Combinations of varietal and technical innovations for the sustainable and integrated management of root-knot nematodes: the GEDUNEM project (2012-2016)

French National INRA Metaprogramme SMaCH
Sustainable management of crop health

Public institutes

INRA SCIENCE & IMPACT PACA

IRD Institut de recherche pour le développement

Institut Sophia Agrobiotech

Alénya Roussillon

French extension services and technical institutes

APREL
Association Provençale de Recherche et d'Expérimentation Légumière

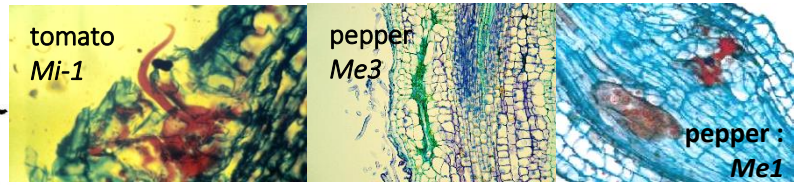
AGRICULTURES & TERRITOIRES CHAMBRES D'AGRICULTURE

GRAB Groupe de Recherche en Agriculture Biologique

Farmers
South of France

Caroline Djian-Caporalino INRA, IPN team

Context



Root-knot nematodes (*Meloidogyne* spp.)

➢ a major problem in organic and conventional horticulture especially in warm areas and under shelters

✓**~ 10% of yield loss (50 billion $ losses) frequently cited** *(Raaijmakers et al., 2009; Jones et al., 2011)* **but much higher % observed under local conditions** *(Wesemael et al., 2011)*

✓ **Some quarantine species** in Europe

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

➢ current restrictions of chemical nematicides (MBTOC 2006; EC Directive 1107 / 2009)

➢ alternative techniques but only partially efficient when used alone *(Collange et al. 2011)*

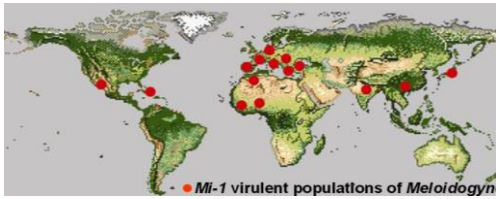
Resistant vegetables

➢ most of vegetables are host plants (problem for rotations), few RKN R-genes available and fewer commercial cultivars available
(Starr et al. 2002 ; Villeneuve & Djian-Caporalino 2013)

✓ ***Mi-1*** gene in tomato (efficient up to 30°C)

✓ ***Me(s)* and *N*** genes in pepper (stable at high T°C)

➢ some R-genes can be overcome
(Djian-Caporalino et al. 2011; Thies 2011; Tzortzakakis et al. 2014)



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

✓ **Alternance of *R*-genes in rotation**

✓ **Pyramiding of 2 *R*-genes in one genotype** *(Me1 & Me3)*

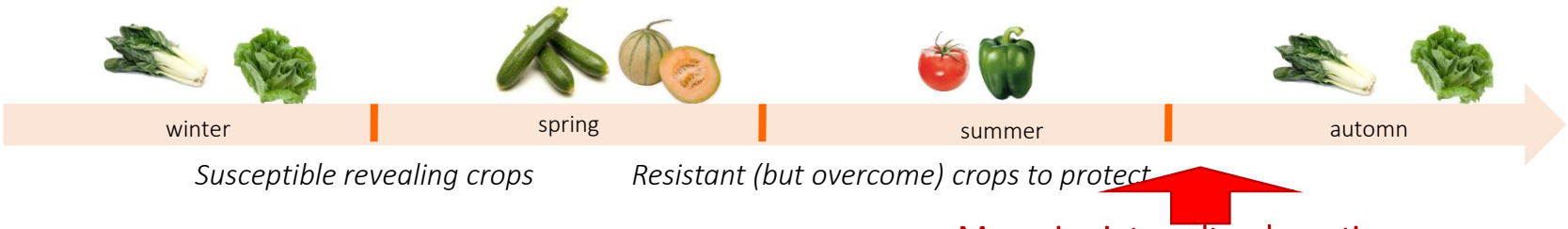
(Djian-Caporalino et al. 2014)

The main questions of the Gedunem project

- 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 against RKN?**
- 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** to producers (yield, work organisation, etc.)?

Experimental approach

Propose and evaluate, over 4 years, innovative vegetable cropping systems in experimental stations and commercial farms



4 geographical sites in the South of France

A farmers' survey to estimate the acceptability of prototypes to farmers and ways of improvements

28 farmers located in the South of France, in 2014

The cropping systems

co-designed between scientists and R & D actors

3 versions adapted to the different constraints of farms in the study area combining genetic and agronomic levers:

- **S1** = biofumigant sorghum as green manure

  (rich in dhurrin, precursor of HCN, for biofumigant effect)

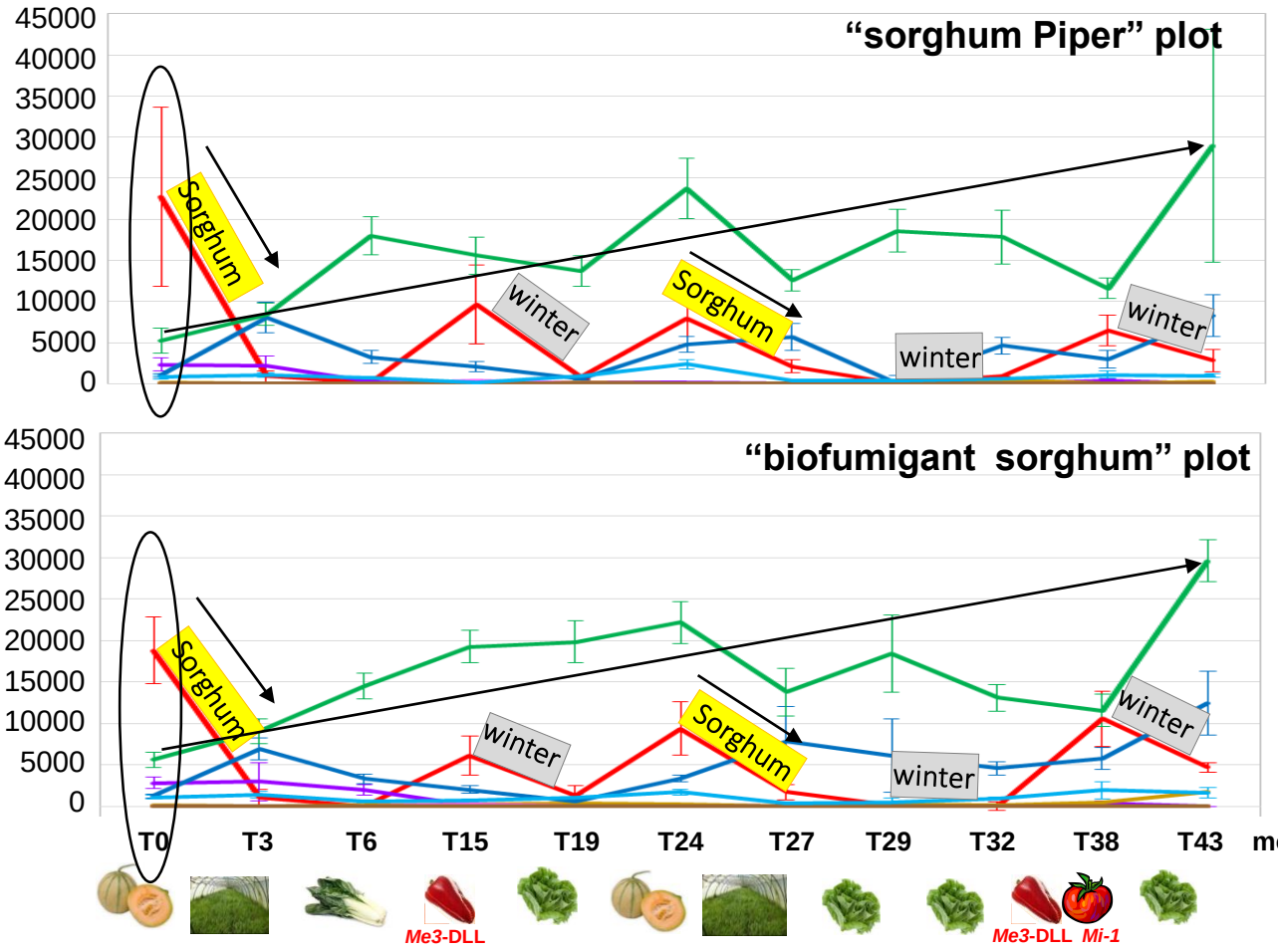
- **S2** = resistant pepper pyramiding 2 genes (*Me1* & *Me3)* as trap crop green manure

- **S3** = solarisation in summer 1 year/2 + bad host plant in winter

Example of results

S1 Sorghum as green manure

Nematodes/ liter of soil



Nematode families found:

- ***Meloidogynidae***
- ***Hoplolaimidae***
- ***Telotylenchidae***
- ***Tylenchidae***
- **non phytoparasitic species** (= usefull saprophagous species)

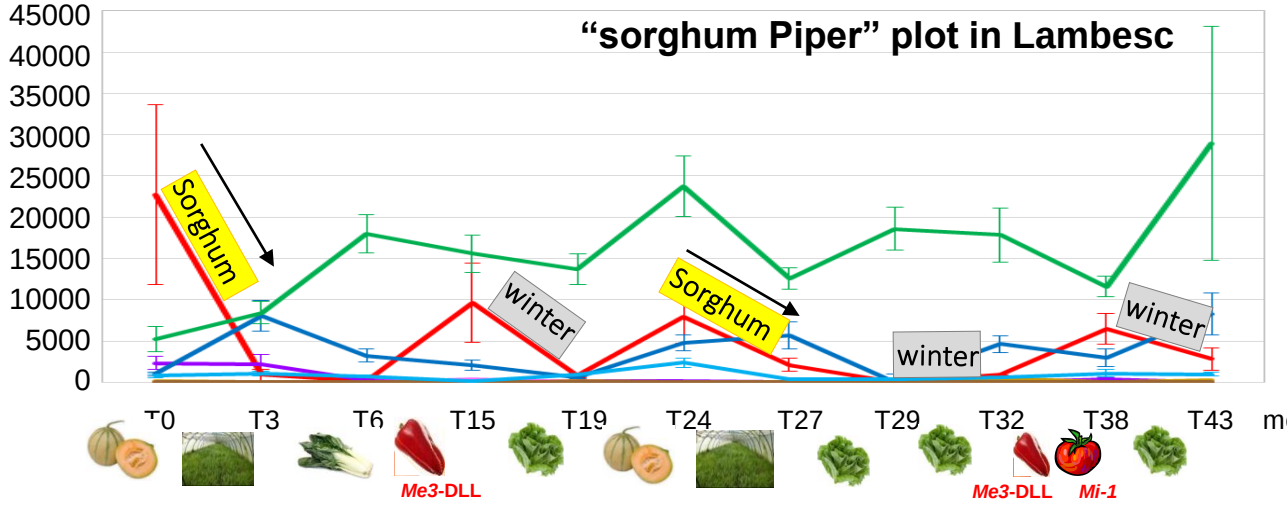
(Goillon et al., Phytoma in press)

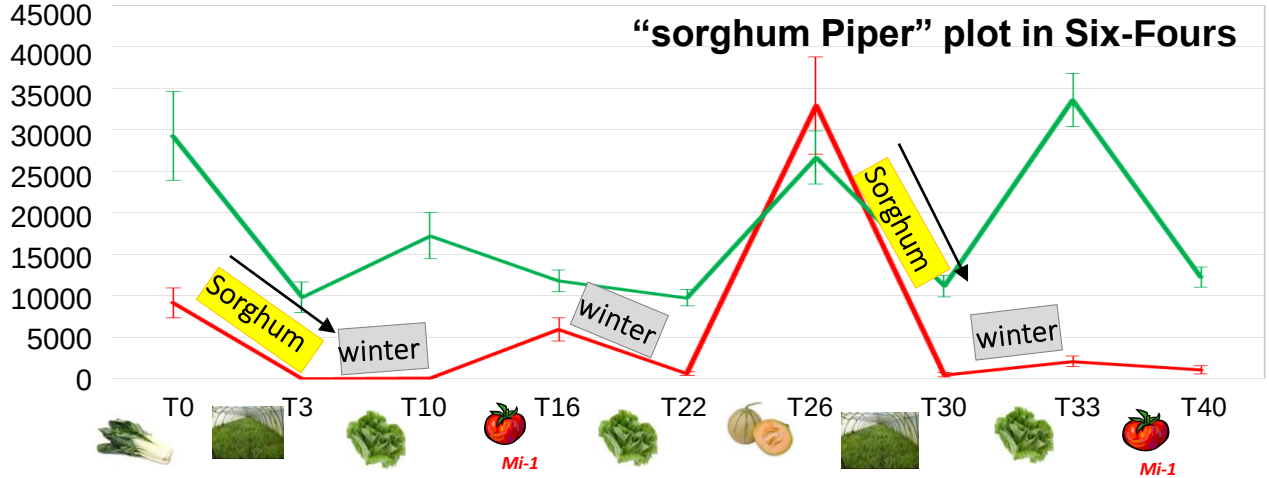
- **High and sustainable decrease of RKN populations after both sorghum** (>90%)
- **Increase of non-phytoparasitic species** => soil ecology improved **with S1**

Example of results

S1 Sorghum as green manure

Nematodes/ liter of soil





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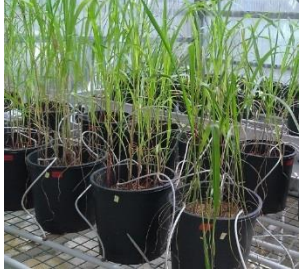
- ***Meloidogynidae***
- ***Hoplolaimidae***
- ***Telotylenchidae***
- ***Tylenchidae***
- **non phytoparasitic species** (= usefull saprophagous species)

- **High decrease of RKN populations after classical sorghum in both plots** (>90%)
- **But non sustainable when low diversity of the nematode communities**

Example of results

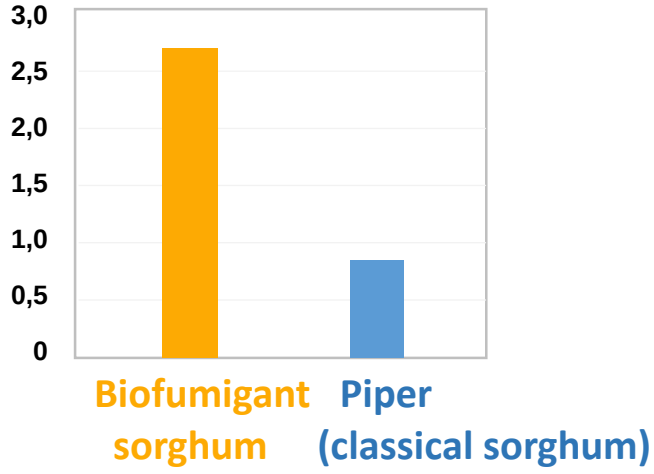
S1 Sorghum as green manure



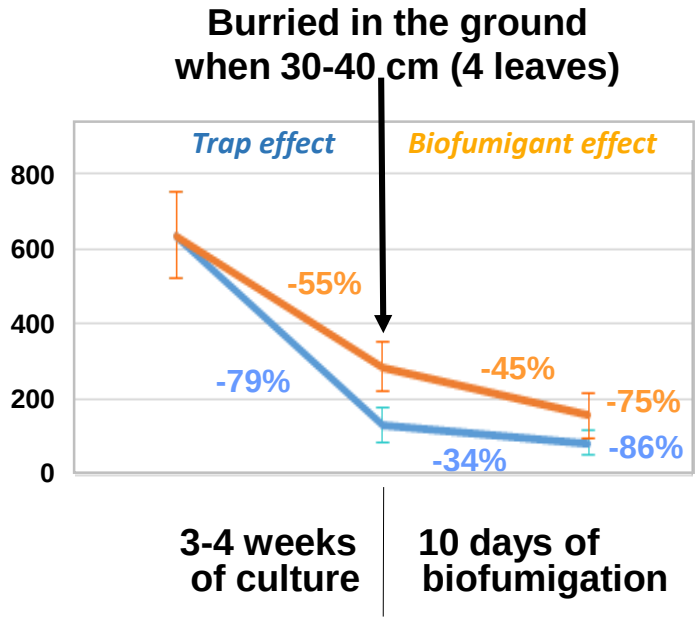
1/ Why 'classical sorghum Piper' and 'biofumigant sorghum' show the same effect ?

Dhurrin content after 3-4 weeks

HCN (cyanhydric acid) intake potential in the soil (kg/ha)



Mean number of RKN / kg of sol



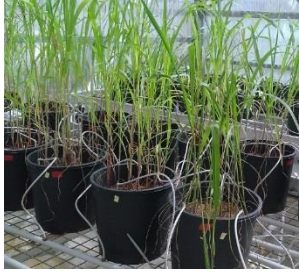
(Goillon et al., Phytoma in press)

- Higher dhurrin content of 'Biofumigant sorghum'
- Higher trap effect of 'Classical sorghum' after 3-4 weeks of culture

=> Same global effect

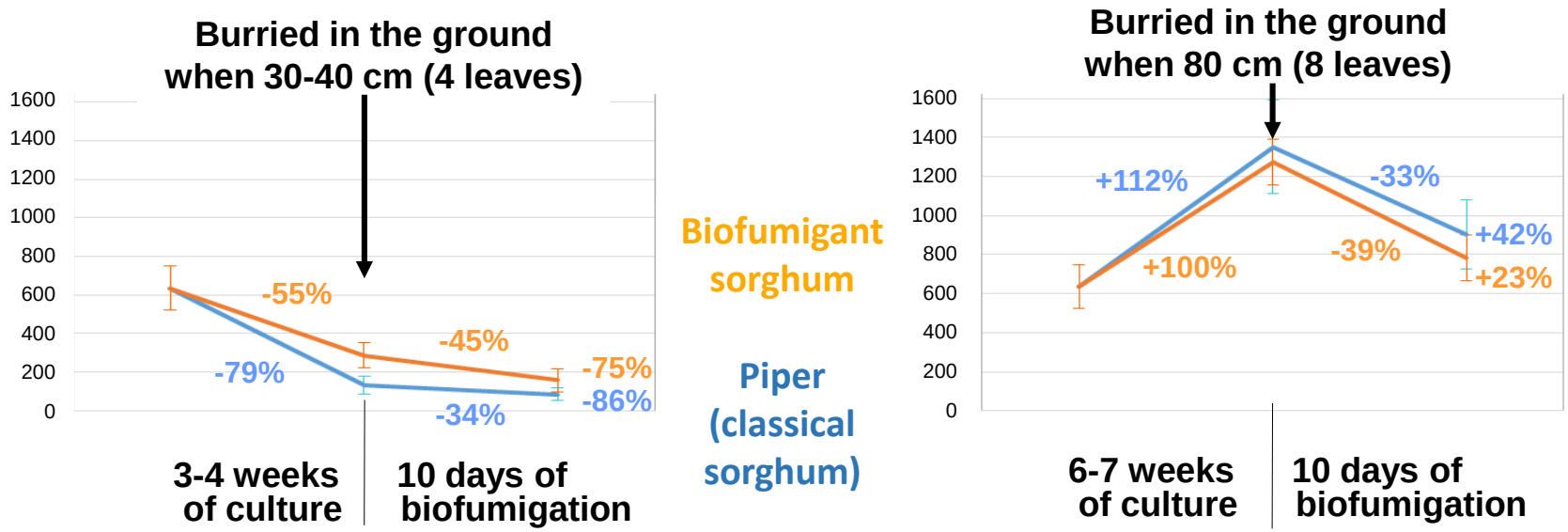
Example of results

S1 Sorghum as green manure



2/ How to use the Sorghum as biofumigant green manure?

Mean number of RKN / kg of sol



(Goillon et al., Phytoma in press)

- **High decrease of RKN in the soil with both sorghum if buried before 3-4 weeks of culture**
- Better efficacy with a 30-day-biofumigation, watering and plastic covering the soil

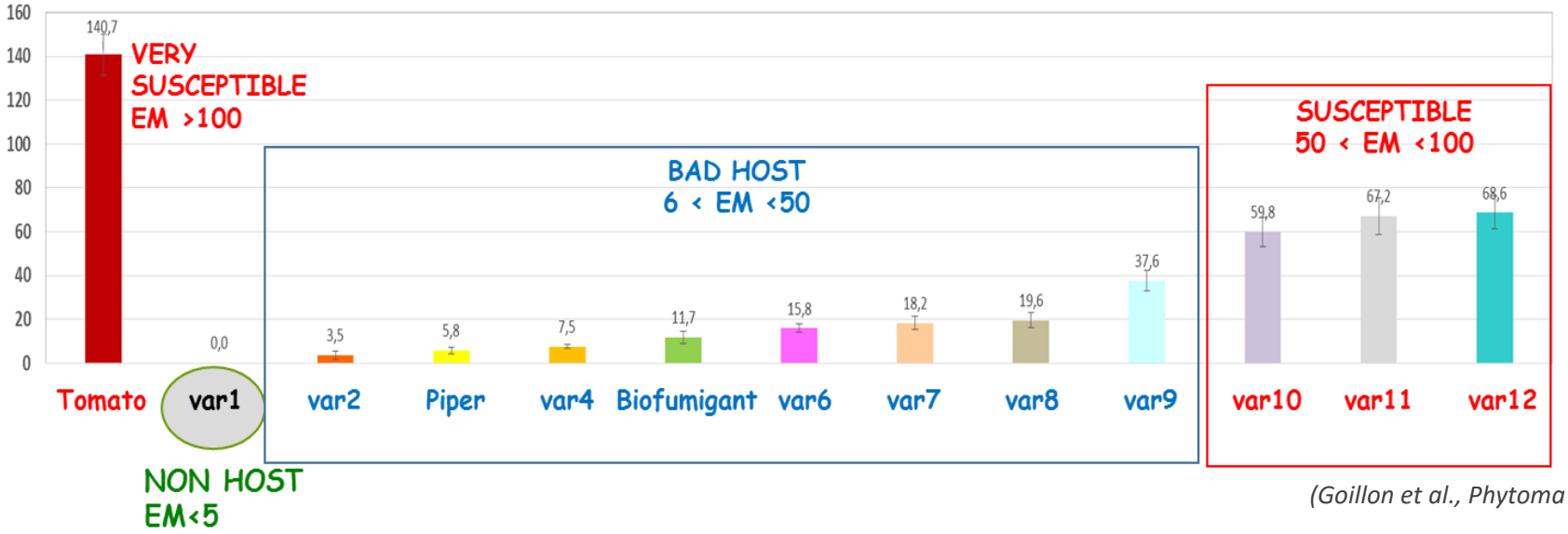
Example of results

S1 Sorghum as green manure

3/ Are all sorghum trap plants?

Susceptibility of several varieties of Sorghum from UPL

Mean number of egg masses (EM) /plant (inoculation: **600** *M. incognita*/plant)



(Goillon et al., Phytoma in press)

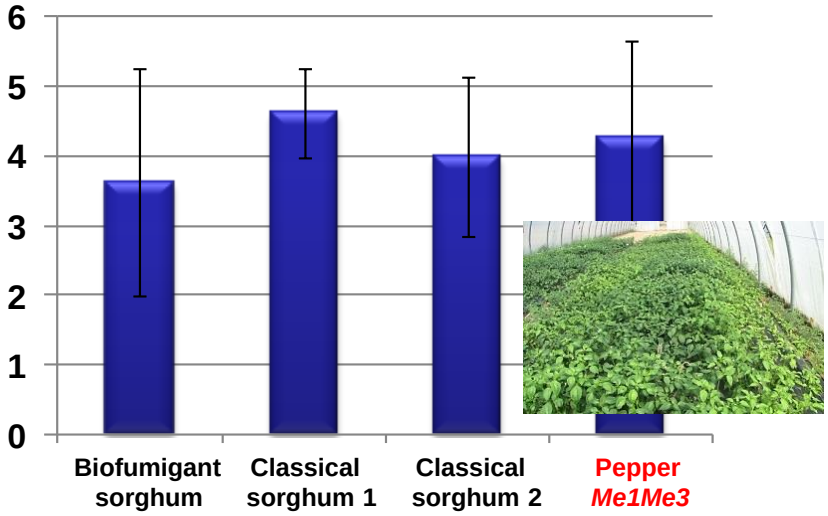
- **A high varietal effect**
- **Only one variety is non host** (**0** gall & EM) => could be cultivated more than 4 weeks without multplying RKN

Example of results

S2 *R*-peppers pyramided for *Me1* and *Me3* as 'trap crop' green manure

What potential as green manure?

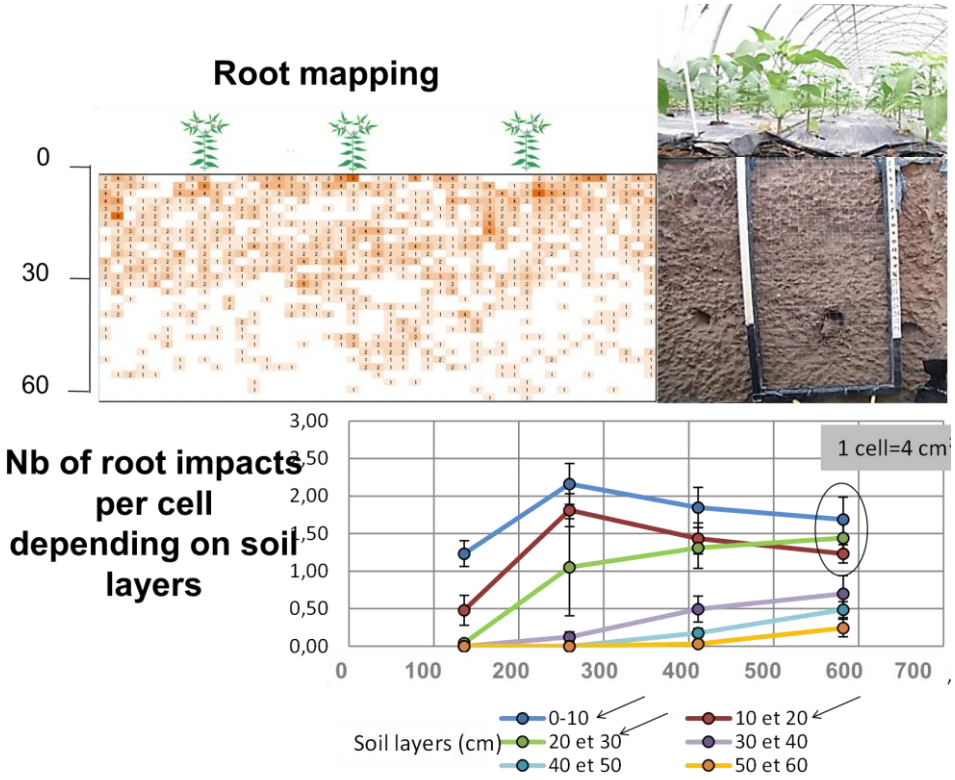
Comparison of buried dry matter (tonnes per hectare) for each green manure



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

(Navarrete et al., submit to Agron. Sustain. Dev.)

What potential of soil colonization by *R*-pepper roots? (to trap nematodes)

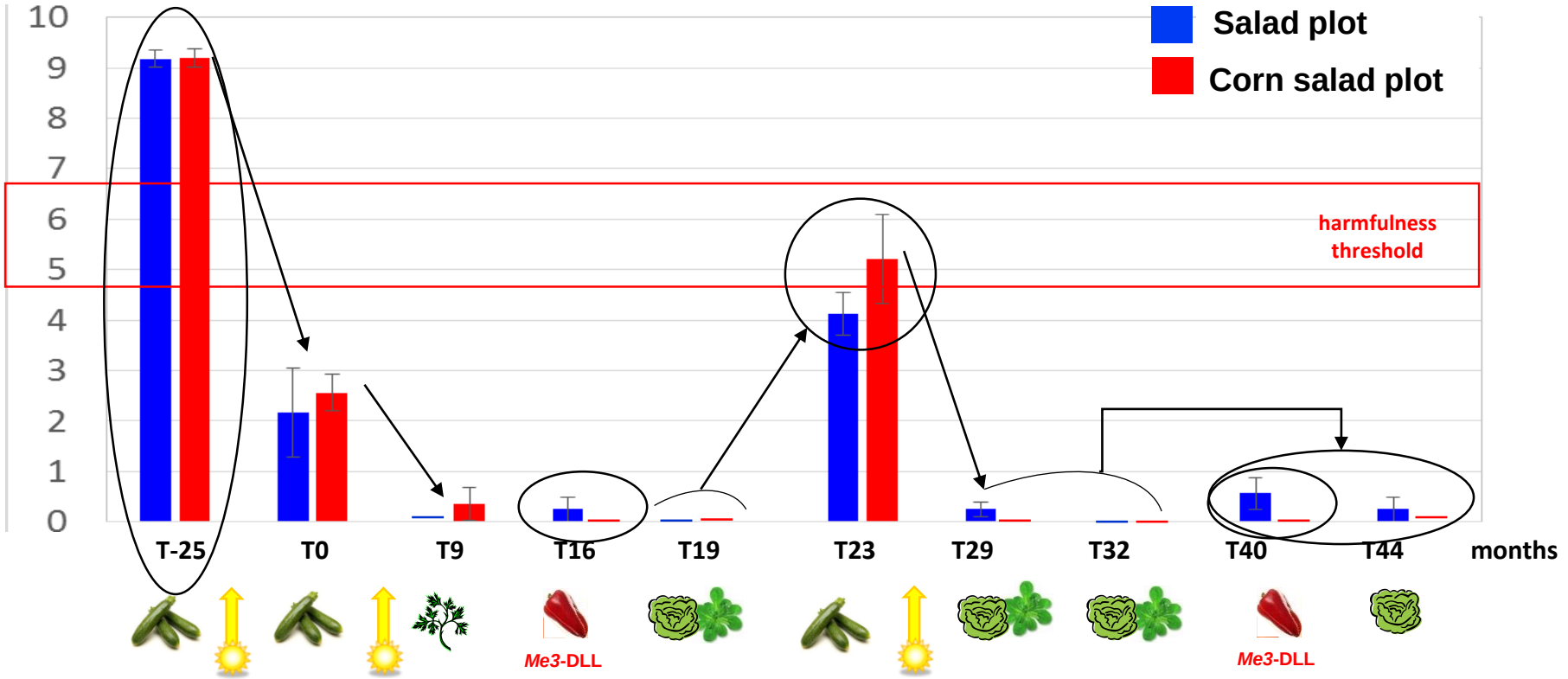


Strong root colonization up to 30 cm depth => allows to shorten culture from 10 to 7 weeks

Example of results

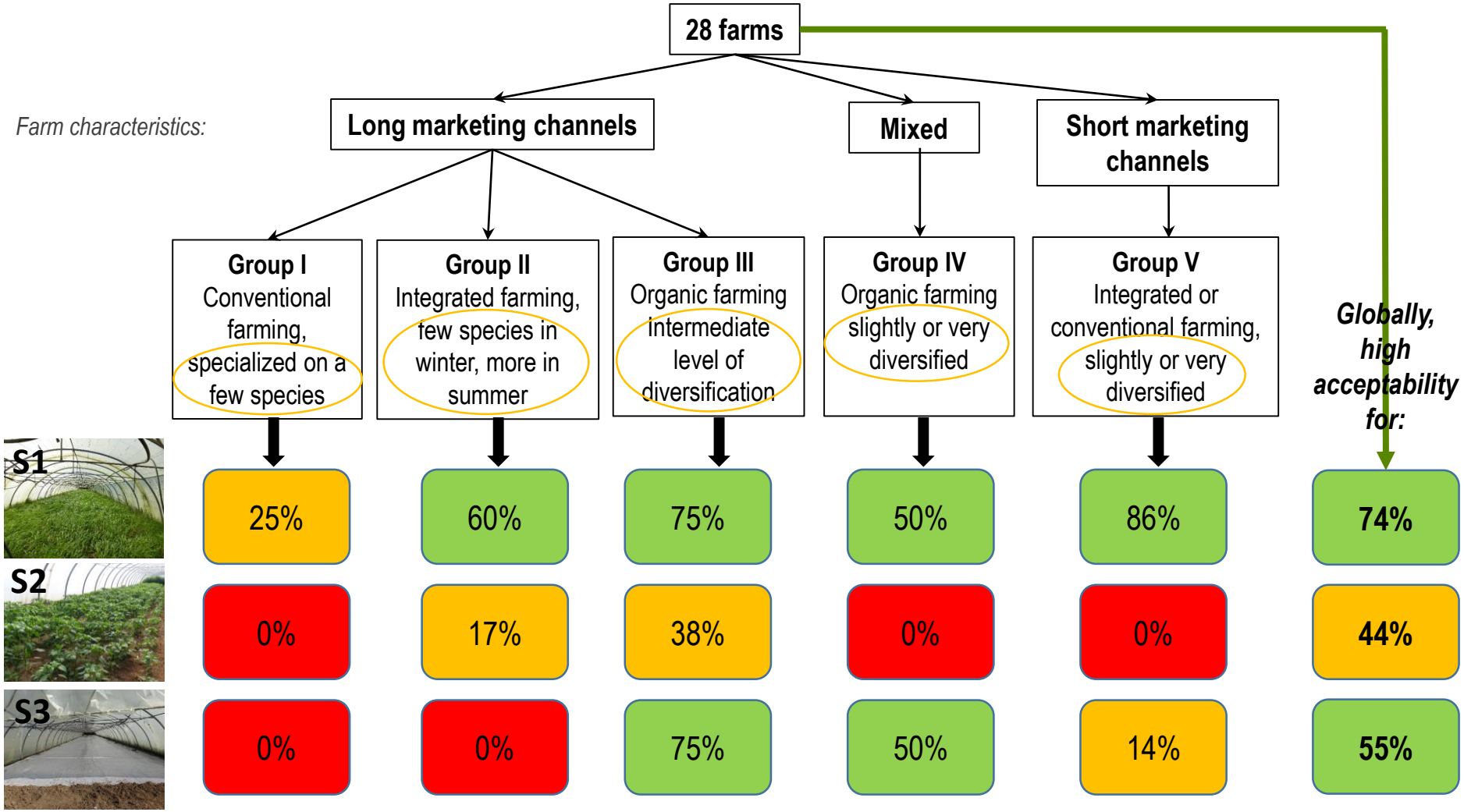
S3 Solarisation and bad host plants

Mean root gall index *on central rows*



- Zucchini highly infested at the beginning (> harmfulness threshold)
- Solarisation efficient : at least, 50% reduction of RKN damages on zucchini / T-25
- RKN-resistance protected
- Corn-salad (bad host plant) poorly efficient in winter but efficient when planted early

Survey 2014: % of farmers considering the cropping system prototypes as acceptable



(Furnion 2014)

Overall perspectives

1 Improve the efficiency of these innovative cropping systems

Combining crop rotations with crops and intercrop practices

Maintening an efficient protection of plant resistance

Increasing the diversity of the nematode communities (high impact)

2 New opportunities for breeding in Solanaceae

Developping homozygous *Me1/Me3* genotypes to decrease seed costs (using them as trap crop green manure)

3 Improve the acceptability to farmers

Making them compatible with farm constraints

Designing strategies at farm scale: spatial and organizational combinations of the cropping systems

Designing organisational innovations: new marketing outlets, management of cover crop seedlings in nurseries…

For details

GEDUNEM

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