What variety for sustainable banana cropping systems: Cavendish cultivars or Black Sigatoka resistant hybrids?

Management of banana functional traits

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Current banana cropping systems for exportation are based on Cavendish bananas:
- sturdy
- high productivity
- susceptible to Sigatoka diseases
- high nutrients and water requirements
=> intense use of fertilizers and pesticides

In the French Antilles, the current cropping systems exhibit a good profitability in the context of the European market (subsidy system) and a relative economic stability
The sustainability of these systems is threatened by:

. the effects of chemical inputs on the environment

. the hard working conditions in banana plantations (climbing ladder for bunch care, carrying of heavy bunches, fungicide spraying,...)
Innovative cropping systems are needed

These systems must enable to

. Decrease chemicals inputs use

. Maintain profitability (maintain yield, fruit quality and selling price)

. Suppress hard working conditions (limitation of banana height, worker exposition to pesticides,...)
Request to banana breeding programs to improve banana cropping systems sustainability

Banana ideotype

. Resistant / tolerant to pest and disease
. Big bunch
. short production cycle
. short and sturdy stem
. low water and nutrients requirement
. ......
Conventional banana breeding programs fail to provide this ideal banana

These programs rely on hybridization of wild fertile bananas

Wild bananas:

⇒ good resistance or tolerance to pests and diseases

⇒ No domestication, no selection pressure on productivity, fruit quality and plant morphology

⇒ Ideotype = Letter to Santa Klaus ?
In an agro-ecological approach, the objective is not to propose new varieties but more sustainable cropping systems including (or not) new varieties

Questions:

. Can unfavorable plant traits be modified with suitable cultural practices?

. How to manage trade-off between favorable and unfavorable plant traits to improve banana cropping system sustainability?
Banana functional traits

Functional traits linked to the sustainability of the cropping system:

. Sigatoka diseases resistance

. Nematode susceptibility (multiplication rate)

. Yield components
  Bunch weight
  Cycle duration (Interval harvest n – harvest n+1)

. Fruit functional quality
  Fruit size
  Susceptibility to biotic and abiotic stress

. Plant morphology
  Plant height
  Plant robustness (Girth /Height)
Trait score
0 unfavorable ======> 10 favorable

Banana functional profile
Management of unfavorable plant traits through suitable cultural practices

Cavendish unfavorable plant traits

. Susceptibility to Sigatoka diseases and to nematodes

. Long production cycle

![Graph showing yield elaboration strategy]

Yield elaboration strategy: big bunch – long production cycle

\[ y = 0.0957x + 2.6478 \]

\[ R^2 = 0.2495 \]
Cultural practices to manage Cavendish unfavorable traits:

- **Deleafing** limit the detrimental effect of BSLD on fruit quality (Chillet et al, 2013)

- **Plantation of vitroplants after sanitation fallow** enable to control nematodes populations (Risède et al, 2010)

- **Early sucker selection** decrease cycle duration (Lassoudière, 2007)
CIRAD 925 unfavorable plant traits

. Plant height and plant robustness
Tall banana with thin pseudo-stem

. Bunch weight
Low bunch weight
(Effect on yield balanced by short production cycle)

. Fruit quality
fruit size
susceptibility abiotic stress
How to manipulate unfavorable CIRAD 925 traits?

=> Through the management of parent plant/sucker competition

**Total sucker pruning and late follower selection** decrease competition for light and photo-assimilate between parent plant and sucker
Effects of total pruning and late follower selection  
(from the cycle 2)

- fruit size
- bunch weight  
  Increase in fruit size offset by decrease in fruit number  
  (first cycle excepted)
- plant height
- plant robustness  
  (slight increase)

=> Enable to manipulate unfavorable plants traits
Cultural practices implemented to manage unfavorable plant traits may affect other plant traits linked to cropping system performances

- **Deleafing** => reduce bunch weight => reduce yield (de Lapeyre et al., 2010)

- **Total sucker pruning** => increase cycle duration => reduce yield (Dorel et al, 2016)

**Trade-offs have to be made when designing sustainable cropping systems**
System based on Cavendish cultivars
Sustainability concerns mainly linked to biotic stress management (soil parasites, BSLD) avoiding pesticides use

**Key-components of sustainable cropping system**

. Periodic replantation after sanitation fallow (soil parasites control)

. Sanitary deleafing (Sigatoka diseases control)
  
  Selection of cultivars with good tolerance to deleafing (High ratio Leaf area / bunch weight)
Design of sustainable cropping systems prototypes according to banana functional traits

**System based on CIRAD 925**
Sustainability concerns mainly linked to plant height (difficult working conditions) and fruit quality (fruit acceptability on export market)

**Key-components of the cropping system**

- Adapted sucker management (improve plant morphology and fruit quality)
Assessment of cropping system sustainability

Criteria and indicators for cropping system sustainability evaluation

Performances of innovative cropping system can be evaluated through a set of indicators taking into account the different components of sustainability:

- **Profitability**
  - Yield
  - Production cost
  - Fruit quality

- **Environment**
  - Pesticide use

- **Technical feasibility and social acceptability**
  - Working conditions
  - Plantation longevity
Cropping system score

Unfavorable 0 =======> 10  Favorable

Indicators of sustainability

- Crop Syst Cavendish
- Crop Syst 925
The global evaluation of the cropping system depends on:

. the threshold value required for each indicator

. the weight attributed to each indicator in a global evaluation

=> These parameters vary according to the production context
Production cost
High production cost can be balanced by a grant system if environment friendly cropping systems are implemented (ultra-peripherical European areas).

Fruit quality
Small or delicate fruit can be accepted in some niche markets (school cafeteria, institutional catering,…) or with adapted packaging.
Pesticide use

Environment impact of pesticide can be very acute in small and densely populated islands, less a concern in large and sparsely populated countries.
Working conditions
Access to mechanization and technology can improve working conditions (bunch care, harvest,...)
. Plantation longevity
The effects of plantation longevity on cropping system performance may vary with the topography or the soil suitability for mechanization
Conclusion

The selection of Cavendish cultivars or of the hybrid resistant to Sigatoka diseases CIRAD 925 for sustainable cropping system design depends on the production context:

. With low Sigatoka diseases pressure and good efficiency of fungicides, Cavendish can still be preferred to CIRAD 925. This tendency could be inverted in case of increase with time of black Sigatoka pressure and decrease of fungicide efficiency.

. In countries with low labor cost and difficult access to pesticides, CIRAD 925 could be preferred to Cavendish.
Thank you for your attention