Model-based design of integrated horticultural systems: contributions using multiobjective optimization methods

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Plan

• Introduction
• The developed model
• The optimization problem
• The proposed approach
• Results
• Conclusion and prospects
Introduction

The Integrated Fruit Production:

- economical requirements
- Organoleptic and health quality of fruits
- environment preservation:
  
  Reduce the use of pesticides

Adaptation of production processes to improve crop quality and environment safety:

- Rational chemical control
- Integration of alternative methods
The developed model

- Pruning
- N Fertilization

Stem
- Rosettes growth
- Growing Shoots growth

Leaf area of the tree

Fruit growth

N° fruits

Thinning

N° shoots

% growing shoots

max growth of shoots

Intrinsic rate of pop increase

Intra-specific competition coef

Fall and damages

Aphids’ growth

emigration

mortality

predation

Ladybird release

quality (RI)

Fruit growth

N° fruits

Insecticides

emigration

mortality

predation

Ladybird release
The optimization problem

• **Decision variables**
  - ✓ Pruning
  - ✓ Nitrogen supply
  - ✓ Pesticides characteristics
  - ✓ Winter oil characteristics
  - ✓ Released ladybirds number

• **Criteria**
  - ✓ Fresh mass
  - ✓ Yield
  - ✓ Refractometric index
  - ✓ Selling price
  - ✓ Total quantity of ladybird instars released
  - ✓ Number of insecticide applications
  - ✓ Total number of aphids
  - ✓ Number of growing shoots per tree
  - ✓ Proportion of growing shoots > 30cm
The proposed approach

The proposed approach involves a series of steps: initialization, evaluation, selection, reproduction, and stopping. The evaluation step is highlighted, indicating the choice of individuals and the evaluation of their fitness. The evaluation module aggregates criteria according to the decision-maker's preferences.

Features considered in the evaluation include:
- Pruning intensity
- Nitrogen supply (g/100g)
- Initial decay rate of the winter oil (day⁻¹)
- Initial mortality rate of bloom insecticide (day⁻¹)
- Initial mortality of season insecticide (day⁻¹)
- Decay rate of insecticides (day⁻¹)
- Effectiveness duration (day)
- Number of ladybirds larvae by mean shoot

The model of peach-green aphid-ladybird interactions is shown, with criteria such as 'Bad' and 'Good' and the parameter ranges inf and sup.
The proposed approach

<table>
<thead>
<tr>
<th>Season</th>
<th>first  « No treatment »</th>
<th>second  « Conventional »</th>
<th>third  « Organic* »</th>
<th>fourth  « Integrated »</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Full bloom</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Winter</td>
<td>×</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

The table below shows the values for the proposed approach:

<table>
<thead>
<tr>
<th></th>
<th>Mfr</th>
<th>Yield</th>
<th>SP</th>
<th>RI</th>
<th>nGS</th>
<th>pGS30</th>
<th>INS</th>
<th>TotN_LA</th>
<th>TotN_APH</th>
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</thead>
<tbody>
<tr>
<td>PR_ECO</td>
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<td>2</td>
<td>3</td>
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<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ENV_ECO</td>
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<td>2</td>
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<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Results
Results

![Diagram showing productive-durable relationship with labels for ANIT, CONV, BOL, and INTG]
Results

Productive-durable

- ANIT
- CONV
- BDL
- INTG

\[ p\text{GS30} \]

SP

INS
Results
Results
Conclusion & perspectives

• An evolutionary algorithm to design technical scenarios for integrated fruit production
• Exploring a wide search space and identifying potentially interesting and feasible solutions

• Reformulate the optimization problem
• Design and test new protection strategies
• Develop a non-aggregative approach based on the concept of Pareto dominance.
• Compare theses two approaches
Thank you for your attention!