PRACTICE PERFORMANCES & RESULTS

Pest and disease control with limited recourse to synthetic pesticides and enhanced use of biocontrol

François Lecompte (INRAE), Soukaina EL Mrini (INRA Maroc), Ahlam Hamim (INRA Maroc), Sophie Bomel (INRAE), Douae Lamrahli (Messem), Hicham Essrifi (Messem), Ahmed Taleb (Danone), Aziz Didicheikh (GIZ)

01.01.2018 to 31.12.2020

Supported by:
Objectives

1. Collect data on pesticide use on strawberry field crops in 4 partner farms (Morocco);

2. Propose strategies to reduce pesticide use while maintaining good health of crops;

3. Test reduction strategies in 5 farm labs in the area of Gharb-Loukkos. → Objective not fully achieved
Summary of pesticide use in 4 partner farms

• **Treatment Frequency Index (TFI) calculation** → Issues on this calculation

TFI’s plot = \( \sum \frac{\text{Applied dose}}{\text{Registered dose}} \times \frac{\text{Treated surface}}{\text{Plot surface}} \) = Number of treatments on the plot

As Applied dose = Registered dose and Treated surface = Plot surface

Sanitary pressure and nature of pests are not the same during the growing season

• **Data collection** (2017-2018):

<table>
<thead>
<tr>
<th>Farm</th>
<th>TFI</th>
<th>Season (weeks)</th>
<th>TFI/weeks</th>
<th>Powdery Mildew</th>
<th>Grey Mould</th>
<th>Aphids</th>
<th>Mites</th>
<th>Noctuids</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>22</td>
<td>17</td>
<td>1,29</td>
<td>12</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>P2</td>
<td>12</td>
<td>17</td>
<td>0,71</td>
<td>6</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>7</td>
<td>31</td>
<td>0,22</td>
<td>4</td>
<td></td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>P4</td>
<td>13</td>
<td>33</td>
<td>0,39</td>
<td>8</td>
<td></td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

• The **specifications were scrupulously respected**: registered dose; authorized products on export markets; alternation of active ingredients
## Strategies to reduce pesticide use while maintaining good health of crops

**Protocol**: Preventive strategy with **prophylaxis** (pest and disease outbreak checks, infested parts removed, etc.) and **biocontrol** (biological control agents, biocontrol products and defense inducers). **Reduce synthetic pesticides use** in prevention of diseases.

<table>
<thead>
<tr>
<th>Pest and disease</th>
<th>Prevention</th>
<th>Identified risks</th>
<th>Proven severe infestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powdery Mildew</td>
<td>Sulfur, Essential oil, Potassium carbonate</td>
<td>Translaminar pesticide (Cyflufenamid)</td>
<td>Systemic fungicide (Azoxystrobin + Difenoconazol)</td>
</tr>
<tr>
<td>Grey mould</td>
<td>Essential oil, Biocontrol <em>(Bacillus subtilis, Pythium oligandrum)</em></td>
<td>Contact pesticide (Fenhexamid)</td>
<td>Systemic fungicide (Cyprodinil + Fludioxonil)</td>
</tr>
<tr>
<td>Aphids</td>
<td>Biocontrol <em>(Aphidius colemani)</em></td>
<td>Biocontrol (Maltodextrin, Pyrethrum)</td>
<td>Systemic insecticide (Pirimicarb, Cyantraniliprole)</td>
</tr>
<tr>
<td>Mites</td>
<td>Biocontrol <em>(Phytoseilus persimilis)</em></td>
<td>Biocontrol (Maltodextrin, Pyrethrum)</td>
<td>Systemic insecticide (Bifenazate)</td>
</tr>
<tr>
<td>Thrips</td>
<td>Biocontrol <em>(Orius laevigatus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noctuids</td>
<td>Biocontrol <em>(Bacillus thuringiensis)</em></td>
<td>Biocontrol (Bacillus thuringiensis)</td>
<td>Systemic pesticide (Emamectin benzoate)</td>
</tr>
</tbody>
</table>
Experiment 2019 - 2020

- Several issues (time for implementation combining with irrigation and fertilization protocol implementations, coordination with growers)
  Data collection: **October (plantation) 2019-March 2020**
  Protocol implementation (experimental plot = “exp.”): **January-March 2020**
- Partial TFI 2019-2020 (farm plot vs experimental plot):

<table>
<thead>
<tr>
<th>Farm</th>
<th>October-March = total</th>
<th>Plantation-December</th>
<th>January-March</th>
<th>October-March=total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TFI total « farm »</td>
<td>TFI/week « farm »</td>
<td>TFI « farm »</td>
<td>TFI « exp.»</td>
</tr>
<tr>
<td>P1</td>
<td>16</td>
<td>0,84</td>
<td>13</td>
<td>-</td>
</tr>
<tr>
<td>P2</td>
<td>14</td>
<td>0,58</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>P3</td>
<td>14</td>
<td>0,58</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>P4</td>
<td>15</td>
<td>0,63</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>P5</td>
<td>9</td>
<td>0,41</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

- No major damage observed during the first weeks of harvest → results need to be consolidated
Perspectives

- Substantial TFI observed → reductions are possible
- **Consider the implementation of IPM strategies**: prophylaxis, effective treatment equipment, use of biocontrol products instead of synthetic pesticides and avoid making preventive fungicide sprays.
- **Develop international scientific collaboration** on IPM strategies for the reduction of pesticide use in strawberry production basins.
Innovative strategies for the control of grey mould on strawberry leaves

P. Nicot, J.F. Bourgeay, F. Lecompte, M. Bardin - INRAE
History of experiments and selection of practice

- **Background**: reduced N fertilization decreases leaf susceptibility to *Botrytis cinerea* and impacts the efficacy of biocontrol agents


- **Varietal effect and possible negative impact** of continuously reduced N nutrition on fruit yield?

- **How early** can the beneficial effect of reduced N against grey mould be expressed? (avoid yield losses) => kinetic studies to target transient beneficial effects

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Onset of differentiated nutritional treatments

“starvation”: 0.5 mmol NO$_3^-$

“1/2 reduced”: 5 mmol NO$_3^-$

“normal”: 10 mmol NO$_3^-$

Strawberry growth with uniform N fertilization

S0

S1
  Week 1

S2
  Week 2

Apply biocontrol agent

S3
  Week 3

S4
  Week 4

Inoculation on leaves, lesions measured 96h after inoculation, without biocontrol

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Friendly Fruit Project – Annual and Final Project Meeting 01-02 December 2020
Description of the practice selected for the leaflet

What?
Decrease leaf susceptibility to the agent of grey mould *Botrytis cinerea* by **transient reductions of nitrogen supply** and release of biocontrol agents.

Why?
To control an important fungal disease of strawberry with little or no recourse of fungicides.

Status?
Validated experimentation requiring additional farm trials
Main steps to implement this practice

**Implementation**
 Reduce N supply for 2-3 weeks
 Complement with the application of a biocontrol agent

**Conditions of use:**
 No extra time for the modification of the nutrient solution
 For the application of biocontrol agent, one or several sprays (ca 2.5 hours/ha).

**Interactions:**
 Possible synergy with genetic resistance and defense inducers (not evaluated).
Expected Key result / Message to take home

- Reduced disease severity with low N supply
  - starting 1-2 weeks after onset of N stravation (-20%)
  - ≈ -40% after 3-4 weeks
  - for 2 strawberry varieties
  - for 2 strains of *B. cinerea*

- Useful effect of biocontrol agent at high and half-reduced N level for one variety

**Transient N reductions and applications of a biocontrol agent limit the severity of grey mould infections.**
Practice Performances

**AGRONOMY & ENVIRONMENT**

- **Pesticide reduction** effect not known yet.

- **Reduction of nitrogen use** (mitigation of eutrophication and/or GHG emission).

- Potentially **no effect** on yield and fruit quality.

- **Possible positive or negative effects on post harvest diseases** and potential reduction of fungicides but to be tested in real production conditions.

**Costs & benefits**

- No specific investment required.

- **No extra time required** for setting-up of the practice.

- **Little time needed** for management of the composition of nutrient solutions.

- **Decreased costs** for N fertilizers.

- **Additional costs** for the purchase of the biocontrol product and extra time needed to spray.

**OPERATIONALITY**

- **Ease to implement**
  - The practice would require a training course to be implemented

- **Ready to use**
  - Additional information on farm trials is required before implementation

- **Investment cost**
  - N/A

- **Time to set-up**
  - Time to manage

- **Fruit production**

**Positive outcome**

**Neutral to positive outcome**

**Areas of improvement**

**Critical points**

---

Friendly Fruit Project – Annual and Final Project Meeting 01-02 December 2020
Roadmap for transfer – Next steps

Communication through professional channels (technical institutes and farms advisors)

This practice, validated in experimental conditions will require additional farm trials

Of particular interest would be an assessment of the practice (in experimental or farm conditions) on possible beneficial effects on

• flower protection against infection by airborne inoculum
• postharvest quality
Optimization of the mineral nutrition of strawberry crop: Monitoring using a theoretical fertilization schedule and soil bioavailability tests

François Lecompte (INRAE), Soukaina EL Mrini (INRA Maroc), Ahlam Hamim (INRA Maroc), Sophie Bomel (INRAE), Douae Lamrahli (Messem), Hicham Essrifi (Messem), Ahmed Taleb (Danone), Aziz Didicheikh (GIZ)

01.01.2018 to 31.12.2020

Supported by:

Climate-KIC is supported by the EIT, a body of the European Union
History of the experiment and selection of practice

• **Context**
To meet the environmental challenges caused by the leaching of fertilizers into the environment, fertilization management is the key tool for farmers to reduce their consumption of inputs.

• **Method**
Monitoring of soil and plant status and adjustment of fertilizer inputs by moving from a static fertilization program to a new one based on data on soil and plant status.

The experiment was conducted in 5 farm-labs in the area of the Gharb-Loukkos in Morocco and lasted for first 6 months of the growing season 2019-2020.
Practice description

What?
Monitor the fertilization of strawberry crop based on a theoretical fertilization schedule, a P and K test at the beginning of the season and N tests during the cycle.

Why?
To preserve nutrient resources and limit losses to the environment and pollution by adapting inputs to the crop's needs while maintaining yield levels.

Status?
Ready to use
Main steps

1. Create a theoretical fertilization schedule (N, P, K) based on the expected biomass and nutrient levels.

2. Obtain a maximum quantity to be provided per element which is fractionated into theoretical doses according to the development kinetics of the crop.

3. These theoretical doses are adjusted according to an initial test for P and K, and during the cycle for nitrogen using a portable reflectometer (Nitrachek®).

<table>
<thead>
<tr>
<th>Nitrate concentration in soil solution (mg/l)</th>
<th>Multiplying coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 100</td>
<td>1.5</td>
</tr>
<tr>
<td>100-150</td>
<td>1</td>
</tr>
<tr>
<td>150-200</td>
<td>0.8</td>
</tr>
<tr>
<td>C &gt; 200</td>
<td>0.5</td>
</tr>
</tbody>
</table>
Key results

<table>
<thead>
<tr>
<th>Values over 6 months</th>
<th>Low inputs (kg/ha)</th>
<th>Farmer (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>54.2 ± 5.2</td>
<td>127.1 ± 8.1</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>5.7 ± 0.3</td>
<td>63.3 ± 14.8</td>
</tr>
<tr>
<td>Potassium</td>
<td>108.4 ± 5.7</td>
<td>135.2 ± 8.3</td>
</tr>
<tr>
<td>Marketable yield (g/plant)</td>
<td>379 ± 63</td>
<td>392 ± 63</td>
</tr>
</tbody>
</table>

Average significant reduction of 88% for Phosphorus and 54% for Nitrogen over the first 6 months of the crop season.

Monitoring with the help of theoretical fertilization planning and bioavailability tests makes it possible to reduce fertilizer consumption, maintain yield and limit environmental pollution.
Practice Performances

**AGRONOMY & ENVIRONMENT**

- **Pesticide reduction** has not been studied.
- **Reduction** in the use of N & P (less GHGs) and energy related to the pump injecting the fertilizers.
- **No loss of yield** but result to be consolidated.
- **Reduction** in the consumption of fertilizers, and potentially their loss in the environment.

**COSTS & BENEFITS**

- **Investment cost**: Low investment cost and quickly amortized.
- **Time to set-up**: Time required to set up the schedule is low.
- **Time to manage**: Time required for monitoring is low and distributed over the production period.
- **Reduction of costs related to fertilizers.**

**HUMAN ASPECTS & FEASIBILITY**

- **Ease to implement**: A well-known alternative practice that has already proven successful.
The alternative practice is efficient and ready to implement

- **Leaflet** (overall method and results)
- **Short report** (detailed method and results) to be distributed to the 5 farmers
- **Short training session** for the technical consulting staff
- **Berry school event** (Morocco)
Thank you for your attention!

François Lecompte (INRAE), Soukaina EL Mrini (INRA Maroc), Ahlam Hamim (INRA Maroc), Sophie Bomel (INRAE), Douae Lamrahli (Messem), Hicham Essrifi (Messem), Ahmed Taleb (Danone), Aziz Didicheikh(GIZ)

01.01.2018 to 31.12.2020

Supported by:

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PRACTICES PERFORMANCES & RESULTS

Pesticides reduction on strawberry field with the development of a new sprayer

Sébastien Cavaignac - Invenio

01.01.2018 to 31.12.2020

Supported by:

Climate-KIC is supported by the EIT, a body of the European Union
History of experiments and selection of practice

<write a short overview of the experiments that have been tested since the start of the project AND why this particular practice/experiment was retained as the most promising in terms of results and future transfer>

The sprayer that we developed have a treatment module with a protection box to avoid the treatment deviation and to protect the user. An impeller on the top and an air release allows a shuffling of leaves.

Nozzles are on the top and on the sides for an homogen and good application.
Description of the practice selected for the leaflet

<table>
<thead>
<tr>
<th>What?</th>
<th>Developing a sprayer adapted to strawberry production which only sprays the necessary amount of product by mixing air with the product during the treatment.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Why?</td>
<td>Improving treatment efficiency, reducing phytopharmaceutical product quantity and reducing risks for the user.</td>
</tr>
<tr>
<td>Status?</td>
<td>Promising but needs further research</td>
</tr>
</tbody>
</table>
Main steps to implement this practice

1- The user of the sprayer needs:
   • The first possibility is to use a towed device with a traditional attachment.
   • The second possibility is to use an independent motorisation which allows to work in autonomy (robotisation) or by electric control.

2- Same intervention date, same products for control and for new sprayer but with less volume for new sprayer

Condition of use: the practice is suitable for strawberry fields, as a substitute to classical treatment machine.
Expected Key result / Message to take home

• With new sprayer:
  - No difference on insect pest and disease protection (same percent of plants with aphids)
  - Spraying of pesticides is more homogen on the old and young leaves, on the floral scape and on the heart with the new sprayer.
  - With the same products concentration, reduction of 60% spray volume and active compound.
  - Same yield
Practice Performances

**Agronomy & Environment**

60% pesticides reduction.

No change of the fertilizer amount and the energy used.

Same yield.

Diminution of the impact of pesticides on the environment and of residue on fruits with a diminution of spray volume and active compound.

**Costs & Benefits**

Low cost and auto-construction possible.

Little time for implementation.

Little for using.

Valorisation of production with a diminution of pesticides impact on the environment and on the user and diminution of input costs (water and pesticides).

**Operationality**

The practice is easy to use and it allows a better protection for the user but needs to test in farm.
Roadmap for transfer—Next steps

<p><em>please describe how the practice can/ will be transferred to growers after the end of Friendly Fruit</em></p>

- Apply for a « Enveloppe soleau » and if it is relevant for a patent
- Apply for « innovation competitions » in order to promote the solution
- Validate Friendly Fruit results and try to optimize pesticide use (until which level is it possible to decrease? are the results depending on the products or pest?)
- Once validated, in partnership with INRAE, transfer to the producers
  - either directly (plan for self-construction)
  - or via agro equipment manufacturer
Biocontrol on apple for primary scab

Anne Duval-Chaboussou, CTIFL
Antony Leblois, La Morinière
Claude Coureau, CTIFL

01.01.2018 to 31.12.2020

Supported by:
Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union
### History of experiments and selection of practice

List of Biocontrol tested on primary scab:

<table>
<thead>
<tr>
<th>Year</th>
<th>Active substance</th>
<th>Commercial name</th>
<th>Mode of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Phosphonate de potassium</td>
<td>Soriale® 1,86 L/ha</td>
<td>Fungicide + Elicitor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soriale® 4 L/ha</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>Essentiel oil Basic substances</td>
<td>Medinbio Several products</td>
<td>Fungicide + Elicitor</td>
</tr>
<tr>
<td></td>
<td>Cerevisiané</td>
<td>Romeo®</td>
<td>Elicitor</td>
</tr>
<tr>
<td>2020</td>
<td>Cerevisiané</td>
<td>Romeo®</td>
<td>Elicitor</td>
</tr>
<tr>
<td></td>
<td>Sulfuric clay + horsetail extract</td>
<td>Myco-Sin®</td>
<td>Fungicide</td>
</tr>
</tbody>
</table>
What? Alternative substances applied as preventive or curative control on primary scab, Rule to applied: scab modelisation "RIMpro model" and level of risk

Why? Control primary scab contamination

Status? Substances not registrated for scab control (registration on other species or use, basic substances or essential oil, physical barrier)
Main steps to implement this practice

Follow risk forecast on a scab model and decide to spray

Scab contamination (model)

Day of the view

Scab contamination risk with weather forecast
## Synthesis of results

<table>
<thead>
<tr>
<th>Year</th>
<th>Active substance</th>
<th>efficiency</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Phosphonate de potassium</td>
<td>0 (1,86 L/ha)</td>
<td>Registrade to 1,86 L/ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td>++ (4 L/ha)</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>Essentiel oil Basic substances</td>
<td>++</td>
<td>Expensive (X3 normal price)</td>
</tr>
<tr>
<td></td>
<td>Cerevisiane</td>
<td>0</td>
<td>No efficiency</td>
</tr>
<tr>
<td>2020</td>
<td>Cerevisiane</td>
<td>0</td>
<td>No efficiency</td>
</tr>
<tr>
<td></td>
<td>Sulfuric clay + horsetail extract</td>
<td>+++</td>
<td>Same as Copper</td>
</tr>
</tbody>
</table>
Result with Myco-Sin®

% of scab on shoots

Same efficiency than Copper in preventive scab control + addition of sulfur
Practice Performances

Sulfur Clay + Horsetail extract (Myco-Sin®)
Very easy if it is registered

 высоко ожидания от культиваторов
много активных веществ удалены
Biocontrol on apple for fungal diseases in storage

Christine Tessier, La Morinière
Claude Coureau, CTIFL

01.01.2018 to 31.12.2020

Supported by:
List of Biocontrol tested on *gloeosporium*:

<table>
<thead>
<tr>
<th>Year</th>
<th>Active substance</th>
<th>Commercial name</th>
<th>Mode of action</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Phosphonate de potassium</td>
<td>Soriale® 1,86 L/ha</td>
<td>Fungicide + Elicitor</td>
</tr>
<tr>
<td></td>
<td>Yeast extract</td>
<td>JDE01</td>
<td>Elicitor</td>
</tr>
<tr>
<td></td>
<td>Cerevisiane (yeast)</td>
<td>Romeo®</td>
<td>Elicitor</td>
</tr>
<tr>
<td>2019</td>
<td>Essentiel oil Basic substances</td>
<td>Medinbio HPRO à 40 L/ha Khi² à 5 L/ha</td>
<td>Fungicide + Elicitor</td>
</tr>
<tr>
<td></td>
<td>Cerevisiane</td>
<td>Romeo®</td>
<td>Elicitor</td>
</tr>
<tr>
<td>2020</td>
<td>Calcium polysulfur</td>
<td>Curatio®</td>
<td>Fungicide</td>
</tr>
<tr>
<td></td>
<td>Calcium Polysulfur</td>
<td>Curatio®</td>
<td>Fungicide</td>
</tr>
</tbody>
</table>
What? Alternative substances applied as preventive or curative control on storage diseases, Rule to applied: before or after a rain, 6 weeks before harvest, repeat each 20 mm.

Why? Control *Gloeosporium* (most *Neofabraea Alba*)

Status? Substances not registrated for preharvest (registration on other species or use, basic substances or essential oil, physical barrier)
Main steps to implement this practice

Follow rain 6 weeks before harvest, prevent treatment (try curative too for Myco-Sin®)
# Synthesis of results

<table>
<thead>
<tr>
<th>Year</th>
<th>Active substance</th>
<th>Efficiency</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Phosphonate de potassium</td>
<td>+</td>
<td>Works at the beginning of storage (3 months)</td>
</tr>
<tr>
<td></td>
<td>Yeast extract (JDE1)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cerevisiane (yeast)</td>
<td>+</td>
<td>Works at the beginning of storage (3 months)</td>
</tr>
<tr>
<td>2019</td>
<td>Essentiel oil</td>
<td>0</td>
<td>A lot of rain in 2019, hard to have a good protection (more than of 40 mm between two spray)</td>
</tr>
<tr>
<td></td>
<td>Basic substances</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cerevisiane</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>Calcium polysulfur</td>
<td>In storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Calcium Polysulfur</td>
<td>In storage</td>
<td></td>
</tr>
</tbody>
</table>
Result 2018

Less efficiency than the chemical reference

% *Gloeosporium* the 4 March
Practice Performances

Sorale®
Roadmap for transfer– Next steps

Very easy if it is registered and efficient

❖ high expectation from growers to be free residue at harvest

❖ No registered products in organic