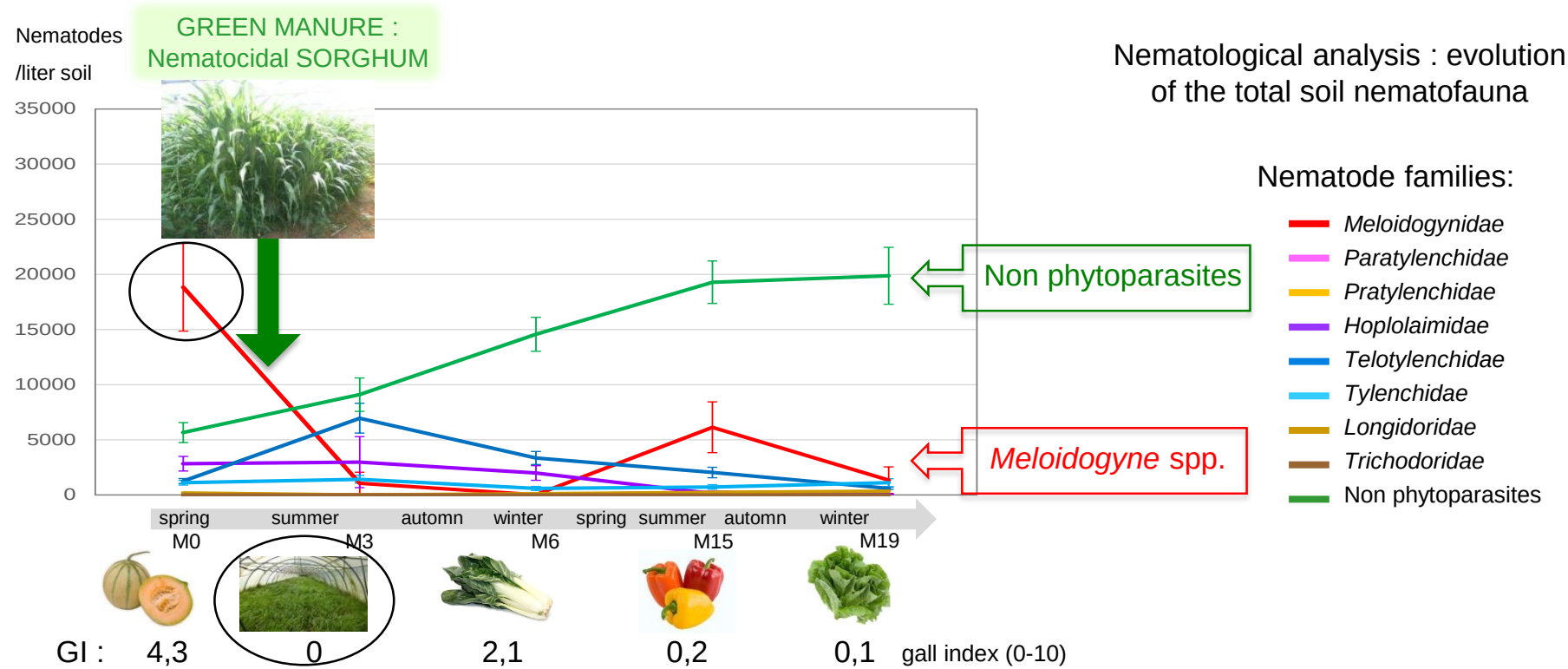
Nematological analysis: evolution of root gall index (GI)





A few preliminary results

2 Sorghum as green manure : Efficient protection of pepper resistance by reducing RKN soil infestation, and soil ecology improved

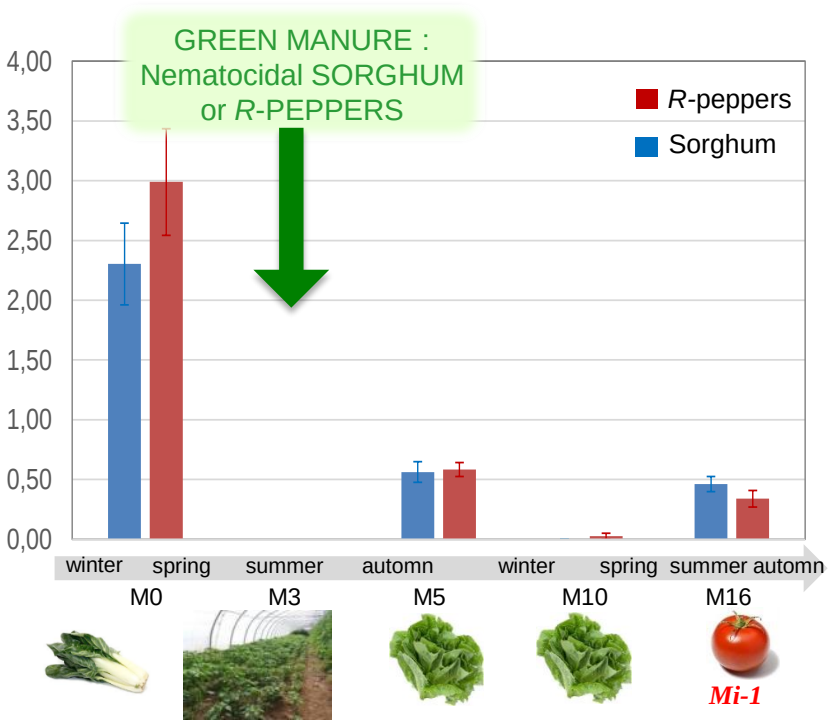


- ***Decrease of RKN populations after Sorghum*** *(>95% => protection of the pepper resistance)*
- ***Increase of non-phytoparasitic species*** *(= usefull saprophagous species => soil ecology improved)*

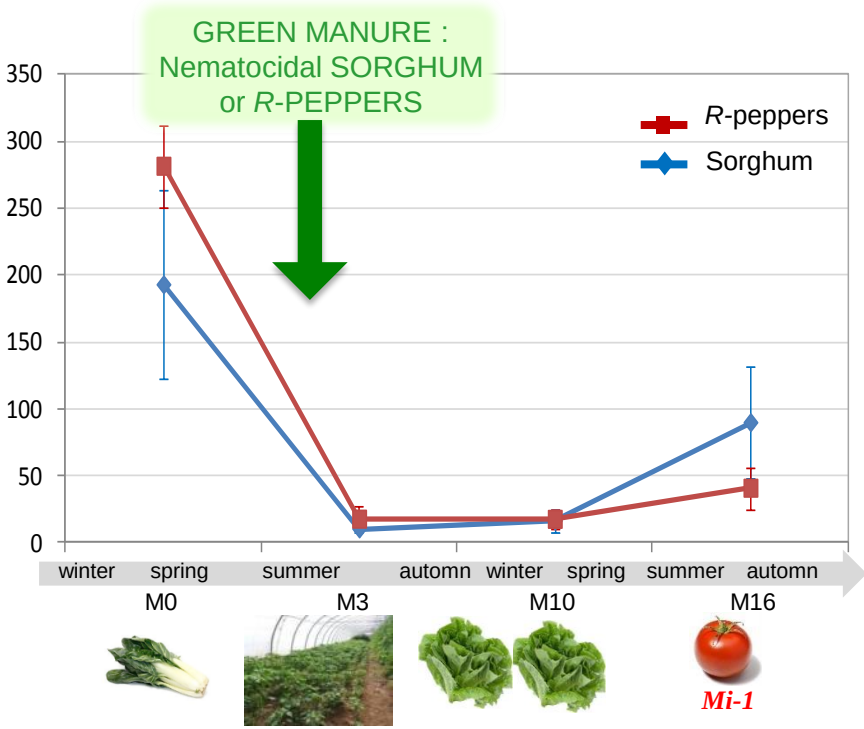
A few preliminary results

3 *R*-peppers pyramided for *Me1* and *Me3* (durable *R* stable at high T°) as 'trap crop' green manure : Efficient protection of tomato resistance

GI = gall index (0-10)



SI = Nb of nematodes in 1 kg of soil



➢ ***Green manure and trap crops: efficient to reduce GI on crops and soil infestation (SI)***

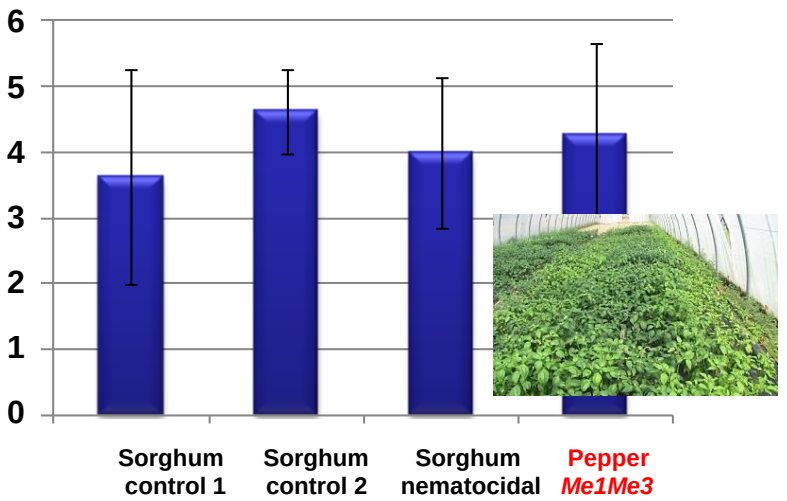
A few preliminary results

4 Agronomic value of *Me1Me3* peppers as 'trap crop' green manure :

a good potential as green manure, and assessment of soil colonization by pepper roots

What potential as green manure?

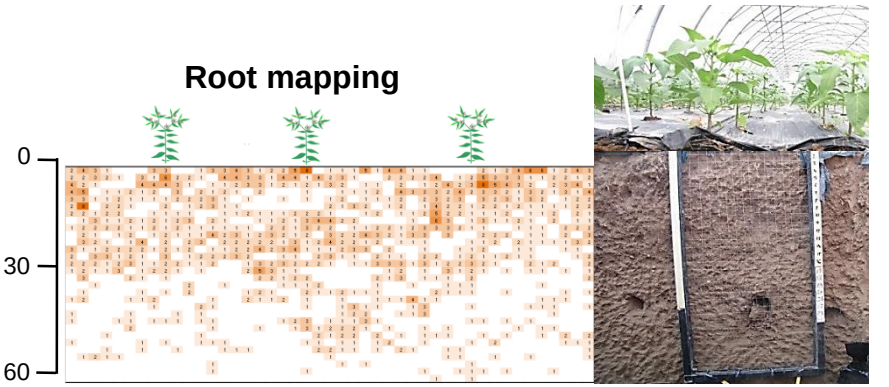
Comparison of buried dry matter (tonnes per hectare) for each green manure



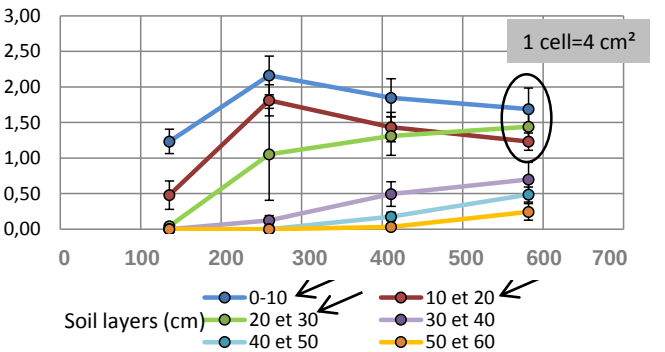
➢ ***Pepper buried dry matter is equivalent to that of traditionally-used sorghum***

What potential of soil colonization by *Me1Me3* pepper roots to better trap nematodes?

Root mapping



Nb of root impacts per cell depending on soil layers



➢ ***Strong root colonization up to 30 cm depth => allows to shorten culture from 10 to 7 weeks***

Conclusions

For plant breeders

1 Strategies to strengthen and increase the *R* durability

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*

Djian-Caporalino *et al. BMC Plant Biology* 2014, Barbary *et al. Theor Appl Biol* 2014

in good agreement with: Brun *et al. New Phytol* 2010 (rapeseed-fungus), Palloix *et al. New Phytol* 2009 (pepper-virus), Fournet *et al. Plant Pathol* 2013 (potato-cyst nematodes)

2 New opportunities for breeding in Solanaceae

A good potential of *R*-peppers pyramided for *Me1* and *Me3*

as 'trap crop' green manure

⇨
- *Durable R stable at high T°*
- *Pepper buried dry matter is equivalent to that of traditionally-used sorghum*
- *A good potential of soil colonization by pepper roots to trap nematodes with a 7-week culture*

Conclusions

For farmers

1 Strategies to control RKN, limiting the use of chemicals and increasing the lifespan of *R*-varieties

Pyramiding > Alternating > Mixture of R-genes ⇔ Sequential use of a single *R*-gene introgressed in a R-background **>>** Sequential use of a single R-gene introgressed in a S background

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

Djian-Caporalino *et al. BMC Plant Biology* 201

in good agreement with: Huang *et al. TAG* 2004, Singh *et al., TAG* 2001, Yoshimura *et al. Mol Breeding* 1995 (rice-bacteria), Hittalmani *et al. TAG* 2000, Zhu et al. *Nature* 2000, Mundt *et al. Euphytica* 2002 (rice-fungus), REX Consortium *Trends Ecol Evol* 2012 (adaptation of xenobiotic to drugs and pesticides)

2 Innovative, sustainable crop production systems

Intercropping management (solarisation, sorghum or *R*-peppers as green manure) : efficient protection of plant resistance and reduction of RKN damages

Experiments still on going

IPN **Sophia**
GAFL & EcoDev **Avignon**
DEAR **Alenya Roussillon**

CBGP **Montpellier**

GRAB **Avignon**

St Remy de Provence

CA06
CA83

farmers South of France & Morocco **idyl**

INRA Metaprogramme SMaCH
Sustainable management of crop health