Challenges of the management of pest and diseases in organic banana production: a holistic and realistic point of view in export systems

L. de Lapeyre, Cirad, GECO
…. and many other contributors !

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Focus of this communication

1. Banana production for exportation

……. Reveals various constrainsts :

Cultivation of Cavendish bananas only

Susceptibility to crop ennemies

Cultivation generally in big farms or small farms in large areas

Large epidemic processes

Shipping 7-20 days

Cooling at 13°C after packing

Greenlife Acceptability of bananas

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Focus of this communication

1. Banana production for exportation

……. Reveals various constrainsts :

Artificial ripenning

Greenlife
Acceptability
of bananas

Commercialisation
mainly in supermarkets

Economic constraints specific to banana markets

* Low prices in supermarkets
* Low tolerance for quality defects
* Short conservation in supermarkets and trade based on very specific pomologic traits

High yields
High quality standards

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Focus of this communication

2. Control of pest and diseases in the frame of organic rules

- No synthetic pesticides

fungicides

herbicides

nematicides

insecticides

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Focus of this communication

2. Control of pest and diseases in the frame of organic rules

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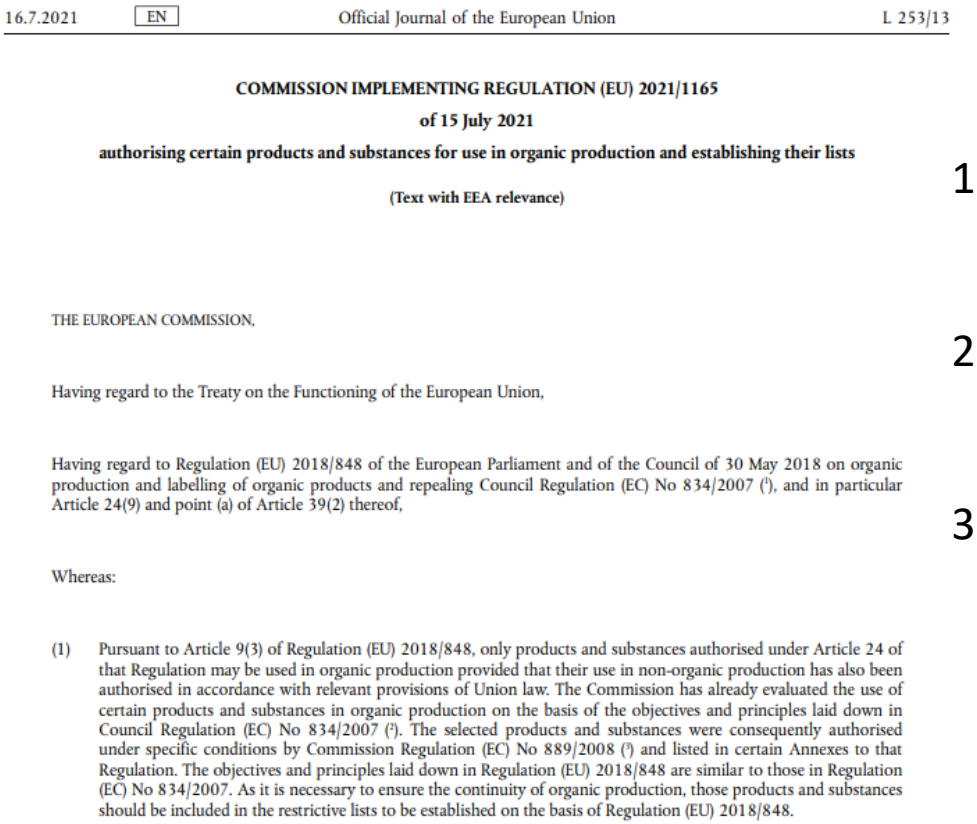
Focus of this communication

2. Control of pest and diseases in the frame of organic rules

- Only some products allowed



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COMMISSION IMPLEMENTING REGULATION (EU) 2021/1165

of 15 July 2021

authorising certain products and substances for use in organic production and establishing their lists

(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007 (1), and in particular Article 24(9) and point (a) of Article 39(2) thereof,

Whereas:

(1) Pursuant to Article 9(3) of Regulation (EU) 2018/848, only products and substances authorised under Article 24 of that Regulation may be used in organic production provided that their use in non-organic production has also been authorised in accordance with relevant provisions of Union law. The Commission has already evaluated the use of certain products and substances in organic production on the basis of the objectives and principles laid down in Council Regulation (EC) No 834/2007 (2). The selected products and substances were consequently authorised under specific conditions by Commission Regulation (EC) No 889/2008 (3) and listed in certain Annexes to that Regulation. The objectives and principles laid down in Regulation (EU) 2018/848 are similar to those in Regulation (EC) No 834/2007. As it is necessary to ensure the continuity of organic production, those products and substances should be included in the restrictive lists to be established on the basis of Regulation (EU) 2018/848.

1. Basic substances (from plants or animals, or mineral origin)
2. Low Risk active substances (ferric phosphate, Laminarin)
3. Micro-organisms

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Focus of this communication

2. Control of pest and diseases in the frame of organic rules

- Only some products allowed

4. Active substances not included in any of the above categories

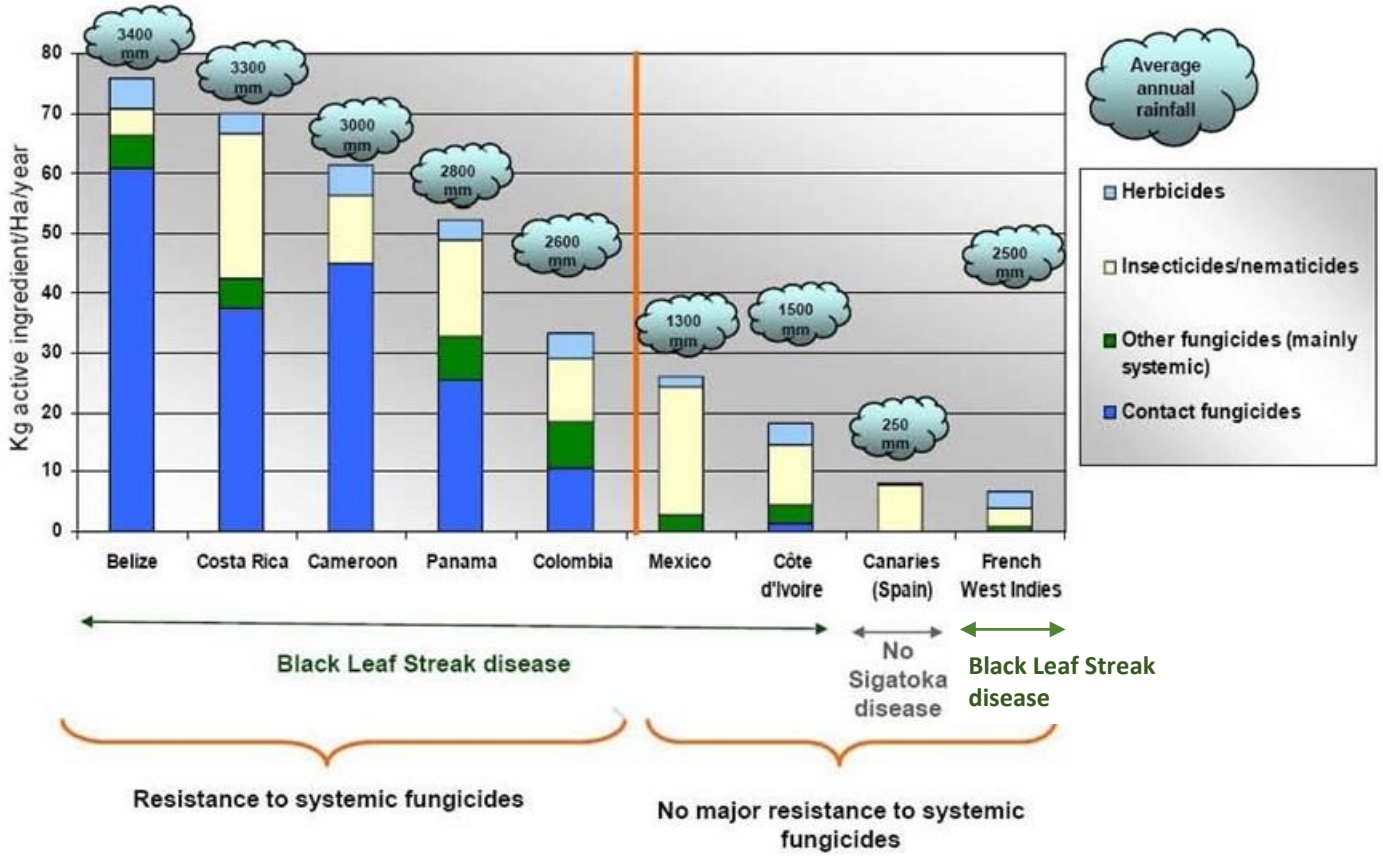
The active substances as approved pursuant to Regulation (EC) No 1107/2009 and listed in the table below may be used as plant protection products in organic production only when they are used in accordance with the uses, conditions and restrictions pursuant to Regulation (EC) No 1107/2009 and taking into account the additional restrictions, if any, in the right column of the table below.

Number and part of Annex (1)	CAS	Name	Specific conditions and limits
139A	131929-60-7 131929-63-0	Spinosad	
225A	124-38-9	Carbon dioxide	
227A	74-85-1	Ethylene	only on bananas and potatoes; however, it may also be used on citrus as part of a strategy for the prevention of fruit fly damage
230A	i.a. 67701-09-1	Fatty acids	all uses authorised, except herbicide
231A	8008-99-9	Garlic extract (*Allium sativum*)	
234A	CAS No not allocated CIPAC No 901	Hydrolysed proteins excluding gelatine	
244A	298-14-6	Potassium hydrogen carbonate	
249A	98999-15-6	Repellents by smell of animal or plant origin/sheep fat	
255A and others		Pheromones and other semiochemicals	only in traps and dispensers
220A	1332-58-7	Aluminium silicate (kaolin)	
236A	61790-53-2	Kieselgur (diatomaceous earth)	
247A	14808-60-7 7637-86-9	Quartz sand	
343A	11141-17-6 84696-25-3	Azadirachtin (Margosa extract)	extracted from Neem tree seeds (*Azadirachta indica*)
240A	8000-29-1	Citronella oil	all uses authorised, except herbicide
241A	84961-50-2	Clove oil	all uses authorised, except herbicide
242A	8002-13-9	Rape seed oil	all uses authorised, except herbicide
243A	8008-79-5	Spearmint oil	all uses authorised, except herbicide
56A	8028-48-6 5989-27-5	Orange oil	all uses authorised, except herbicide
228A	68647-73-4	Tea tree oil	all uses authorised, except herbicide
246A	8003-34-7	Pyrethrins extracted from plants	
292A	7704-34-9	Sulphur	
294A 295A	64742-46-7 72623-86-0 97862-82-3 8042-47-5	Paraffin oils	
345A	1344-81-6	Lime sulphur (calcium polysulphide)	
44B	9050-36-6	Maltodextrin	
45B	97-53-0	Eugenol	
46B	106-24-1	Geraniol	
47B	89-83-8	Thymol	
10E	20427-59-2	Copper hydroxide	in accordance with Implementing Regulation (EU) No 540/2011 only uses resulting in a total application of maximum 28 kg of copper per hectare over a period of 7 years may be authorised
10E	1332-65-6 1332-40-7	Copper oxychloride	
10E	1317-39-1	Copper oxide	
10E	8011-63-0	Bordeaux mixture	
10E	12527-76-3	Tribasic copper sulphate	
40A	52918-63-5	Deltamethrin,	only in traps with specific attractants against *Bactrocera oleae* and *Ceratitis capitata*
5E	91465-08-6	Lambda-cyhalothrin	only in traps with specific attractants against *Bactrocera oleae* and *Ceratitis capitata*

(1) Listing according to Implementing Regulation (EU) No 540/2011, numbers and which category: Part A active substances deemed to have been approved under Regulation (EC) No 1107/2009, B, active substances approved under Regulation (EC) No 1107/2009, C basic substances, D low-risk active substances and E candidates for substitution.

How challenging is it ?

Might be over 80 kg or over 80 pesticide rates used



✓ Pesticide use is generally very important in most tropical humid areas where banana is produced

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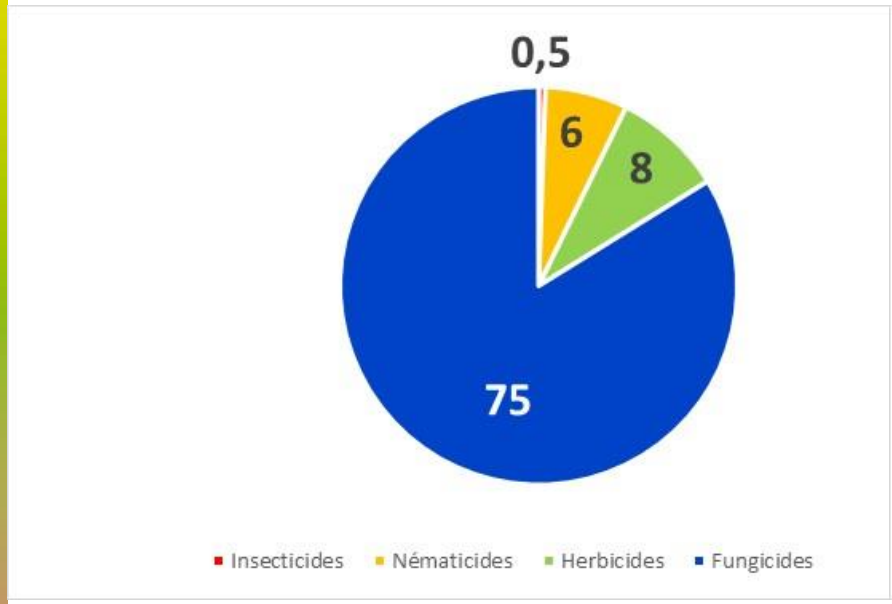
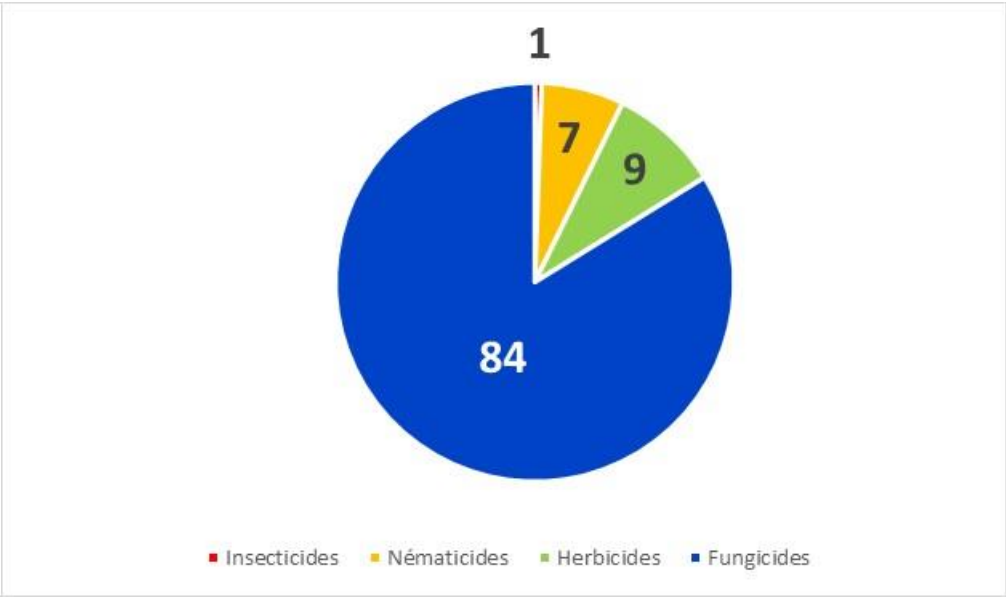
How challenging is it ?

Kg of active ingredient used in one year in a representative conventional farm in humid tropics



% of quantity of active ingredient used in one year in a representative conventional farm in humid tropics



✓ Fungicide use is very important

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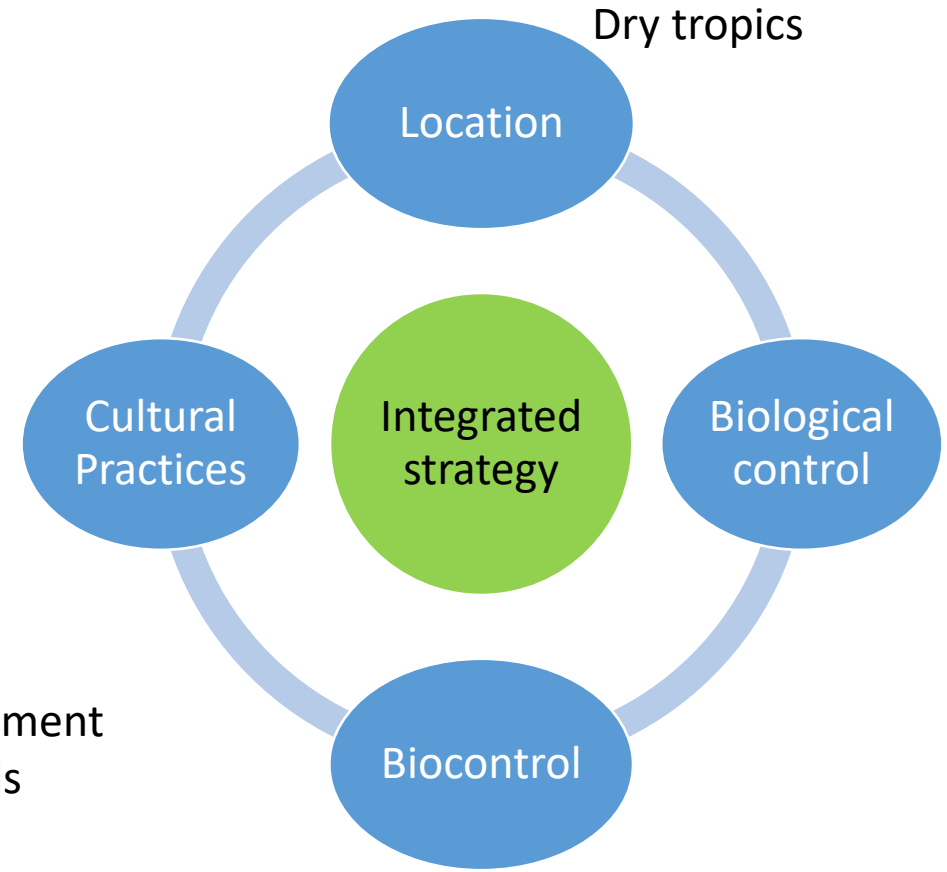
Which levers ?



Dry tropics

- Cultivar
- Crop rotations
- Intercropping
- Prophyllaxy
- Barriers
- Pruning
- Plant nutrition
- Harvest management
- Physical methods
- …….

Biota against biota

- Microorganisms
- Macroorganisms
- Plants

Natural substances (should be approved)

- Plant extracts
- Mineral origin
- Pheromones

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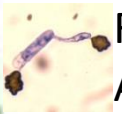
Focus on the most specific problems for OA (replacement of pesticides)

Weeds / competition

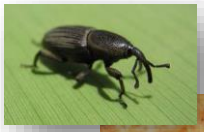
Other conference

Leaves:
Black Leaf Streak Disease

The two most important problems



Fruits:
Anthracnose, Crown rot



Bulb:
Black weevil

Generaly minor problems in dry tropics : efficient solutions exist (Fallow, trapping)

Roots:
Nématodes (Radopholus similis)

Excluded :
* Telluric fungi (*Fusarium* wilt)
* Viral diseases
* Bacterial diseases

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Example 1.
Black Leaf Streak Disease control in organic farms

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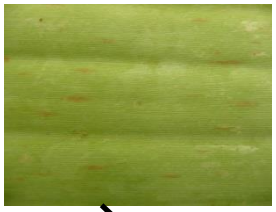

Direct reduction of photosynthesis

Dammages = important defoliation

Yield loss

Indirect Reduction of greenlife

Unexported bunches

Beginning of cycle

Flowering

Harvest

Crop cycle

Sucker

Reduction of yield in next cycle

Shipping

Early ripening

Black Leaf Streak Disease

1. Location of organic farms in dry areas is the most important lever used by farmers

Annual rainfall < 1000 mm mainly to maintain BLSD at low level

Places dedicated to organic banana production	Surfaces	Annual rainfall
Peru (Piura)	9500 ha	100 mm
Ecuador (Machala)	20000 ha	500 mm
Dominican Republic (Mao-Montecristi, Azua)	**18000 ha**	**500-1000 mm**
Ghana	**600 ha**	**700-1000 mm**
Colombia (La Guajira)	3000 ha	700-1000 mm
Mexico (Colima)	4000 ha	700-1000 mm

Water is transported to fields by large canals

Water is pumped or flooded in plots

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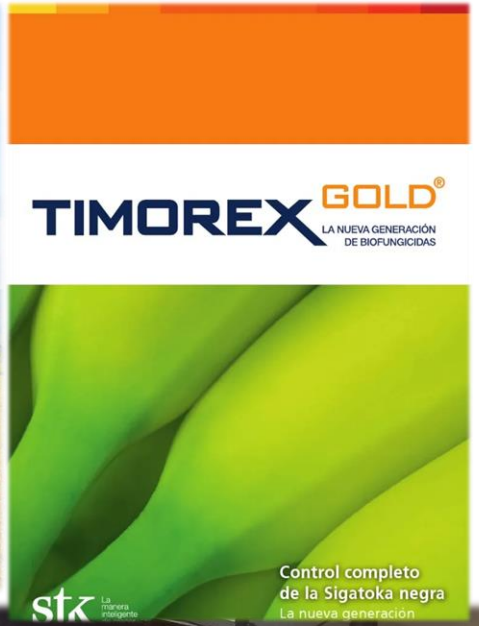
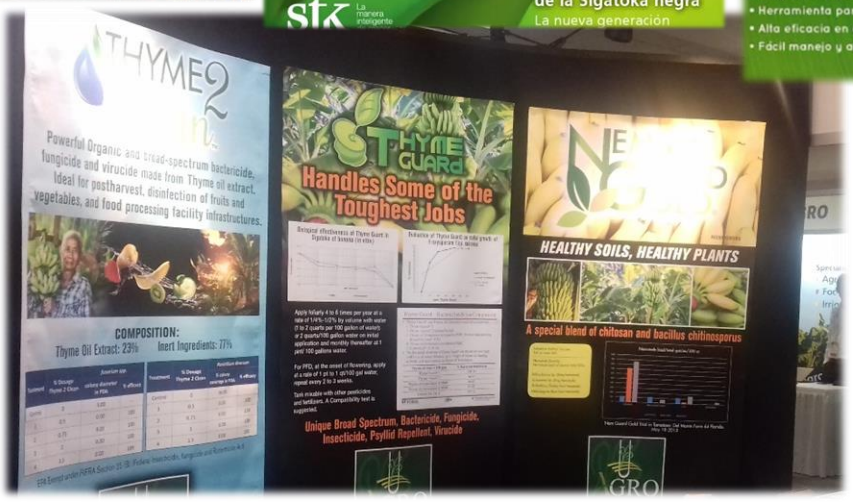
Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle



Lots of advertising !



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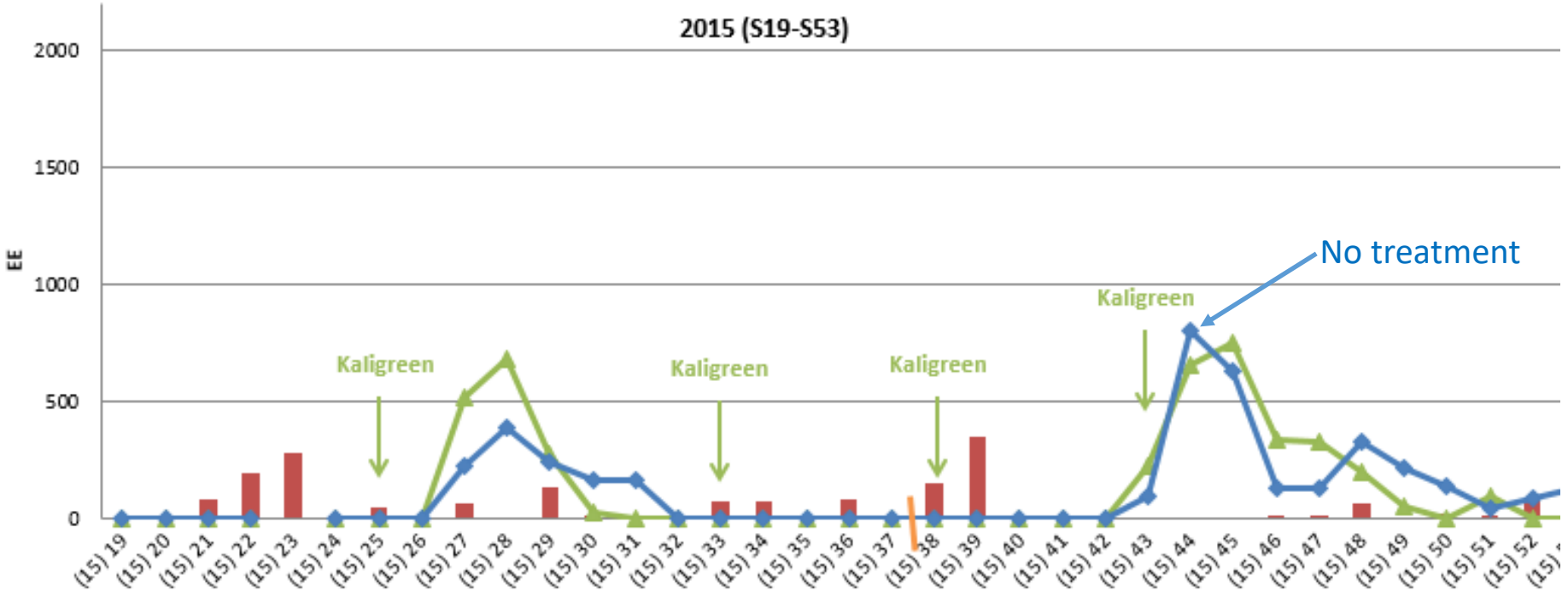
Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle



Dry periods might be a mirage of efficiency !

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Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle

- ✓ Many products have been registered in all organic banana growing countries

- ✓ Efficiency is rarely evaluated in good conditions : low disease level, no untreated control, products are mixed with mineral oil

- ✓ Solid evaluation has been made in different contexts : Dominican Republic, Ivory Coast
- Experimental plots with 3-4 blocks
- **Untreated control** in each block
- **Reference treatment** in each block : mineral oil at 12-15l/ha
- **Broad range of disease descriptors** : SED, YLSt, YLS, Number of lesions, Functionnal leaves at flowering
- **Long period :** several weekly applications (at least 10)

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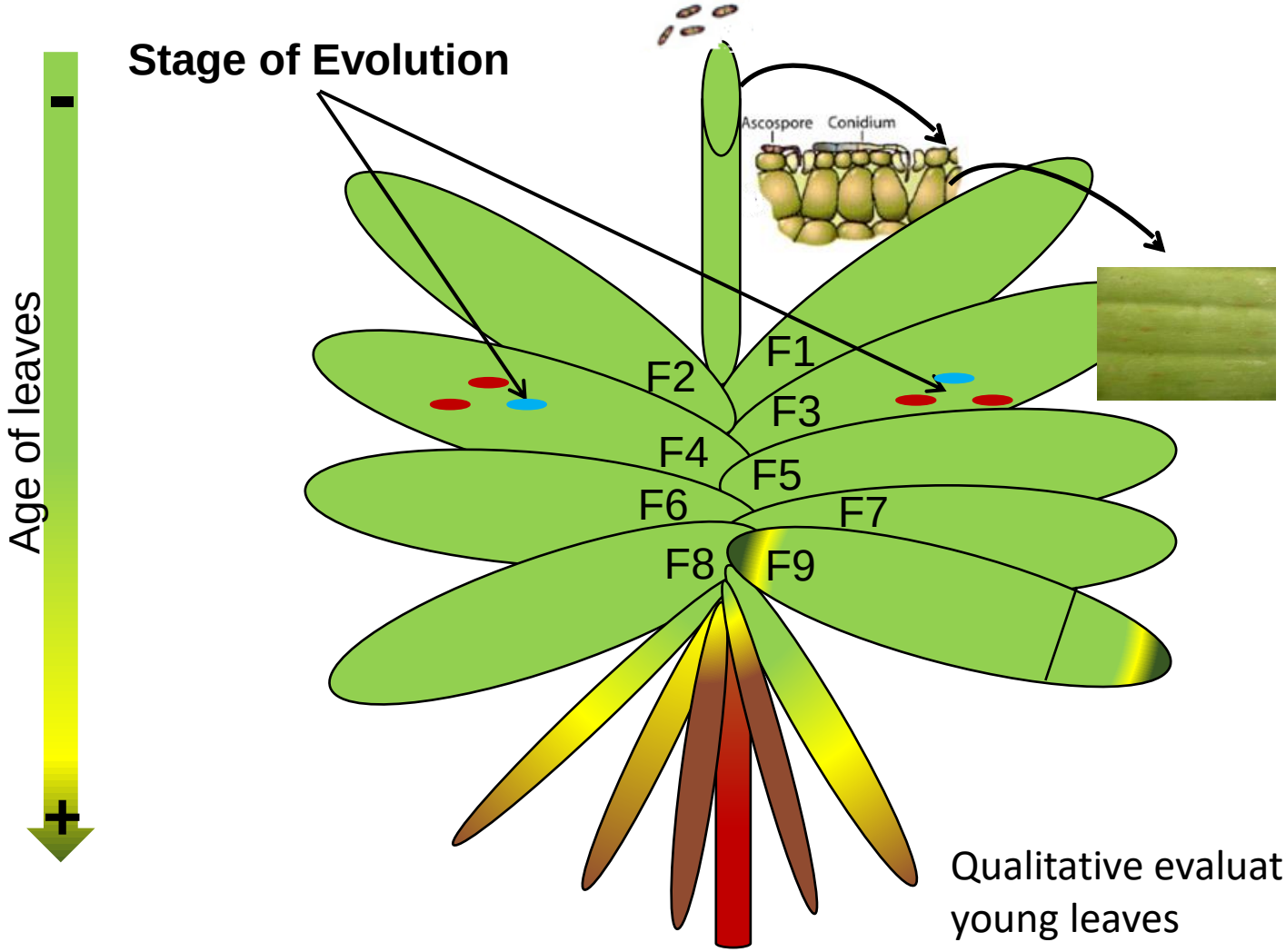
Black Leaf Streak Disease

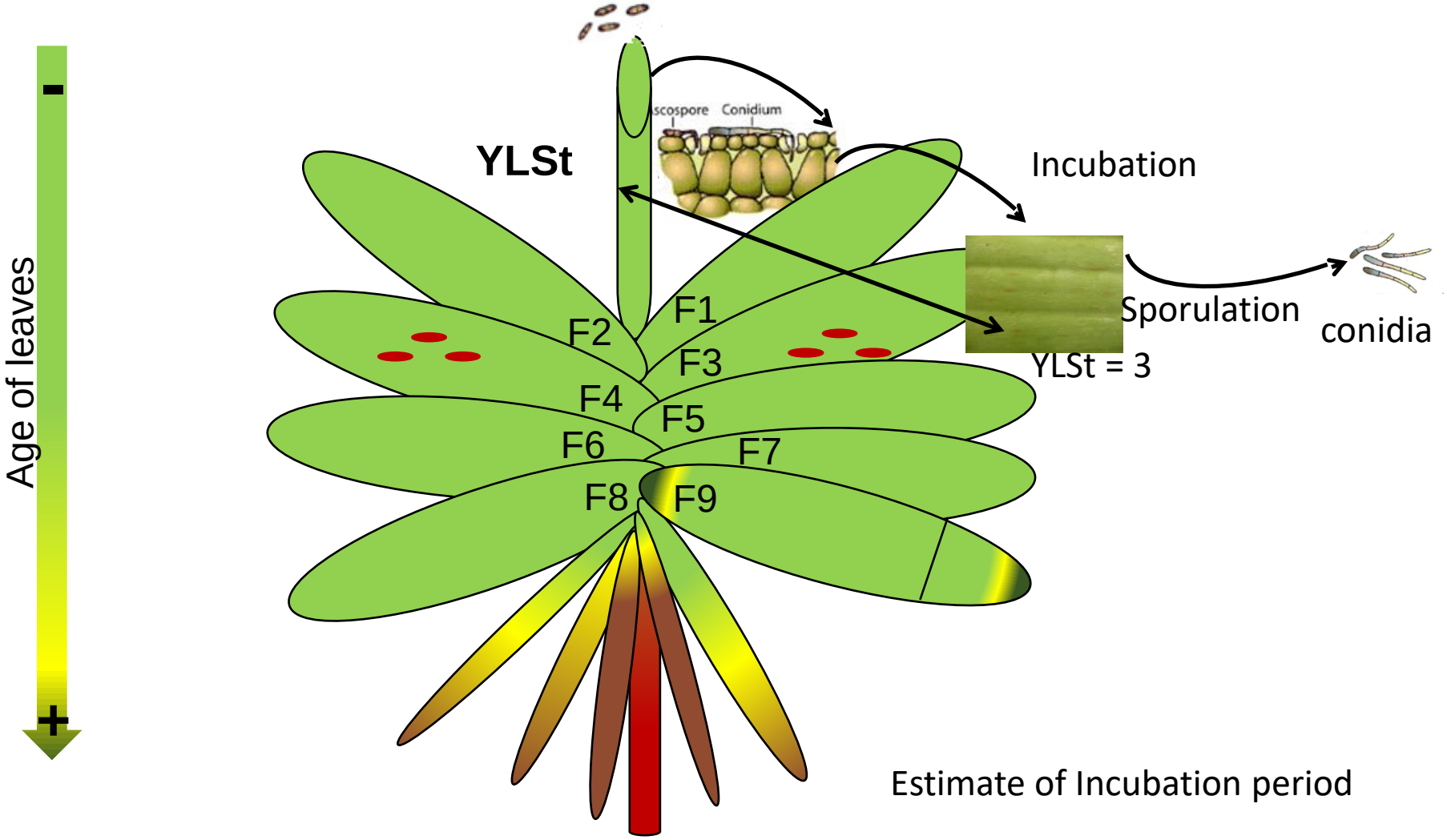
2. The quest for alternative fungicides …. or a miracle



Qualitative evaluation of disease on young leaves

Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle



Black Leaf Streak Disease

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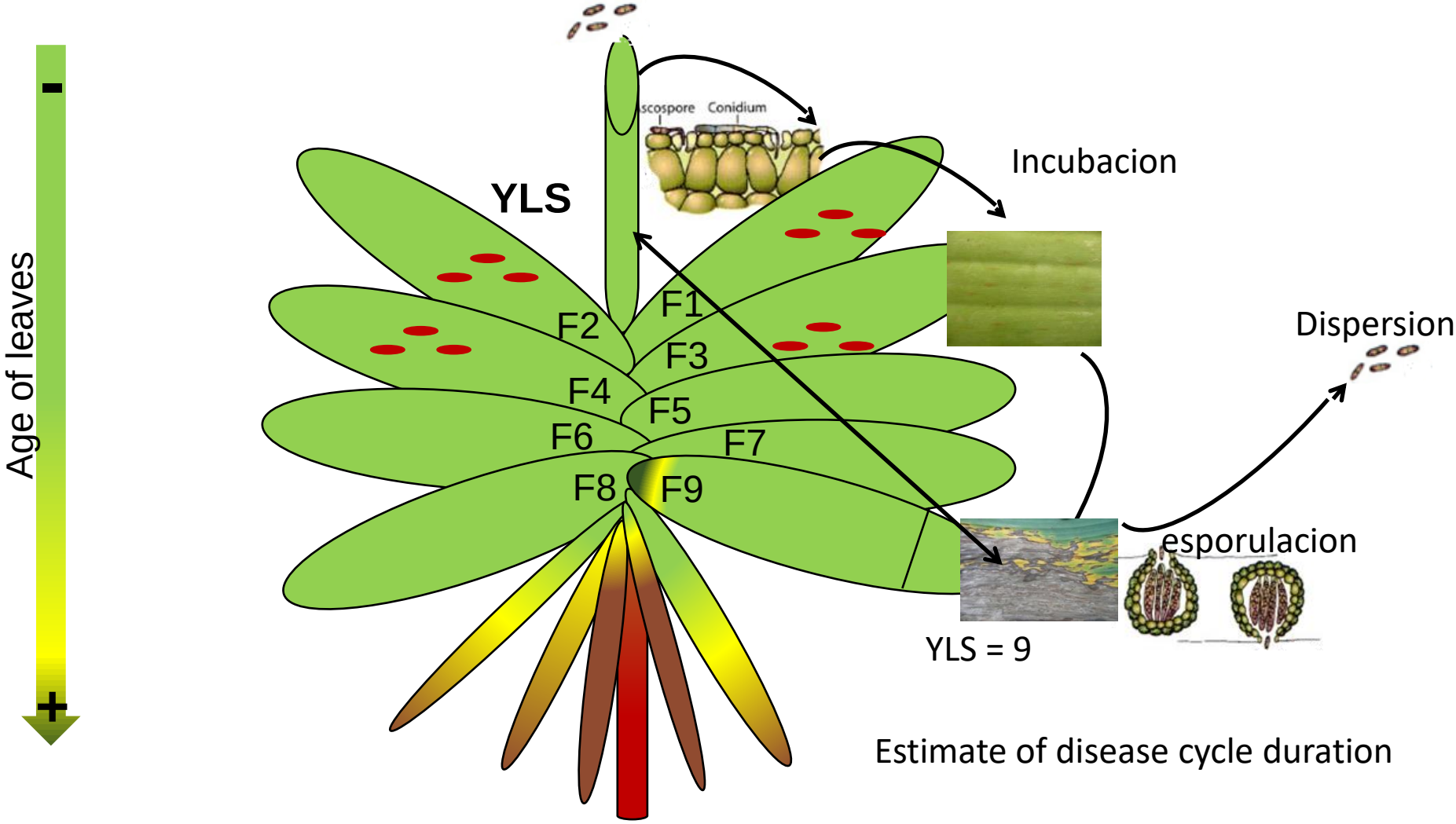
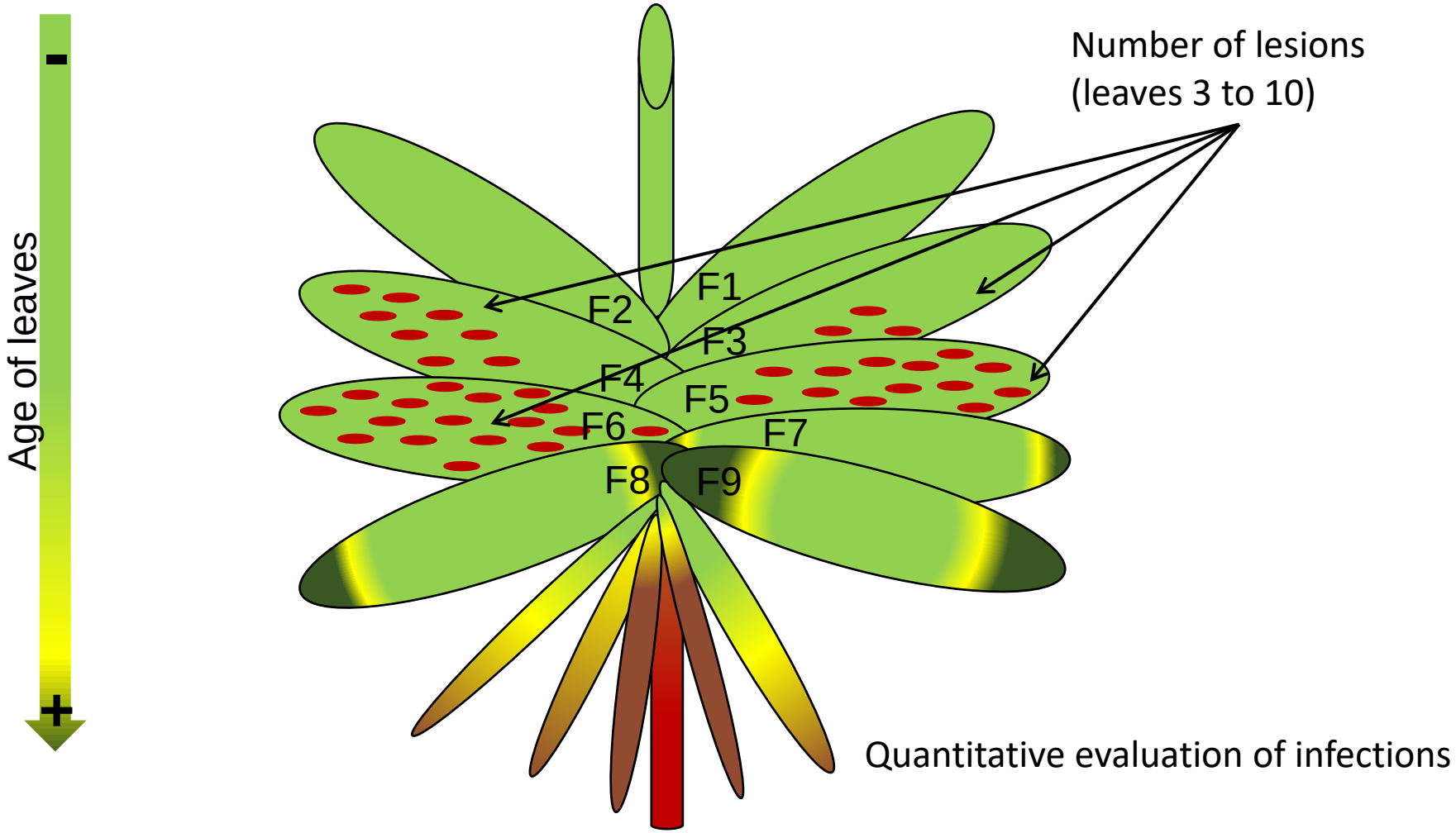


Estimate of disease cycle duration

Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle



Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle

	Untreated control	Defense elicitor	Tea Tree	*Bacillus pumilis*	Potassium bicarbonate	*Bacillus subtilis*	Plant extract (thymol, eugenol)	Mineral oil 15 l/ha
SED	a	a	a	a	a	a	a	b
YLSt	a	a	a	a	a	a	a	b
YLS	a	a	a	a	a	a	a	b
Number of lesions	a	a	a	a	a	a	a	b (-90%)
Green leaves	a	a	a	a	a	b	a	c

- **Most approved biofungicides are ineffective** : no difference with untreated control
- Mineral oil remains the best protection

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Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle

	Untreated control	Eucalyptus extract	Eucalyptus extract + oil	Mineral oil
SED	**a**	**a**	**b**	**b**
YLSt	**a**	**a**	**c**	**b**
YLS	**a**	**a**	**c**	**b**
Number of lesions	**a**	**b**	**d**	**c**
Green leaves	**a**	**b**	**d**	**c**

- Some plant extracts mixed in oil might improve biological efficiency vs reference
- More exploration is needed
- Organic certification is needed (country, UE, EPA, certificaying bodies)

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Black Leaf Streak Disease

2. The quest for alternative fungicides …. or a miracle

- ✓ Mineral oil is generally a good lever for BLSD control but depends on precipitations and irrigation methods.
- ✓ Probably not sufficient in large plantations when rainfall > 1000 mm

Dominican Republic trial	Oil/Forecast year 1	Oil/Forecast year 2	Oil/Forecast year 3
SED	33	316	841
YLSt	8,1	6,0	4,2
YLS	11,3	10,3	7,3
Leaves at hatvest	8,4	8,1	4,2
Number of treatments	1	5	9
Rainfall	352	1145	1602

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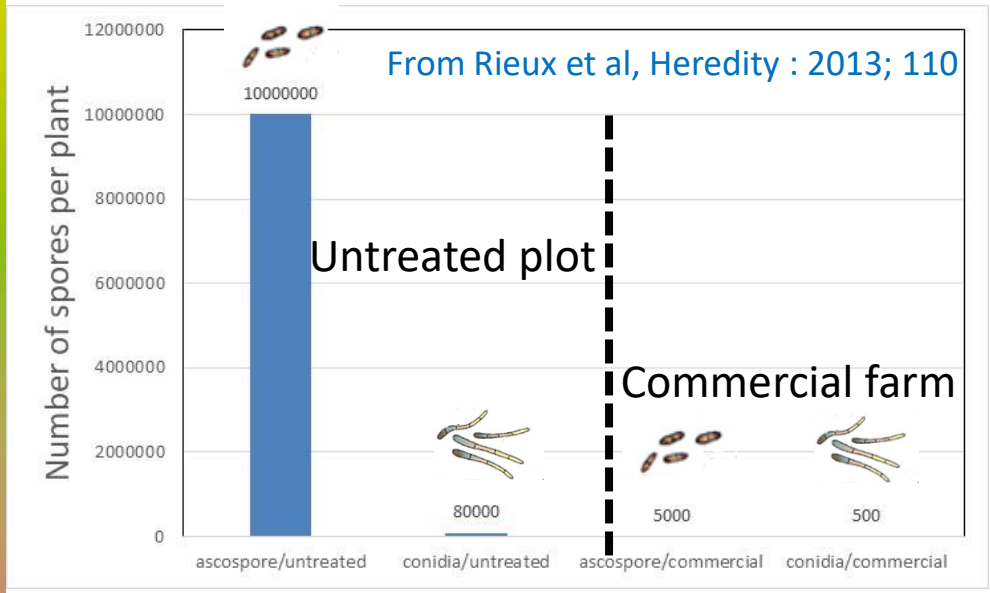
Black Leaf Streak Disease

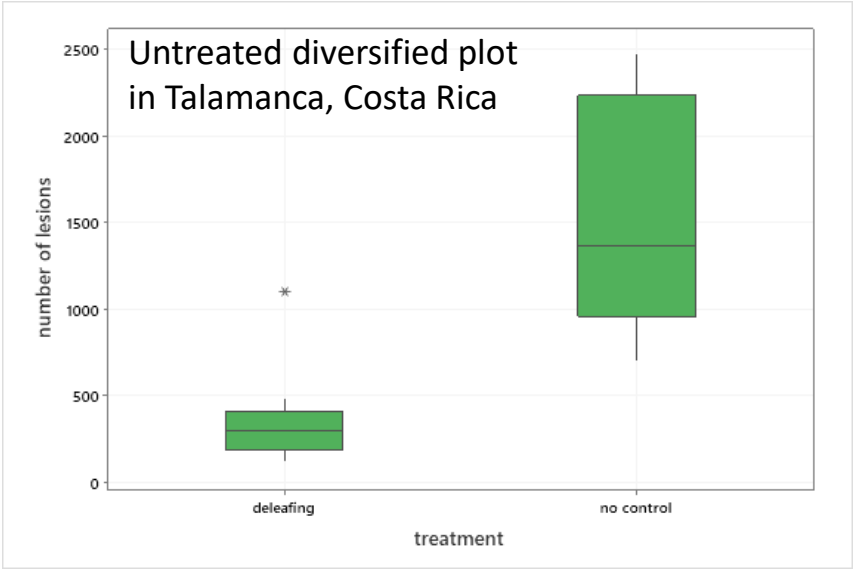
3. Deleafing a multifunctional lever underestimated

A very efficient **prophyllactic tool** largely performed in most banana farms !

❖ Ascospores are very abundant in unmanaged plots



❖ Necrotic leaves might produce large amounts of ascospores for more than 150 days (Gauhl, 1994)



❖ Deleafing of necrotic leaves drastically reduces inoculum abundance

From Poeydebat et al, Phytopathology : 2018; 108

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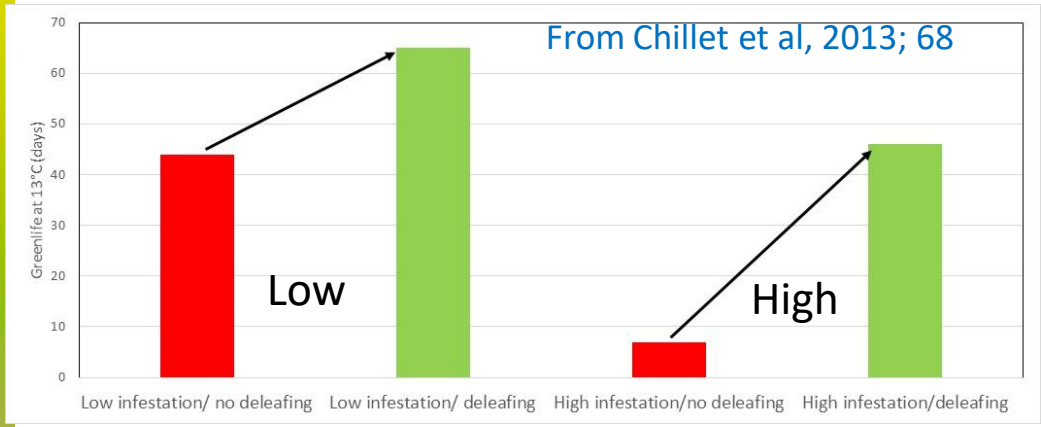
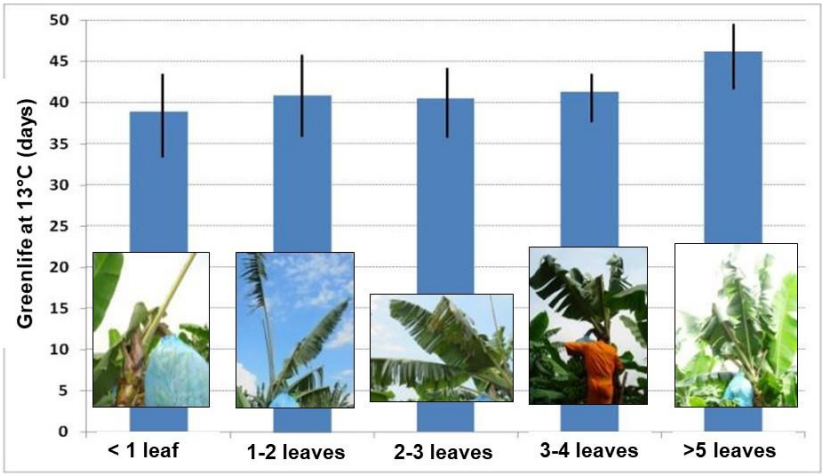
Black Leaf Streak Disease

3. Deleafing a multifunctional lever underestimated

A very efficient and **poorly recognized tool** to mitigate BLSD on greenlife



❖ Deleafing one month before harvest has a strong effect on GL (Yellow Sigatoka)



❖ When regular deleafing of necrotic spots is performed in highly infested spots, GL is not much affected (BLSD)

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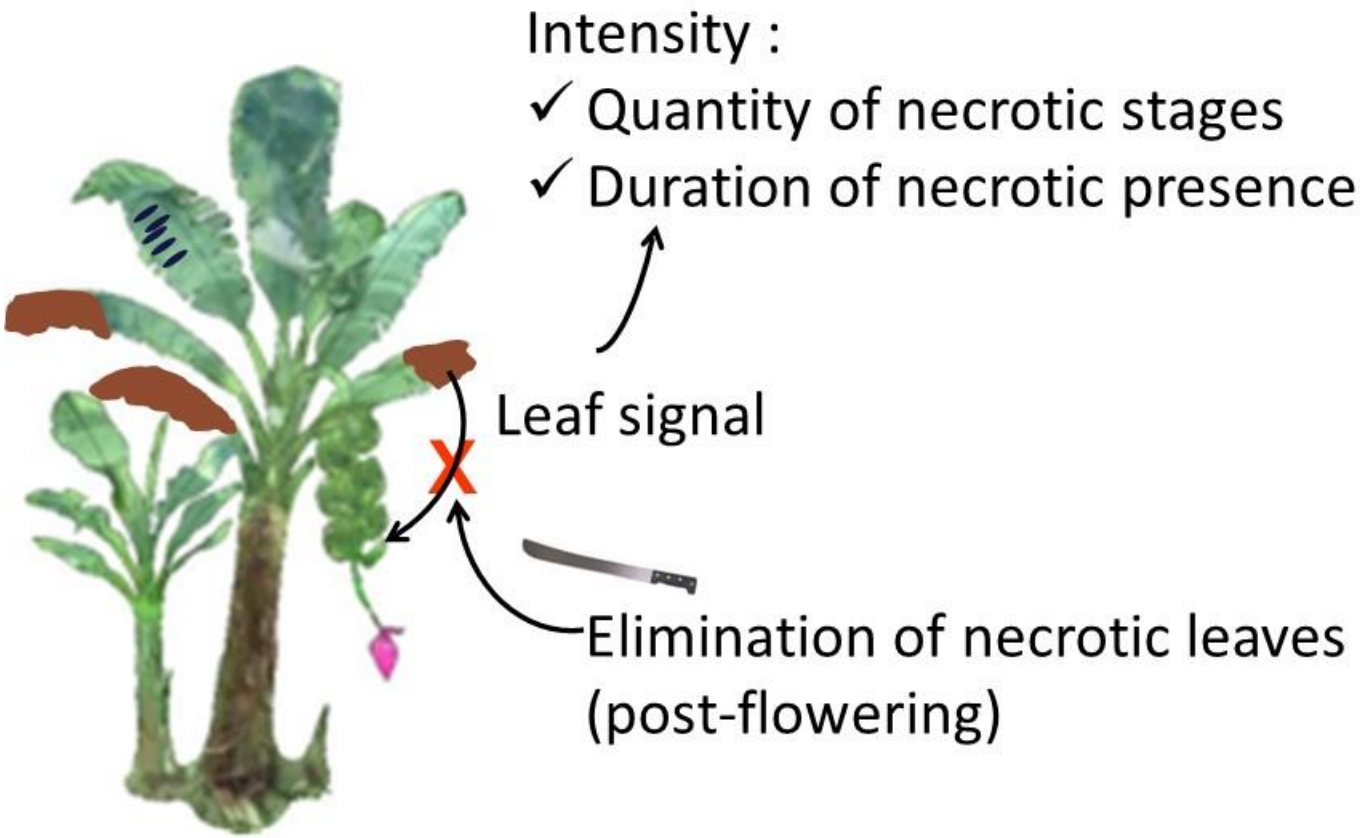
Black Leaf Streak Disease

3. Deleafing a multifunctional lever underestimated

A very efficient and **poorly recognized tool** to mitigate BLSD on greenlife



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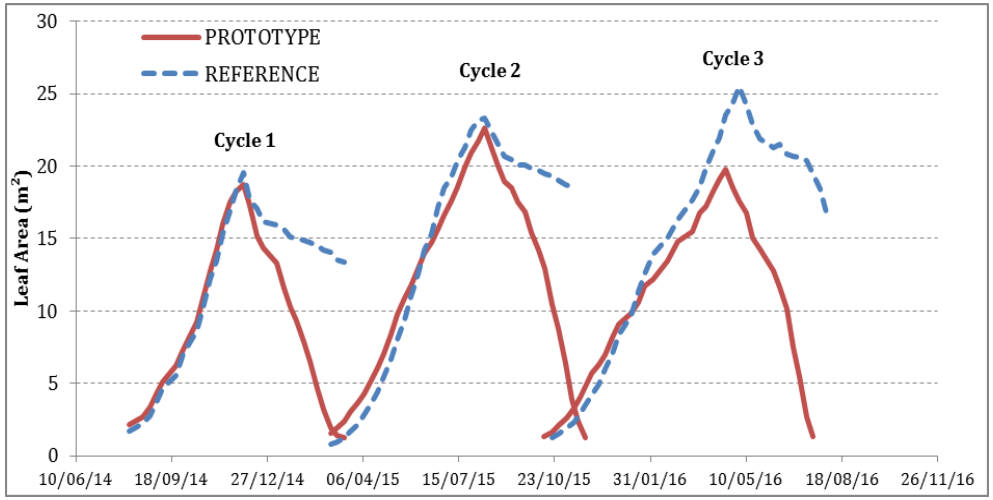
Black Leaf Streak Disease

3. Deleafing a multifunctional lever underestimated

A very efficient and **poorly recognized tool** to mitigate BLSD on greenlife

Comparison of two strategies in Humid climate in Martinique through 3 cycle crops



- Reference = chemical strategy
- Prototype = strategy only based on regular weekly deleafing of necrotic stages

Important defoliation

From Guillermet et al., 2016

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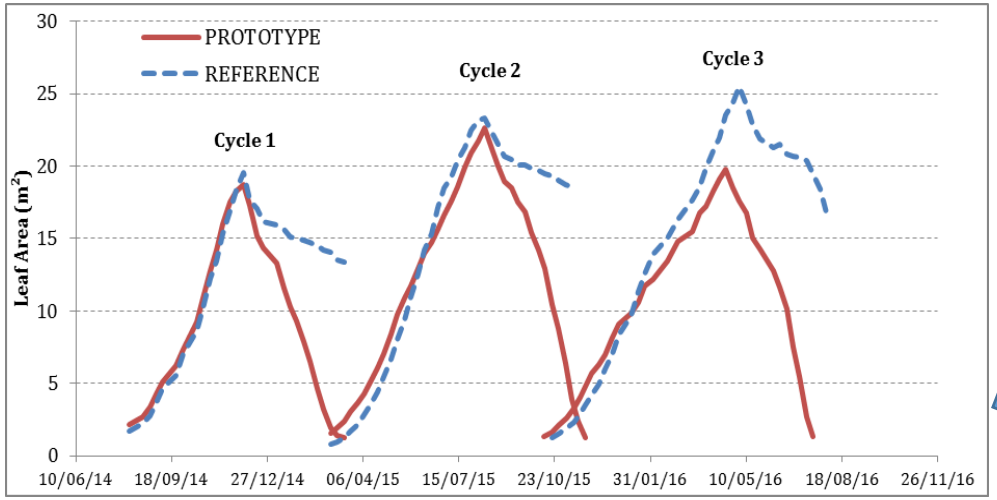
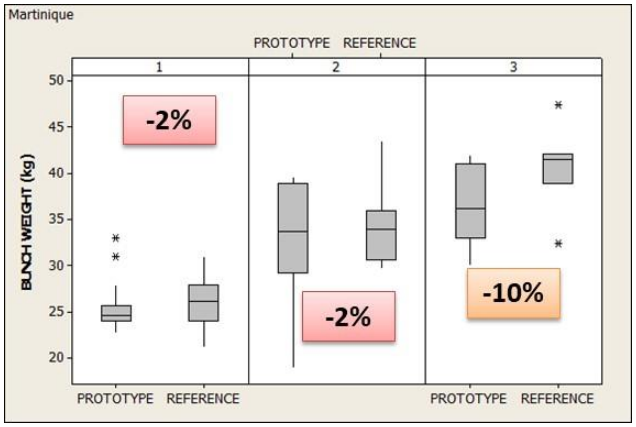
Black Leaf Streak Disease

3. Deleafing a multifunctional lever underestimated

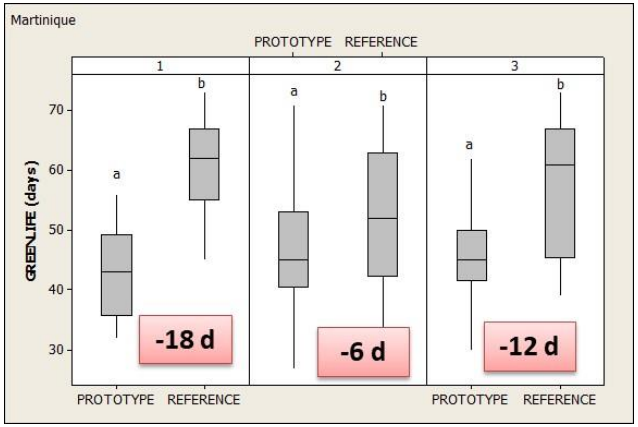
A very efficient and **poorly recognized tool** to mitigate BLSD on greenlife

Comparison of two strategies in Humid climate in Martinique through 3 cycle crops





Moderate reduction of bunch weight



Moderate reduction of greenlife : no ripe

- Reference = chemical strategy
- Prototype = strategy only based on regular weekly deleafing of necrotic stages

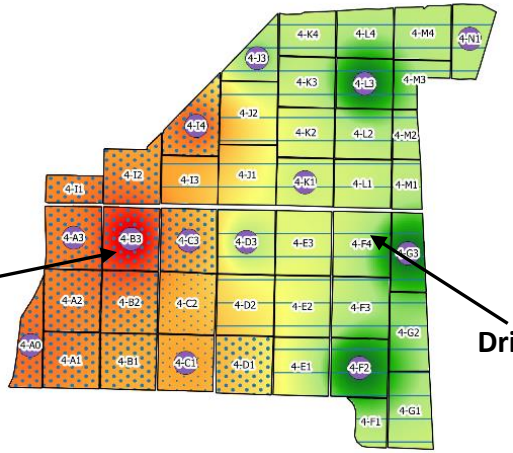
From Guillermet et al., 2016

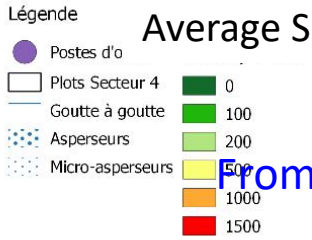
Black Leaf Streak Disease

4. Complementary levers

❖ Irrigation system

Limit wet environment in field

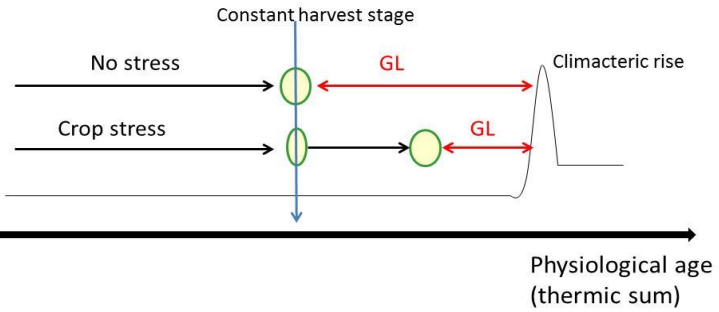




From Ecochard, 2020

❖ Harvest stage according to physiological age

Preserve greenlife even in case of high infestation



❖ Bunch reduction

Compensate leaf surface reduction

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Black Leaf Streak Disease

5. Synthesis of levers for BLSD control in organic farms

Location	Biological contol	Natural substances	Agricultural practices
Dry areas +++++	Microorganisms +/-	Mineral oil +++	Necrotic stages removal +++
		Plant extracts +	Harvest stage ++
			Fruit pruning +
			Irrigation +

All levers must be combined for acceptable control !

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Black Leaf Streak Disease

6. Other levers that need to be further explored

❖ Resistant varieties

Pointe d'or in field

Resistant varieties are available but :

- ✓ Crop management is very different to Cavendish and production costs higher or yield lower (Dorel et al, 2016)
- ✓ Fruits might suffer physiological defects
- ✓ Fruit are not adapted to the transport and the ripening process
- ✓ Fruits are not adapted to trade in supermarkets

Browning on Pointe d'or

Pointe d'or in supermarkets

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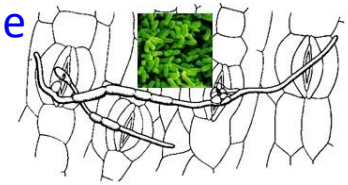
Black Leaf Streak Disease

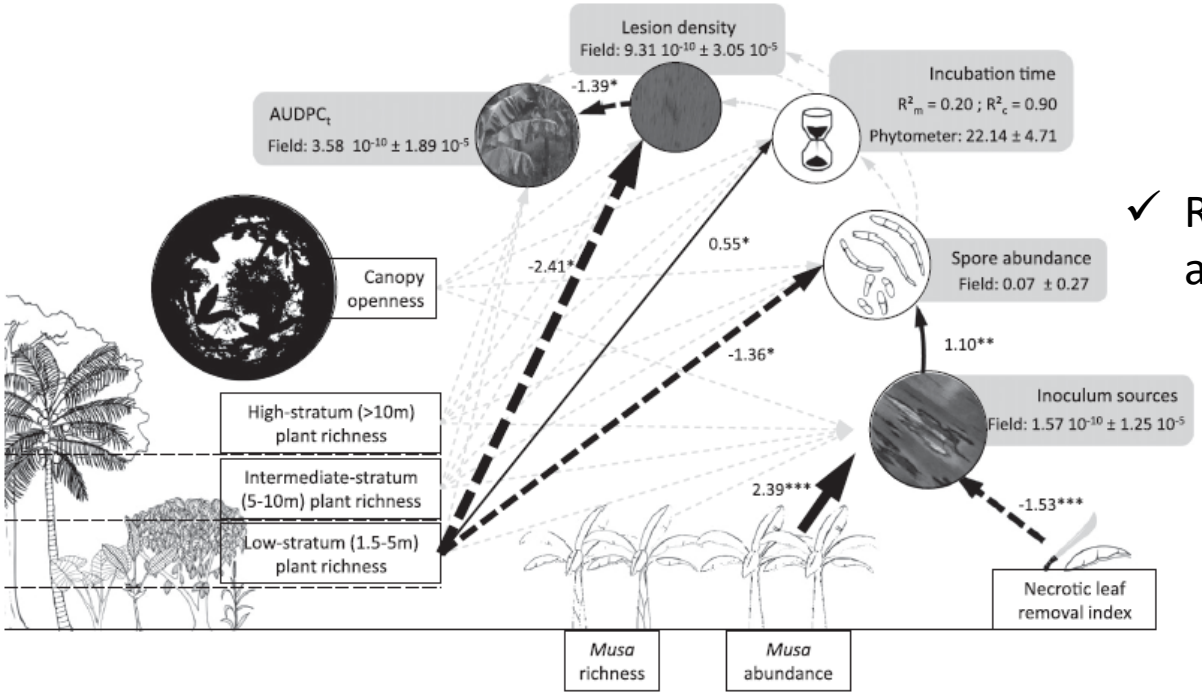
6. Other levers that need to be further explored

❖ Plot diversification with trees (agroforestry)

✓ Barriers to dispersion
longer distance
between hosts

✓ Increase of incubation time
microclimate
phyllosphera microbiome





✓ Reduction of spore abundance
spore interception
less inoculum sources

From Poeydebat et al., Phytopathology, 2018; 108

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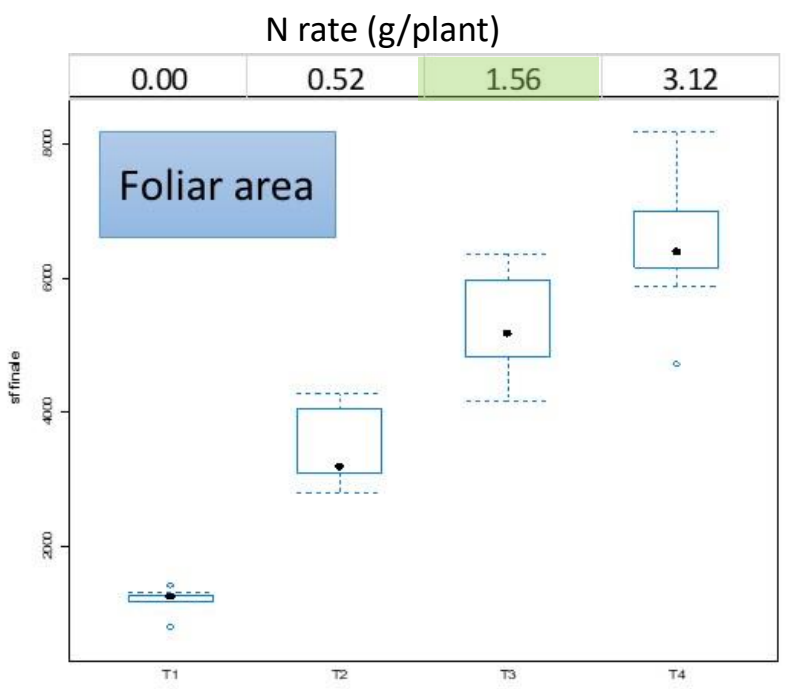
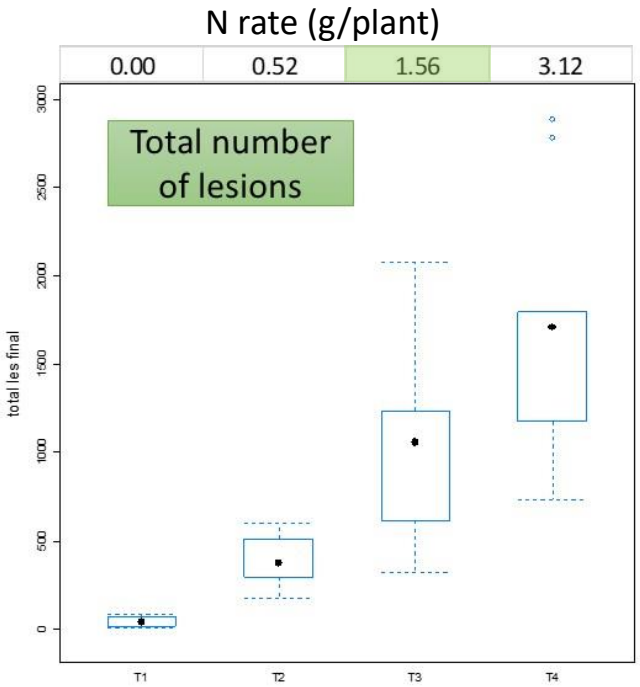
Black Leaf Streak Disease

6. Other levers that need to be further explored

- Plant nutrition





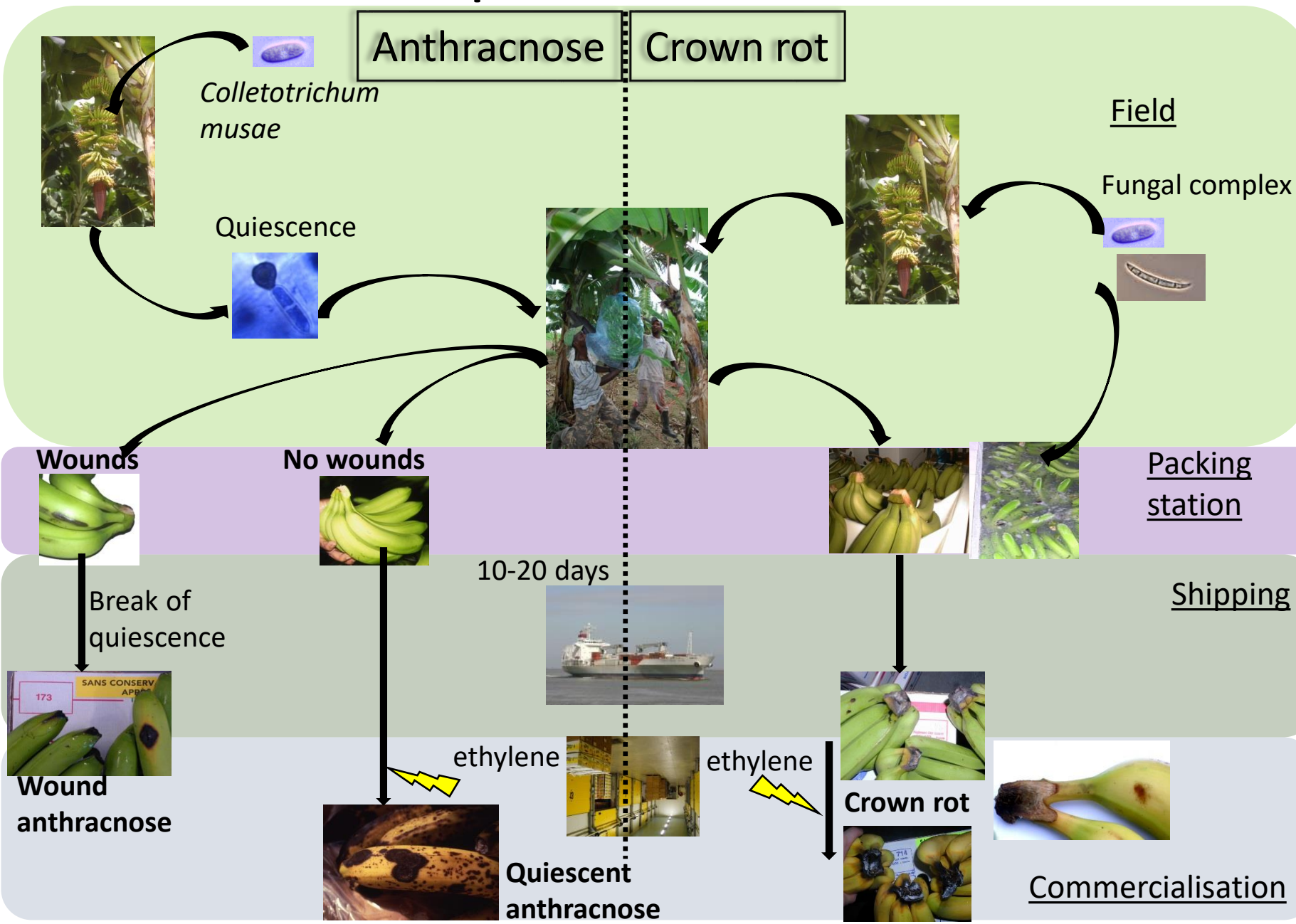
Probably a trade off between plant growth and BLSD development : **an optimum should be found**

Example 2.
Postharvest diseases control in organic farms

Crown rot

Anthracnose

Various postharvest diseases



Postharvest diseases control in organic farms

❖ Synthesis of effective levers

Location	Biological contol	Natural substances	Agricultural practices (pre-harvest)	Agricultural practices (post-harvest)
Ideal place: * dry area and low temperatures (highland) Reduce fruit susceptibility ++	**Should be better explored** Nexy(yeast) +/-	**Should be better explored** * citric acid +	Prophyllaxy : *** Floral remnants + bracts removal** *** Bunch bagging** Reduce fruit infection with C. musae ++++	Prophyllaxy : *** Bunch washing** *** Packing station cleaning** *** Water quality** Reduce crown contamination +++
		Plant extracts +/-	Harvest stage Reduce fruit susceptibility ++	Fruit conservation *** Cooling** *** Modified or controlled atmosphere** +++
			Fruit pruning Reduce fruit susceptibility to CR when NLH is low +	

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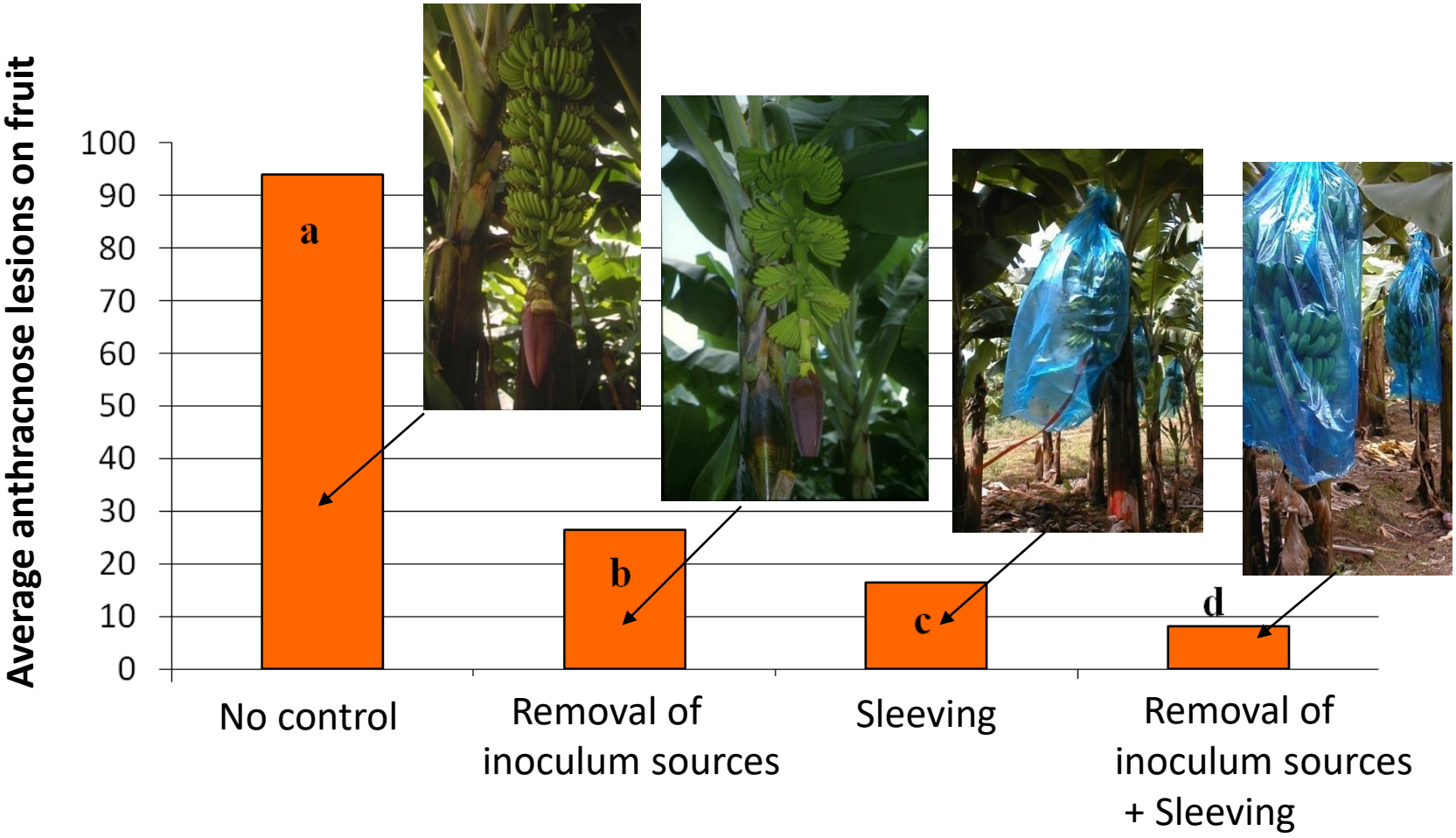
Postharvest diseases control

Effect of removal of inoculum sources and sleeving et on Colletotrichum musae fruit contamination scored at harvest

(Fromde Lapeyre *et al*., Plant Pathology, 2000)



Conclusion…..

- No unique solution (silver bullet) for pest and disease control but an integrated more complex combination of levers
- Organic banana extension to rainy areas relies on new varieties resistant to BLSD
- Future of organic farming is undoubtdely towards a diversification of farms and intercropping with trees

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Thank you for your attention

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