TOPIC 3 - session 2 - Crop and quality management: cultural and post-harvest practices at various organisational levels

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

Metaprogramme SMaCH
Sustainable management of crop health

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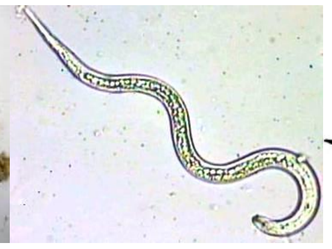
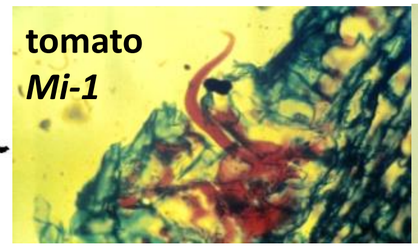
FRANCE

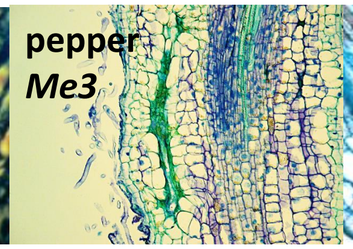
Plant Nematodes Interaction team

Context









Root-knot nematodes (*Meloidogyne* spp.)

➢ microscopic soil-borne roundworms extremely polyphagous with high capacity of adaptation

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

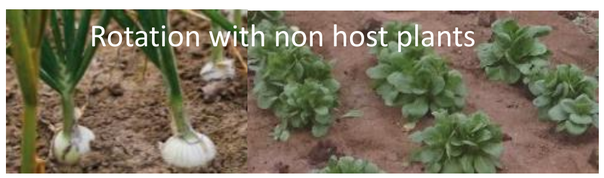
✓ **~ 10% of yield loss (50 billion $ losses) frequently cited** (Raaijmakers et al., 2009; Jones et al., 2011) **but much higher % observed under local conditions** (Wesemael et al., 2011)

✓ **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 (Collange et al. 2011)



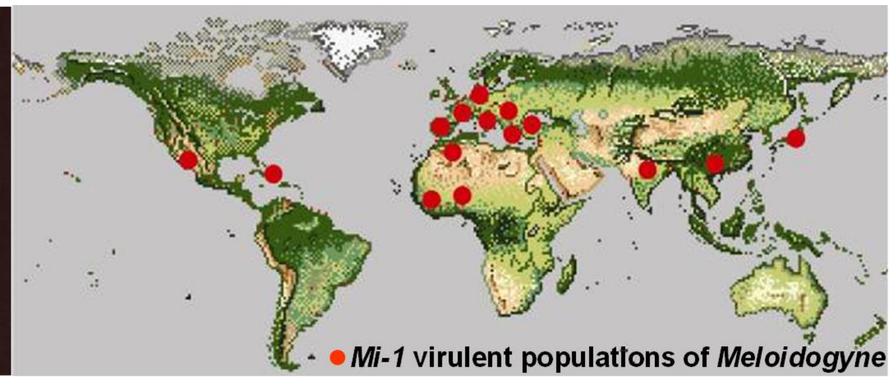
Resistant vegetables

➢ 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 on tomato (varieties and rootstocks) efficient up to 30°C

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

➢ some 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)

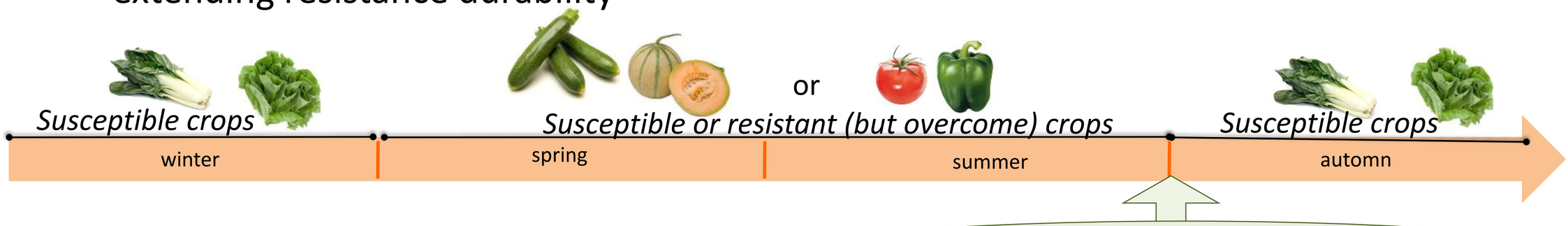


The main questions of the Gedunem project

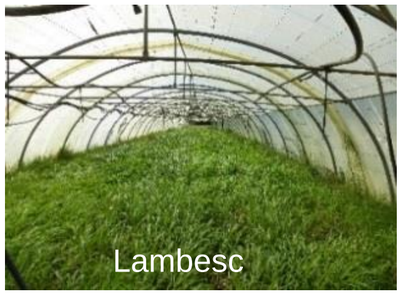
1. What **crop production system(s)** combining *R*-plants management strategie(s) and other cropping techniques (solarisation, intercropping, rotation with non host plants, etc.) to **extend resistance durability and sustainability of the protection against RKN?**
2. What **agronomic** impact (productivity,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

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

Propose and evaluate, over 4 years, innovative vegetable cropping systems in shelters in the Mediterranean region for the sustainable and integrated management of RKN, extending resistance durability



5 geographical sites



12 partners (multidisciplinary)

research

INRA SCIENCE & IMPACT

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

IRD Institut de recherche pour le développement

experimentation-development

GRAB Groupe de Recherche en Agriculture Biologique

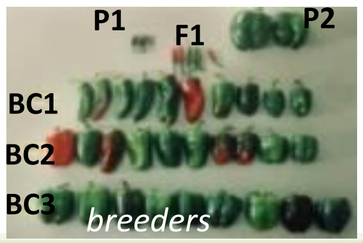
APREL

AGRICULTURES & TERRITOIRES CHAMBRES D'AGRICULTURE

farmers

idyl

South of France & Morocco



The cropping systems

co-designed between researchers 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)

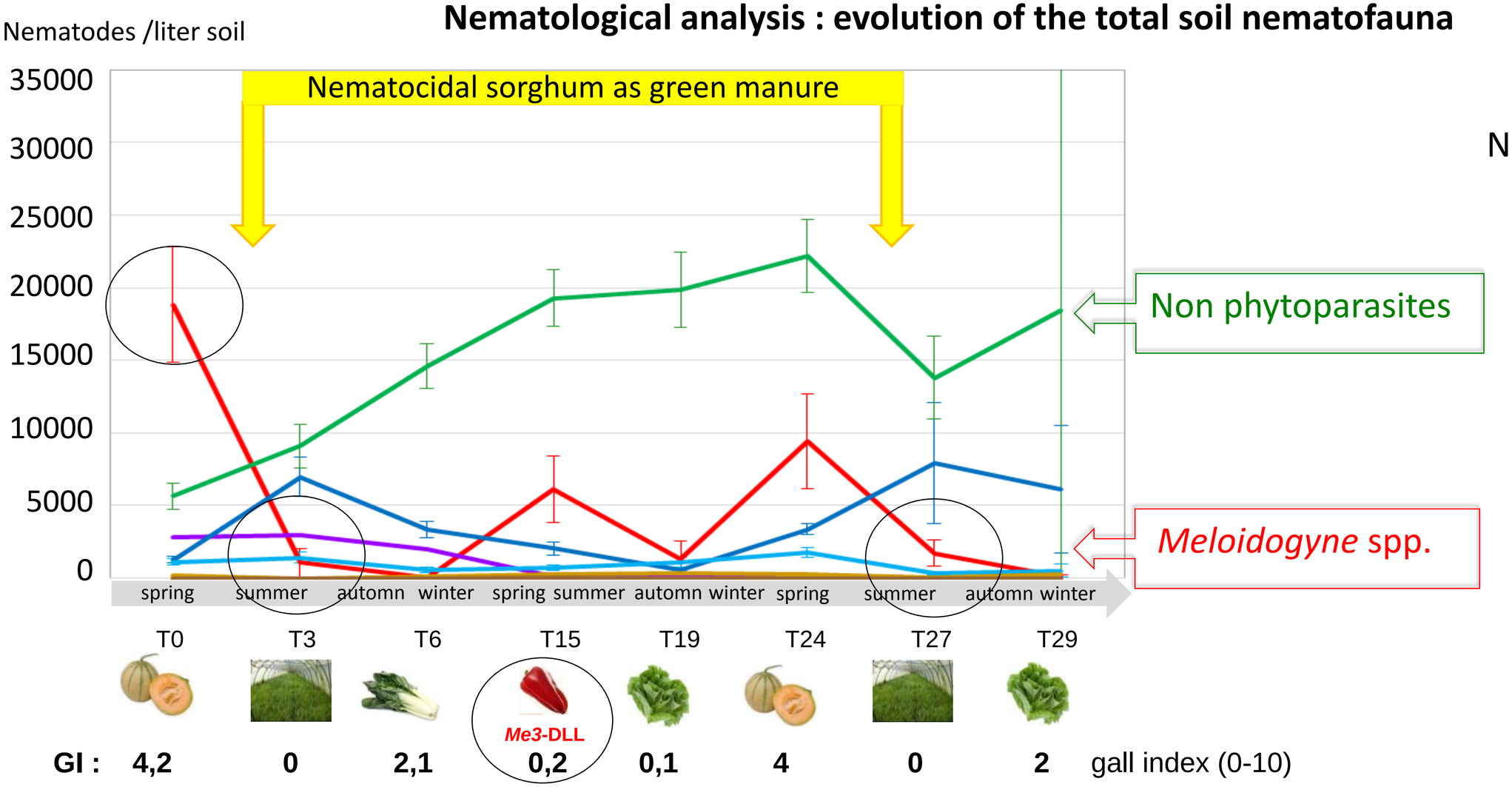
- **S2** = resistant pepper pyramiding 2 genes (*Me1* & *Me3)* as trap crop green manure

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

Example of results

• S1 Sorghum as green manure : Efficient protection of pepper resistance by reducing RKN soil infestation, and soil ecology is improved

Nematological analysis : evolution of the total soil nematofauna



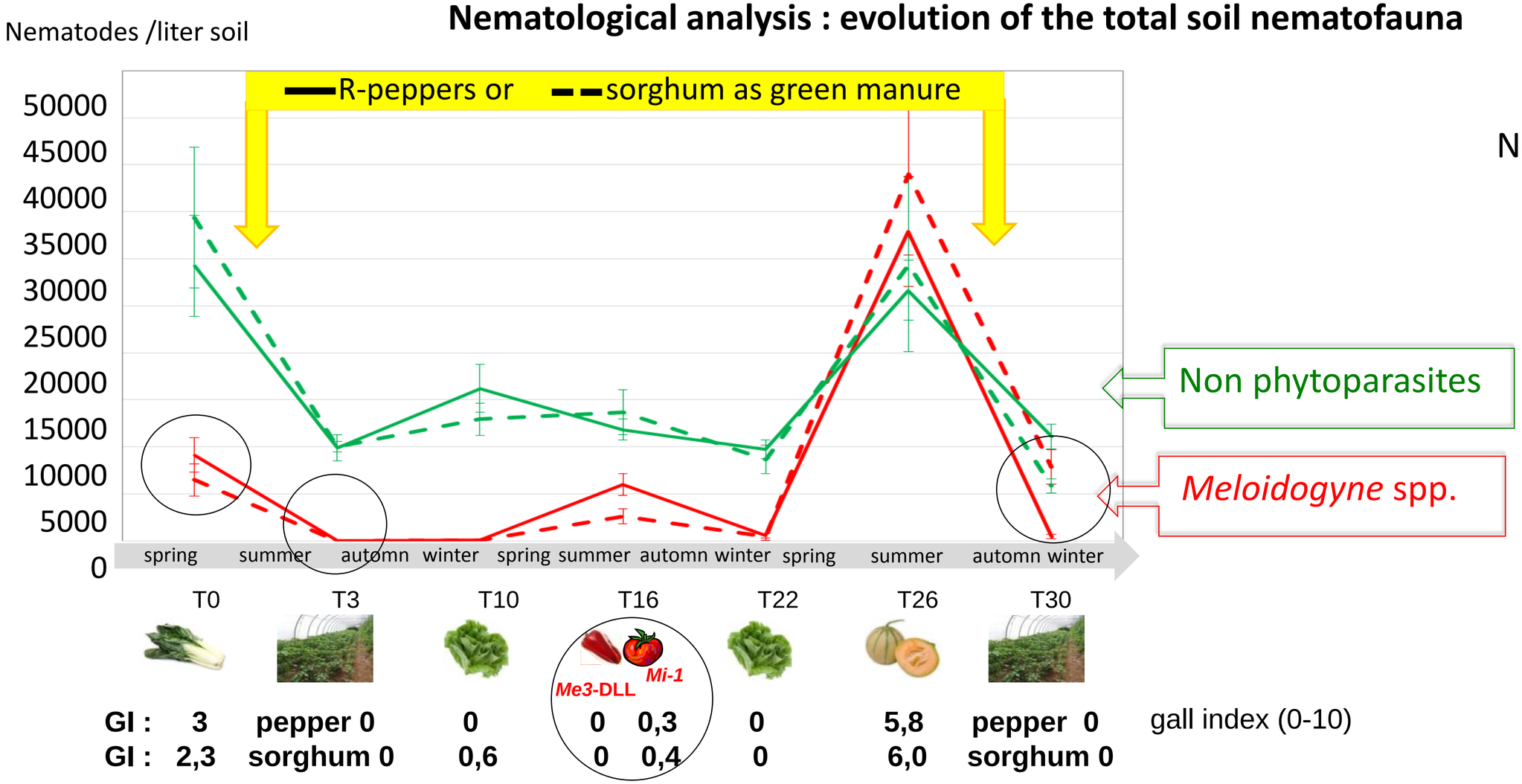
High diversity of the nematode communities

- ***High and sustainable decrease of RKN populations after Sorghum*** *(>95%)=> protection of R-pepper crop*
- ***Increase of non-phytoparasitic species*** *(= usefull saprophagous species => soil ecology improved)* ***with S1***

Example of results

- **S2** **<u>*R*-peppers pyramided for *Me1* and *Me3* (durable *R* stable at high T°)</u>**
  <u>as 'trap crop' green manure :</u> Efficient protection of crops resistance

Nematological analysis : evolution of the total soil nematofauna



	T0	T3	T10	T16	T22	T26	T30
GI :	3	pepper 0	0	0 0,3	0	5,8	pepper 0
GI :	2,3	sorghum 0	0,6	0 0,4	0	6,0	sorghum 0

Me3-DLL *Mi-1*

gall index (0-10)

Low diversity of the nematode communities

- ***High decrease of RKN populations after R-peppers*** *(>95%) => protection of pepper and tomato R-crops*
- ***High reactivity of RKN on susceptible plants*** *(melon)*
- ***Synchronus evolution of RKN and non-phytoparasitic species with S2 (effect of sorghum and R-peppers)***

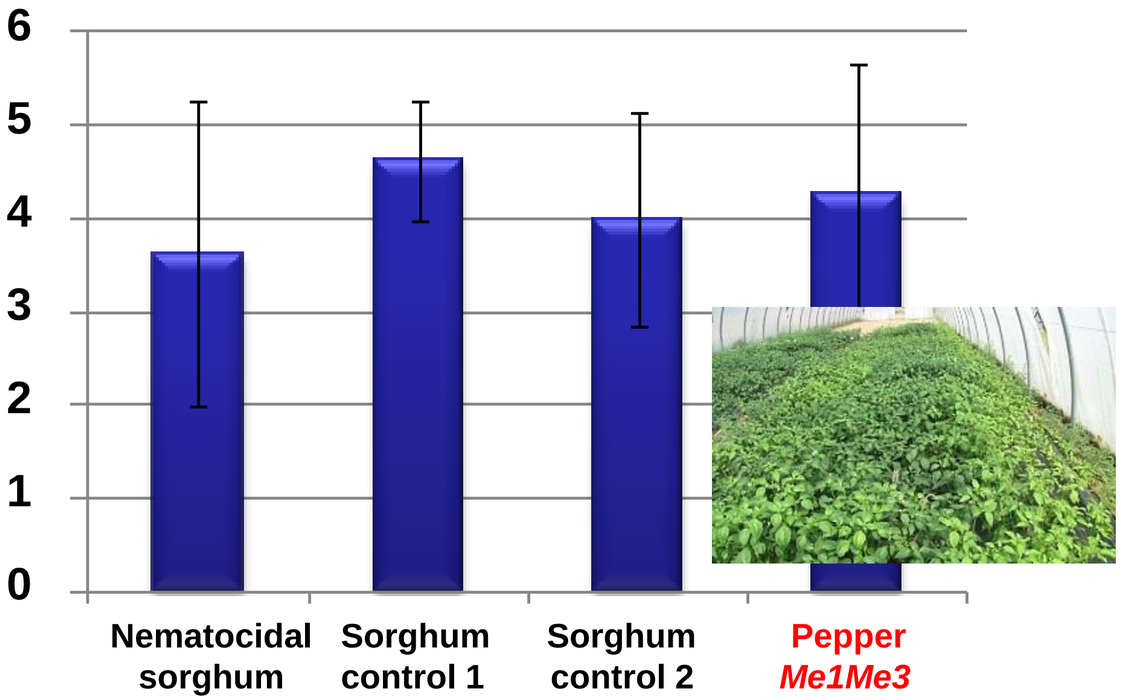
Example of results

- **S2** **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?

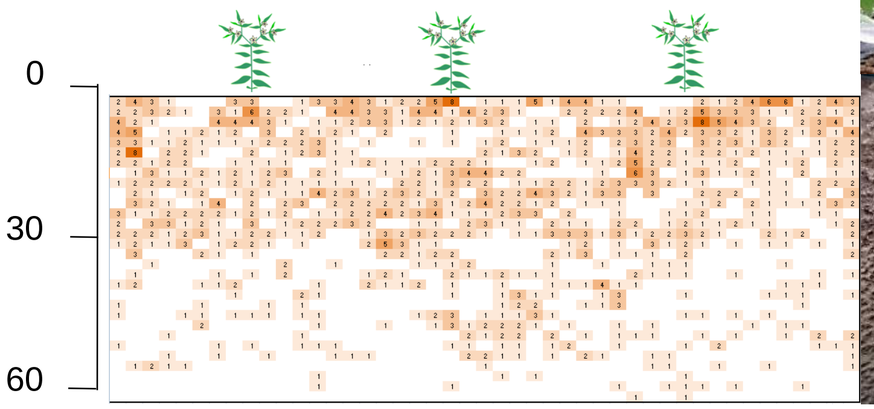
Comparison of buried dry matter (tonnes per hectare) for each green manure



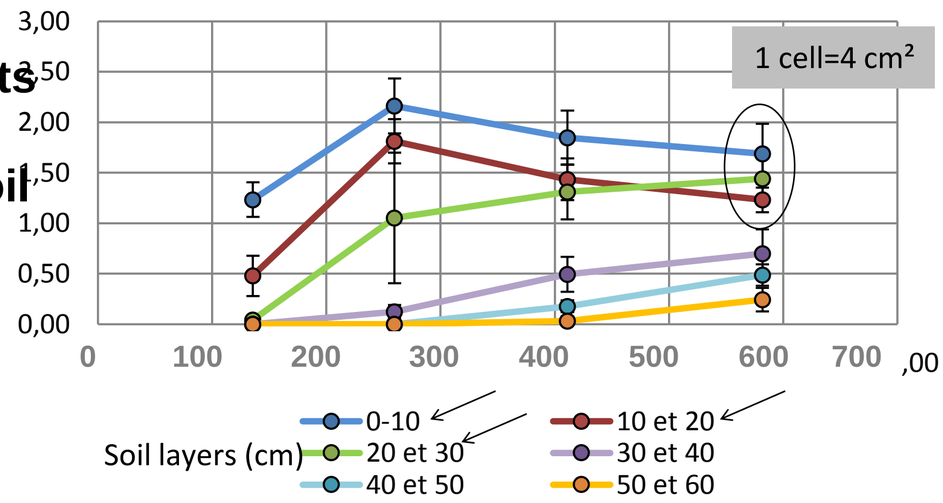
➢ ***Pepper buried dry matter is equivalent to that of traditionally-used sorghum***

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

Root mapping



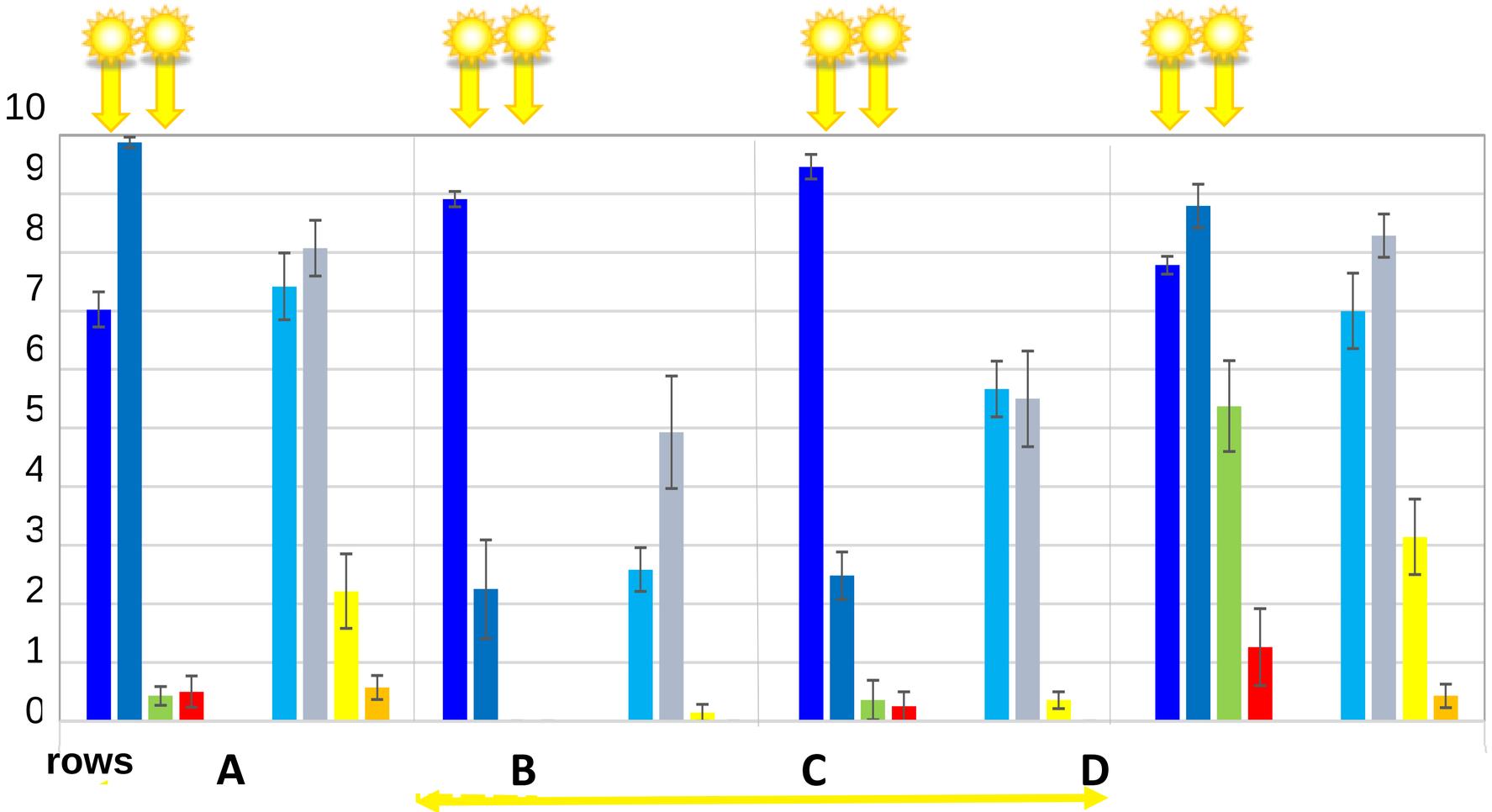
Nb of root impacts per cell depending on soil layers



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

Example of results

S3 Solarisation and bad host plants



T-25 — Spring
Solarisation — Summer
T0 — Spring
Solarisation — Summer
T9 — Winter
T16 — *Me3*-DLL — Summer
T19, T19' — bad host — Winter
T23, T23' — Spring
Solarisation — Summer
T29, T29' — bad host — Winter

- **Zucchini: highly infested**
- **1rst solarisation : efficient on central rows only**
- **2nd solarisation : efficient on rows A, B, C**
- **Efficient protection of pepper resistance on rows A, B, C after solarisation**
- **Winter culture plant too late : nematodes not active =>** no difference between susceptible salads and bad host plants (no gall)
- **Reduction of RKN damages on zucchini in central rows:** half on central rows compared to border rows and compared to T-25
- **3rd solarisation efficient on central rows again**

Conclusions

1 Innovative, sustainable crop production systems

Intercropping management (solarisation, sorghum or *R*-peppers as green manure) : efficient protection of plant resistance, reduction of RKN damages, and high decrease of soil infestation, more durable when high diversity of the nematode communities

Experiments still on going

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

Perspectives

1 Improve the scenario of cropping system with the pepper *Me1 / Me3* as green manure if its effectiveness is confirmed

- looking for best density, best cultivation time
- generating and studying homozygous genotypes combining the two genes to increase efficient seeds at low cost

2 Improve the efficacy and acceptability of the innovative cropping systems at farm scale

- make them compatible with the constraints of farmers (case of farms in conventional agriculture with intensive long crop cycle, which have little motivation to change and for agro-ecological practices)
- make emerge innovative strategies from the combination of plots and cropping systems at the farm scale, to increase their technical and socio-economical resilience maintaining the overall productivity of the farm.

For details

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