Friendly Fruit

PRACTICES PERFORMANCES & RESULTS

Optimization of the mineral nutrition of strawberry crops: 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), Douaé Lamrahli (Messem), Hicham Essrifi (Messem), Ahmed Taleb (Danone), Aziz Didicheikh(GIZ)

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

History of experiments 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 producers 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 program 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 field crops 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 performance 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 culture.
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®).

Nitrate concentration in soil solution (mg/l)	Multiplying coefficient
< 100	1,5
100-150	1
150-200	0.8
C > 200	0.5

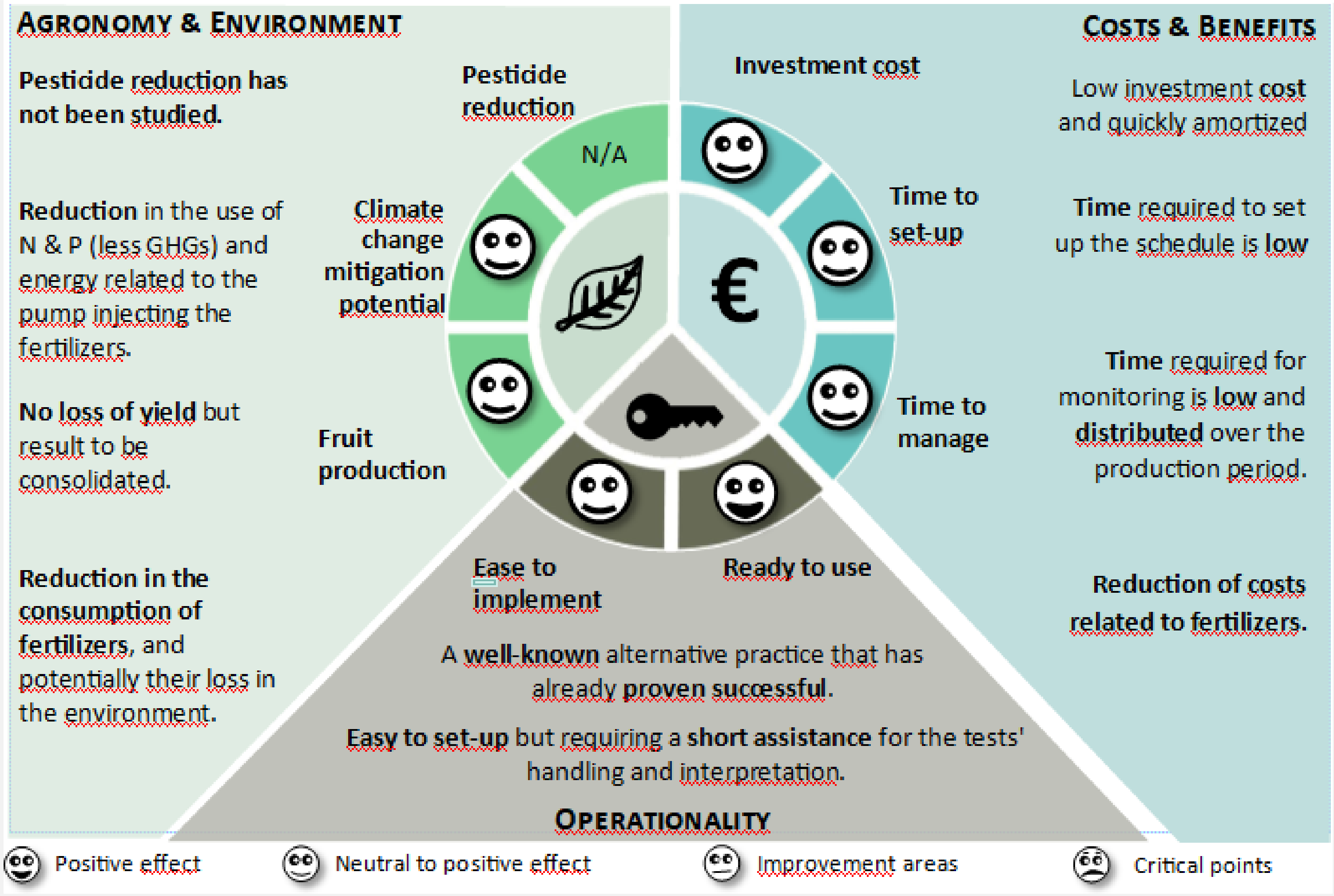
Key results

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

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



Dissemination

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)

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PRACTICES PERFORMANCES & RESULTS

Mechanical weeding on young apple orchard

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

CTIFL SCIENCES & INNOVATION

La Morinière Station d'expérimentations

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

What ? Foliar and residual weed chemical killer compare to mechanical weeding on young orchard

Why ? Europe 2022 End of glyphosate?
Less and less chemical weed killer
End of chemical weeding killer?

More difficult on young orchard: root and trunk sensitivity (nectria canker), competitiveness with weeds

Status ? Mechanical tools for weeding:

- A lot of different tools
- Expensive in invest (availability of tools)
- Expensive in operate (labour, gasoil, maintenance)
- Have a good worker
- Carbon footprint 👎

Herbanet®

Ladurner®

History of experiments and selection of practice

Objective

Compare chemical weeding to mecanical weeding on young plantation, with or without over fertilization.

Material

Variety : Y101 (new variety) on Emla

Plantation 2017

Density : 1 x 3,5 m

Training : axis

Irrigation : Drop 1 L/h

Methods

Modality / Year	2018	2019	2020
Chemical weeding – T0	X	X	X
Mecanical weeding – T1	X	X	X
Mecanical weeding + over fertilization – T2		X	X

Main steps to implement this practice

Chemical weeding

	Date	Chemical	Dose (L/ha)
1ère leaf	20/04/2018	Glyphosate (300 g/L)	1,06
	23/05/2018	Glyphosate (300 g/L)	1,06
		2.4 D (600 g/L)	0,53
	13/06/2018	Glufosinate (150 g/L)	1,66
	13/07/2018	Glufosinate (150 g/L)	1,66
	02/08/2018	Glufosinate (150 g/L)	1,66
2ème leaf	25/03/2019	Glyphosate (486 g/L)	4
		Isoxaben (107 g/L)	4,8
		Napropamide (450 g/L)	5,2
	20/05/2019	Glyphosate (486 g/L)	1,5
	04/07/2019	Glyphosate (486 g/L)	1,5

Mecanical weeding

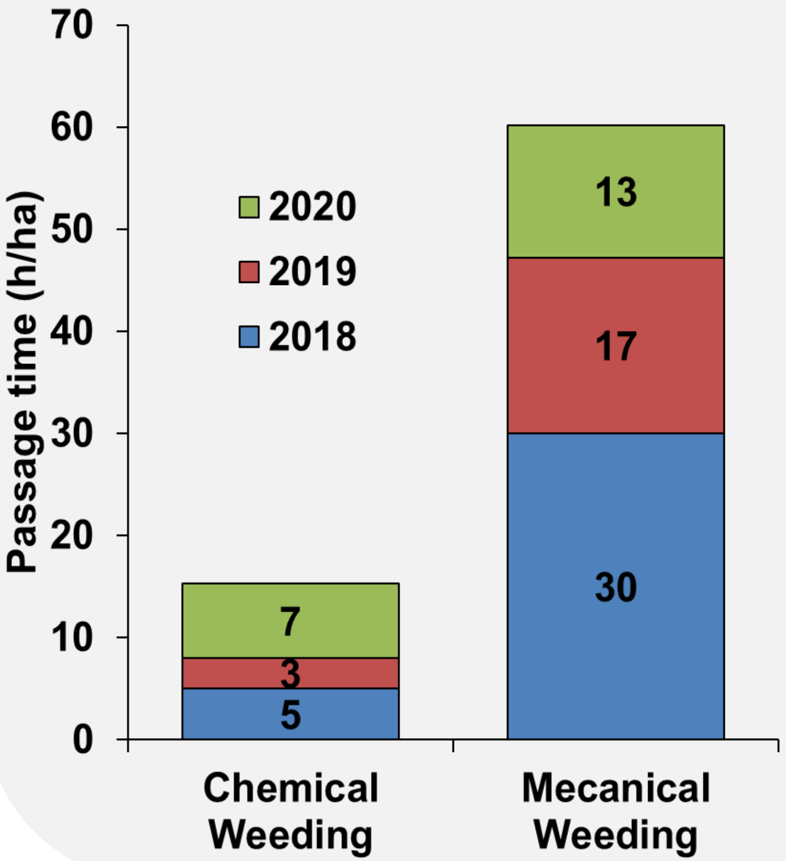
Date	Tool	Brand	Speed (km/h)	Time h/ha
20/04/2018	Hoeing	Solemat	2	2,5
26/04/2018	Disc harrow	Solemat	3	2,5
16/05/2018	Hoeing	Solemat	2	1,7
22/05/2018	Disc harrow	Solemat	3	2,5
20/06/2018	Brush	Solemat	2	2,5
21/06/2018	Disc harrow	Solemat	3	1,7
25/07/2018	Hoeing	Solemat	2	2,5
10/08/2018	Wires	Cucchi	1,5	1,7
12/10/2018	Hoeing	Solemat	2	2,5
20/11/2018	Disc harrow	Solemat	3	2,5
18/04/2019	Disques émotteurs et finger Kress	ALM	4	0,9
14/05/2019	Wires	Cucchi	1,5	4,0
16/05/2019	Hoeing	Boisselet	2	2,5
01/07/2019	Wires	Cucchi	1.5	4,0
02/07/2019	Hoeing	Clemens	2	2,5
23/10/2019	Wires	Herbanet	1.5	4

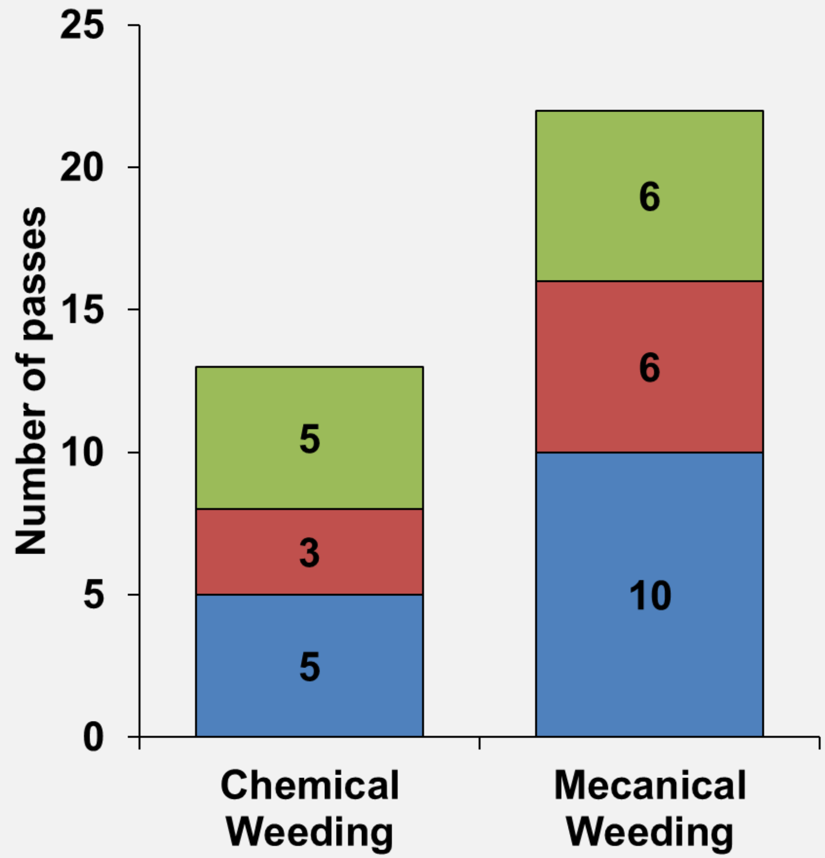
Over fertilization = manure or compost at fall

Synthesis of results

<u>Labour time and number of passage between chemical and mechanical weeding</u>

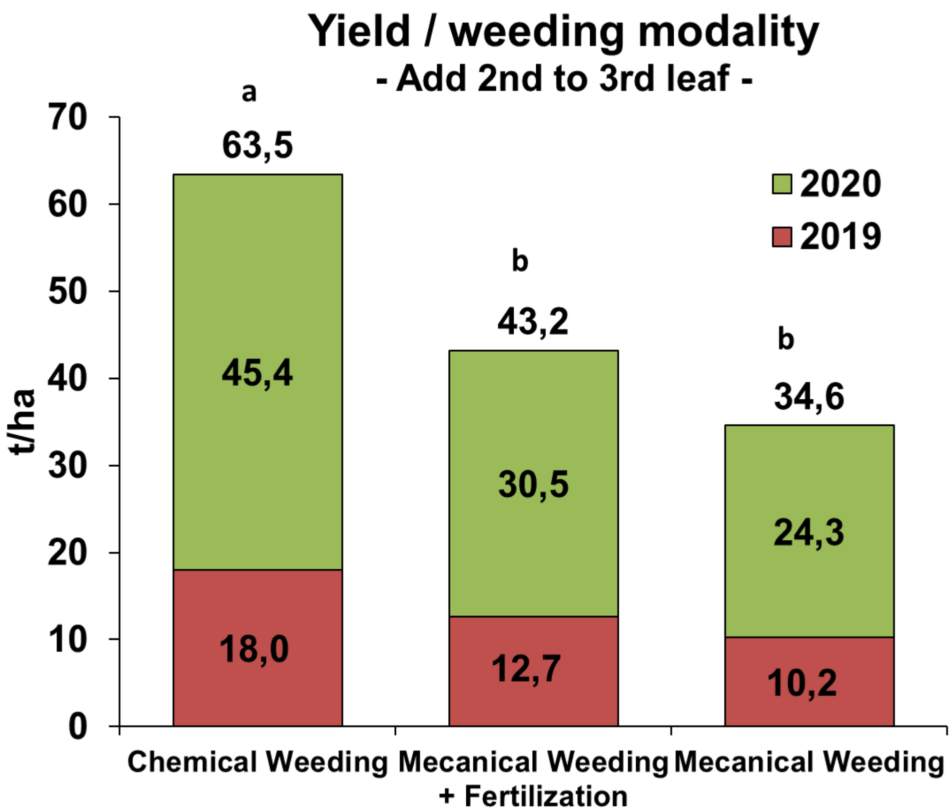
<u>2018 / 2019 / 2020</u>

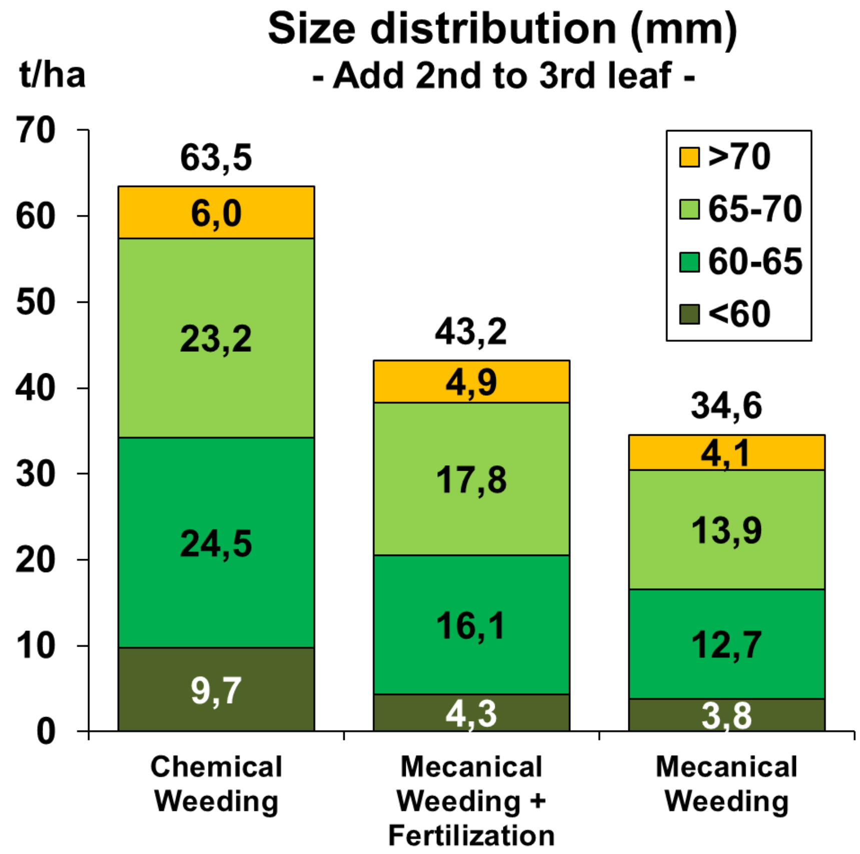




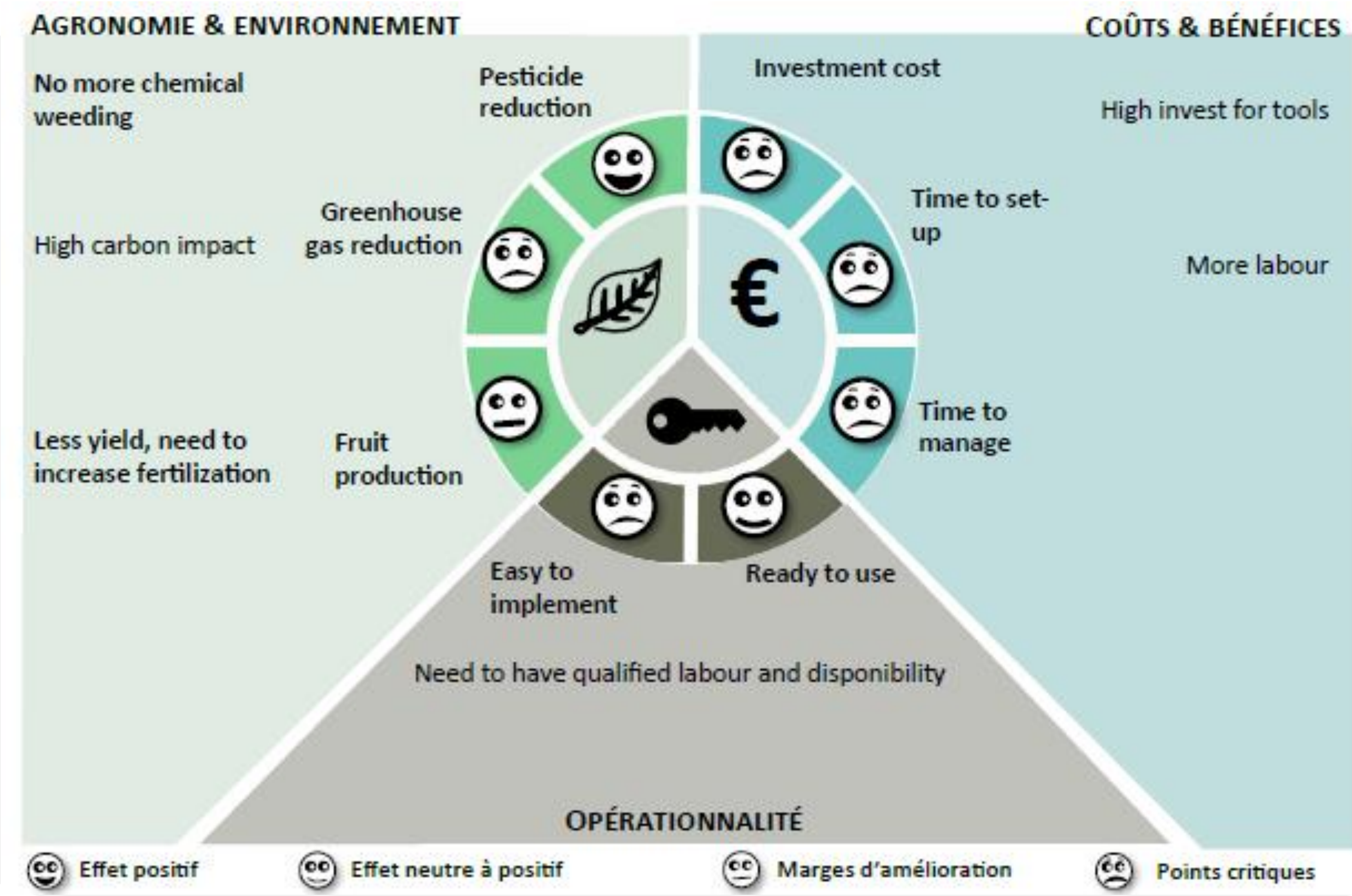
Synthesis of results

Mechanical weeding : Less production, better with over fertilization in fall





Practice Performances



Roadmap for transfer– Next steps

Easy to transfer because already use in organic

- ☞ Expensive for growers / apples should be sold more expensive
- ☞ Buy expensive machine
- ☞ Find qualified labour
- ☞ carbon impact ?

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PRACTICES PERFORMANCES & RESULTS

Interrow management with a sawn grass legume mix

Aude, Annabelle, Lucas, Blandine, Hugo, Olivier, Laurent, Thierry

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

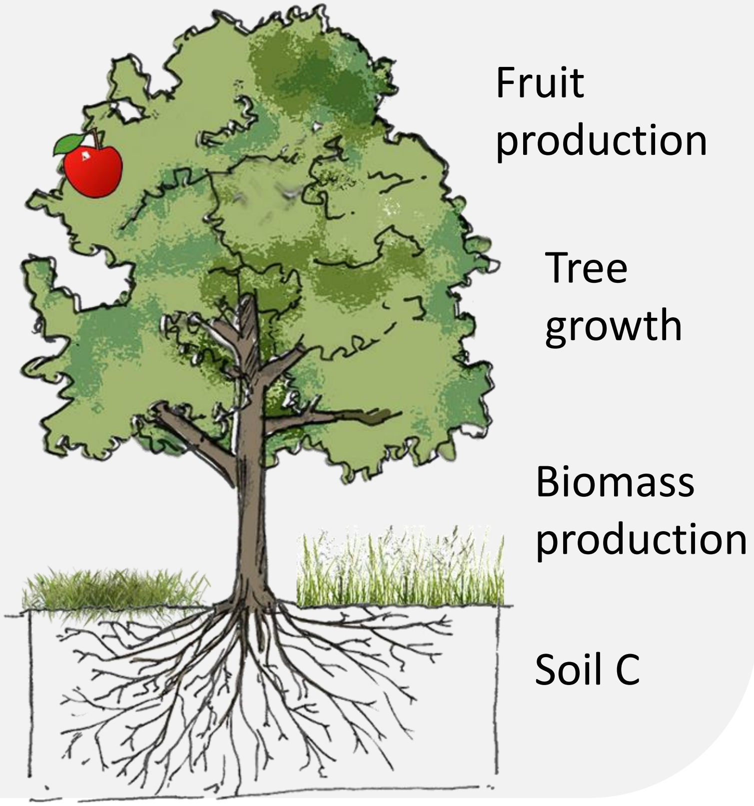
Climate-KIC is supported by the EIT, a body of the European Union

Summary of experiments

Objectives for the 3 years:

To **optimize the cover management on the row/inrerrow** in order to:

- avoid herbicide use
- increase soit carbon inputs
- optimize mechanization.



Tested solutions:

- Full grass cover
- **Grass/legumine mix in the alley** and mechanical weeding on the row
- Control with mown grass in the alley and mechanical weeding on the row

Description of the practice selected for the leaflet

What ?

- A sawn grass/legumine mix on the alley, mown with a delivery on the tree row, combined with mechanical weeding on the tree row.
- In a mature orchard, spontanous grass cover in the tree rows as in order to have a grass cover over the entire orchard, and to avoid herbicide use with mowing combined for row and interrow.

Why ?

These practice combinations have been designed

- to suppress herbicide use,
- to optimise the work organisation, as well as
- to improve the soil health

thanks to the soil incorporation to the ground of the grass/legumine mix.

Main steps to implement this practice

Implementation grass/legumine mix

- Year 1: Seed bed preparation for seed sowing; Sawing and irrigation for 1st growth
- Year 1 & following: Mowing according to growth (3 to 4 times/season) with side delivery
- Earthing up on the tree row in order to incorporate the mulch (5cm depth) with discs.

Implementation fulgrass cover:

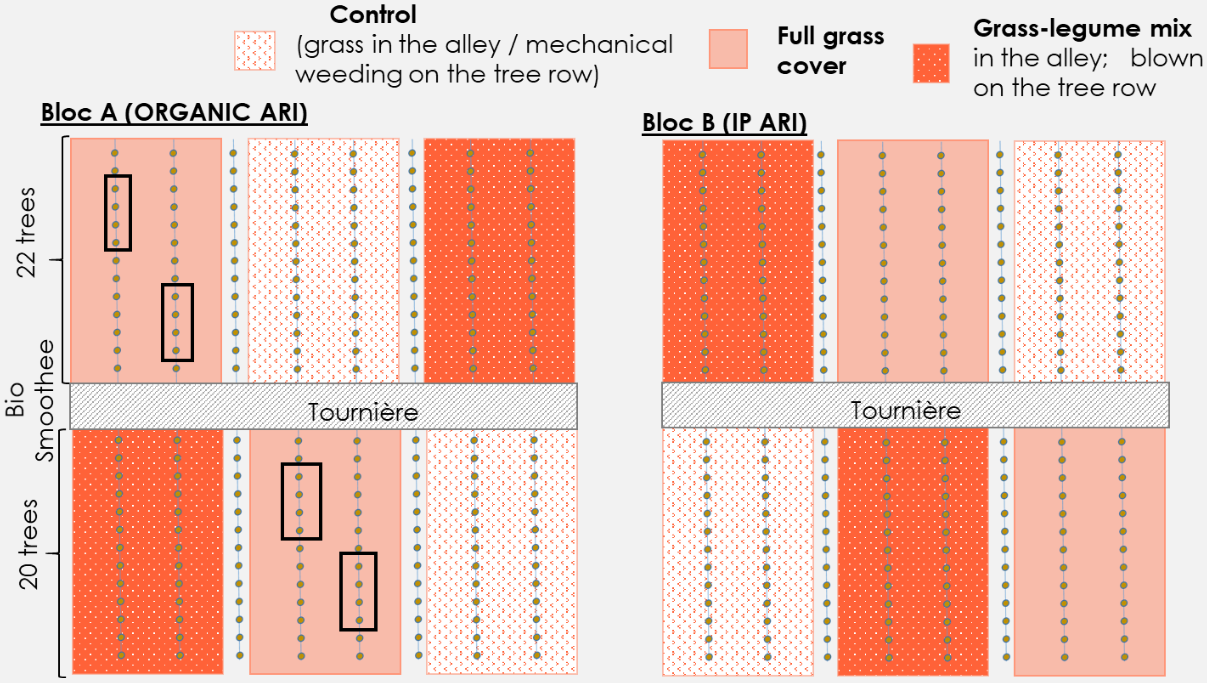
- spontanous growth on the tree row.
- Mowing with satelite according to growth

Interactions:

With fertilizer incorporation and irrigation.

Conditions of use: The composition of the grass /legumine mix has to be adapted to the pedo-climatic context.

Experiment conditions



2 orchards, one organic and one integrated fruit production,

15-years old; 0.3ha each (cv Ariane)

Control with mown gramineae in the alley and mechanical weeding on the row.

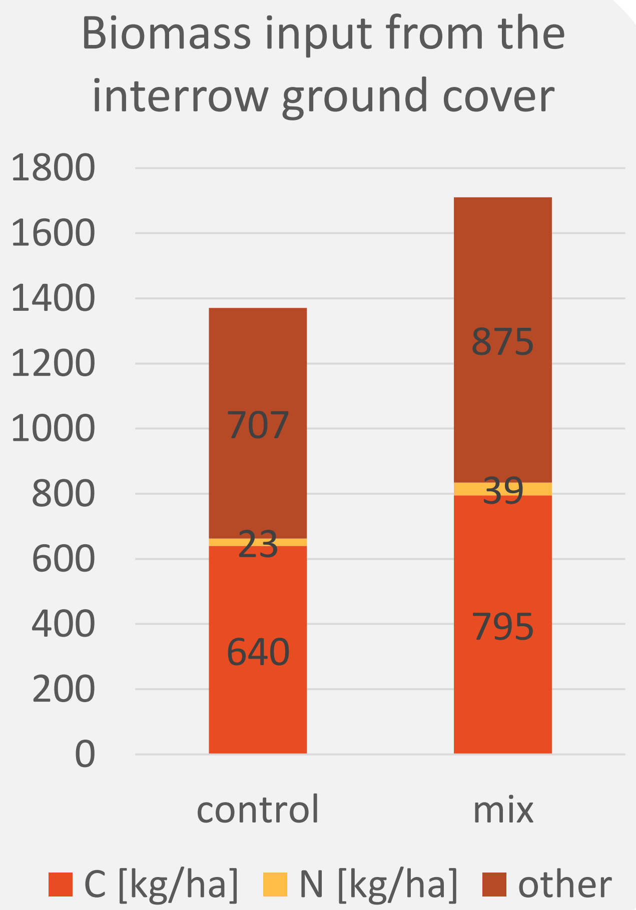
Key result of the experimentation: grass/legumine mix

Status:

Promising but needs to be confirmed

Message to take home :

The grass/legumine mix sawn in the alley and incorporated in the tree row represents a significant input in terms of biomass and C-content in particular. The N-input permit to spare the equivalent of up to 10 units N-fretilizer.



PRACTICE PERFORMANCES

In comparison to an interrow sawn with long lasting sod and a classical mechanical weeding on the tree row.

Agronomy & environment

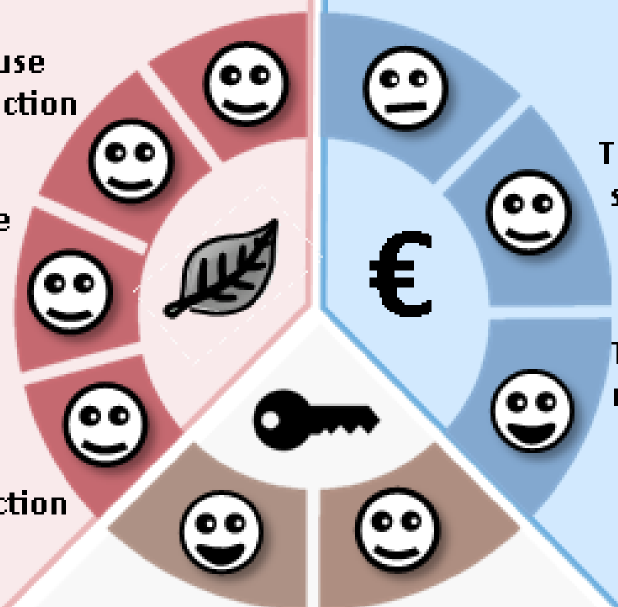
Suppression of herbicide applications by using mechanical weeding

Similar or less mineral N supply by incorporation of legumine.

Potential increase in soil organic matter (to be confirmed).

Compare to mechanical weeding, no effect.

It is compatible with organic farming: it might **improve soil health.**



Costs & benefits

Specific investment for the mowing machine with side depository.

Extra time needed for seed bed preparation in already planted orchard.

No extra time for management.

Initial investment in the mowing machine might be requested, no other investment is requested. It is **compatible with organic** management.

No specific skills or knowledge are requested.

It is a **ready-to-use solution** with available equipment. The seed mix has to be adapted to the farm context, but results need to be further confirmed.

Operationality

Roadmap for transfer– Next steps

Next steps:

- To integrate the soil C analysis and conclude the result synthesis.

These practices will be further experimented.

Scientific publication together with an update on LCA methodology concerning the modeling of C linked to climate change impact category.

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PRACTICES PERFORMANCES & RESULTS

Use of Organic manures as a form of carbon and nutrient fertilization

Glòria Avila (IRTA), Joan Bonany (IRTA)
Rachel Creamer (WUR), Henk Martens (WUR)

01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

History of experiments and selection of practice

Abundance of organic manure in certain European areas is both at the same time an environmental challenge and a opportunity for a circular bio-economy. The experiment consisted in comparing standard mineral fertilization with fertilization with organic manure from pig production. The organic manure was in form of composted solid fraction of pig slurry. Two different applications were tested. Either application on top of the soil combined with standard herbicide application strategy or application on top and the using mechanical weeding which helped to incorporate manure into the soil.

The practice was selected for the potential benefits for climate change. Mineral fertilization accounts for a high proportion of contribution to green house gases. Substitution of mineral fertilization by organic fertilization would potentially contribute to reduce green house gases, improve soil quality and at the same time reduce the environmental pressure of the surplus of pig slurry manure from pig farms in certain European regions. Combination with mechanical weeding would further add value in the sense of reduction of herbicides reducing the environmental impact and contribution to green house gases

Description of the practice selected for the leaflet

What ?

Organic fertilization with compost of solid fraction of pig slurry combined with mechanical weeding on the tree row on apple trees

Why ?

- Closing the cycle of nutrients in the agri-food sector in a specific territory
- Contribute globally to reduce greenhouse gas emissions, minimize dependence on the production of distant inputs, and increase soil quality.

Status ? on-going experimentation

Main steps to implement this practice

The implementation of this practice by growers is very simple. Given the availability of organic manure, in this case, composted solid fraction of pig slurry, the grower should apply the organic manure at the end of winter or beginning of the vegetative season.
Appropiate organic manure spreader with side delivery is more convenient.
Calculation of dosage is based on agronomical principles and estimates of nitrification rates combined with nutrient demand of plants.
If mechanical weeding is used as substitute of chemical herbicide to help in tilling the soil to better incorporate the organic manure into the soil, also appropriate machinery is necessary.

Main steps to implement this practice

Application of Compost of Pig slurry SF

Tree-row management with rolling cultivator + finger weeder (mechanical weed control and SF incorporation)

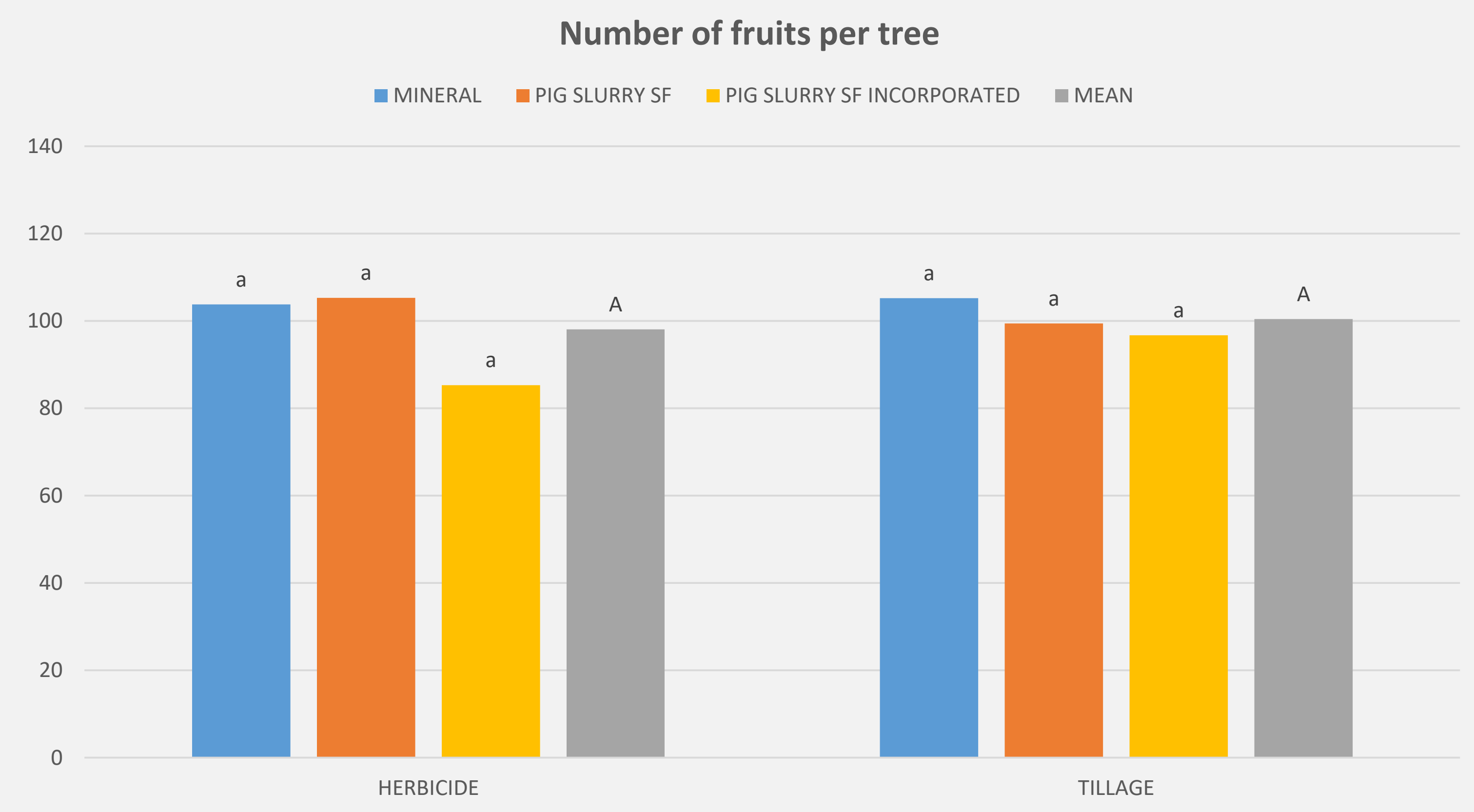
Expected Key result / Message to take home

- No differences between mineral and organic fertilization regarding fruit yield, fruit size or fruit color.
- Foliar content of micro and macronutrients within standard values
- Herbicide suppression with good weed control.
- Mechanical weed control show less mean fruit weight only the first year of conversion and greater fruit color compared to herbicide in the two years of trial.

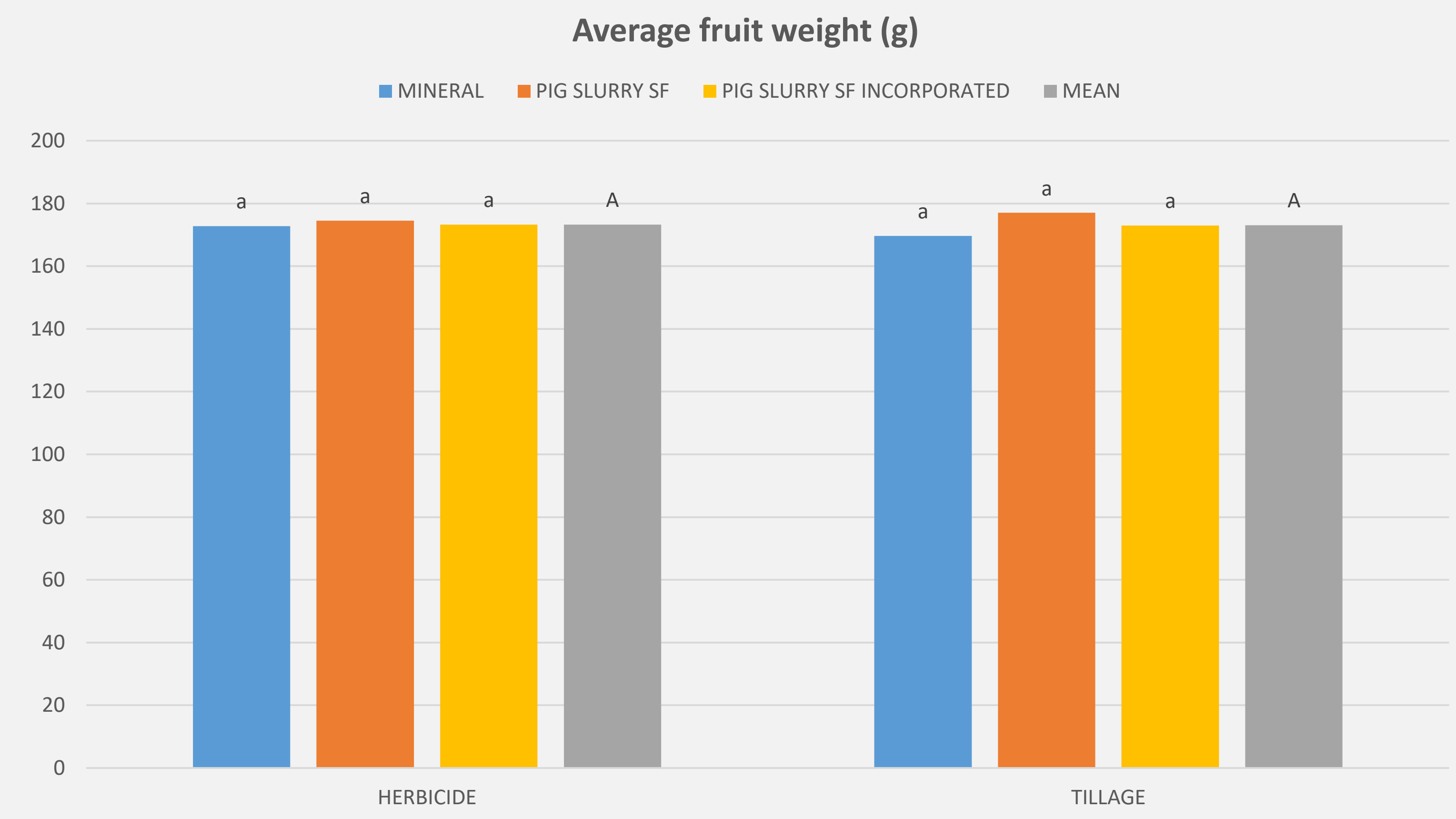
- No data yet on soil biological quality and nitrification rates

- If results are confirmed, substitution of mineral fertilizer by organic manure could contribute to reduction of emission of greenhouses gases and at the same time solve the environmental challenge of surplus organic manure from pig farms

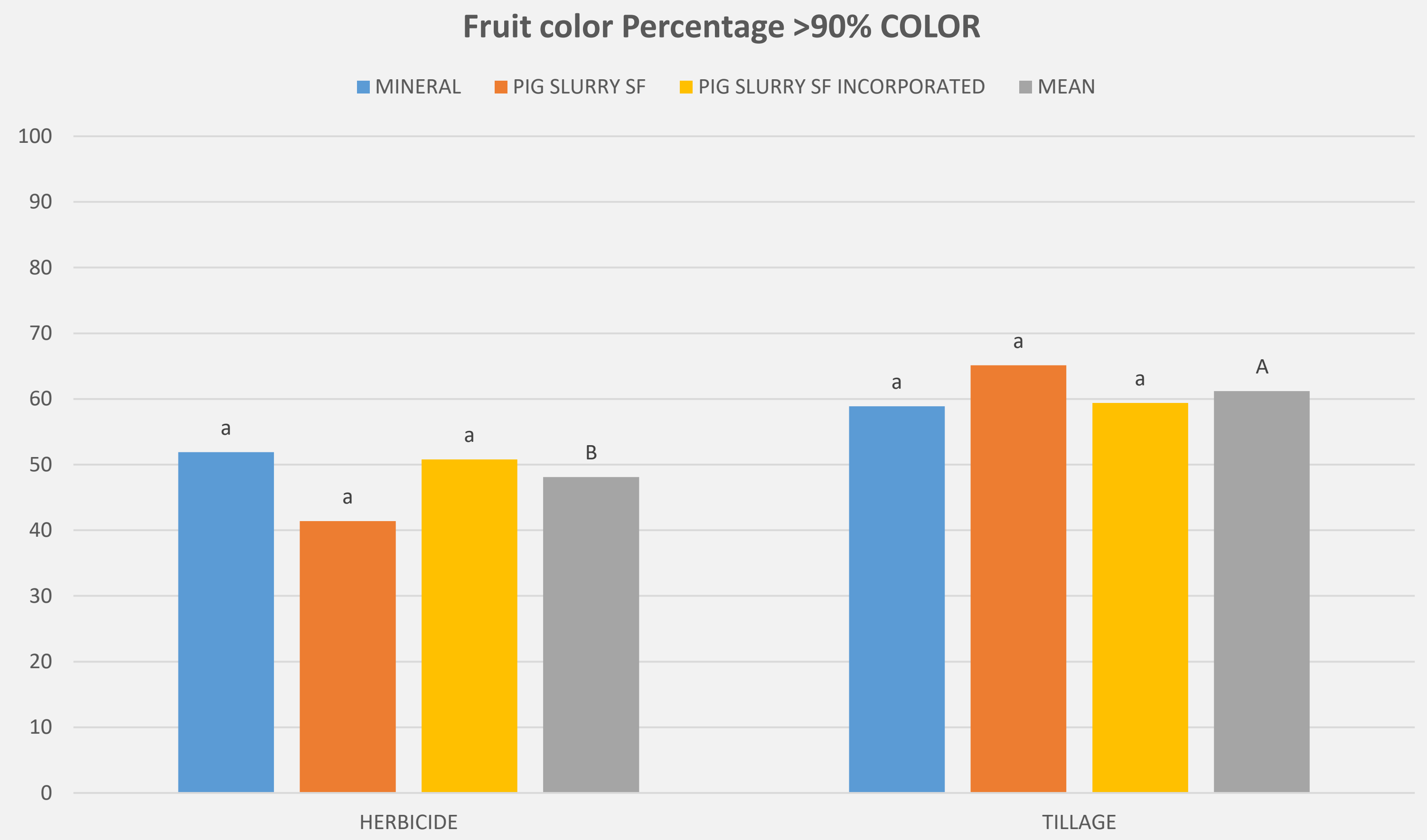
Results 2020 (2ond year)



Results 2020 (2ond year)



Results 2020 (2ond year)



Practice Performances

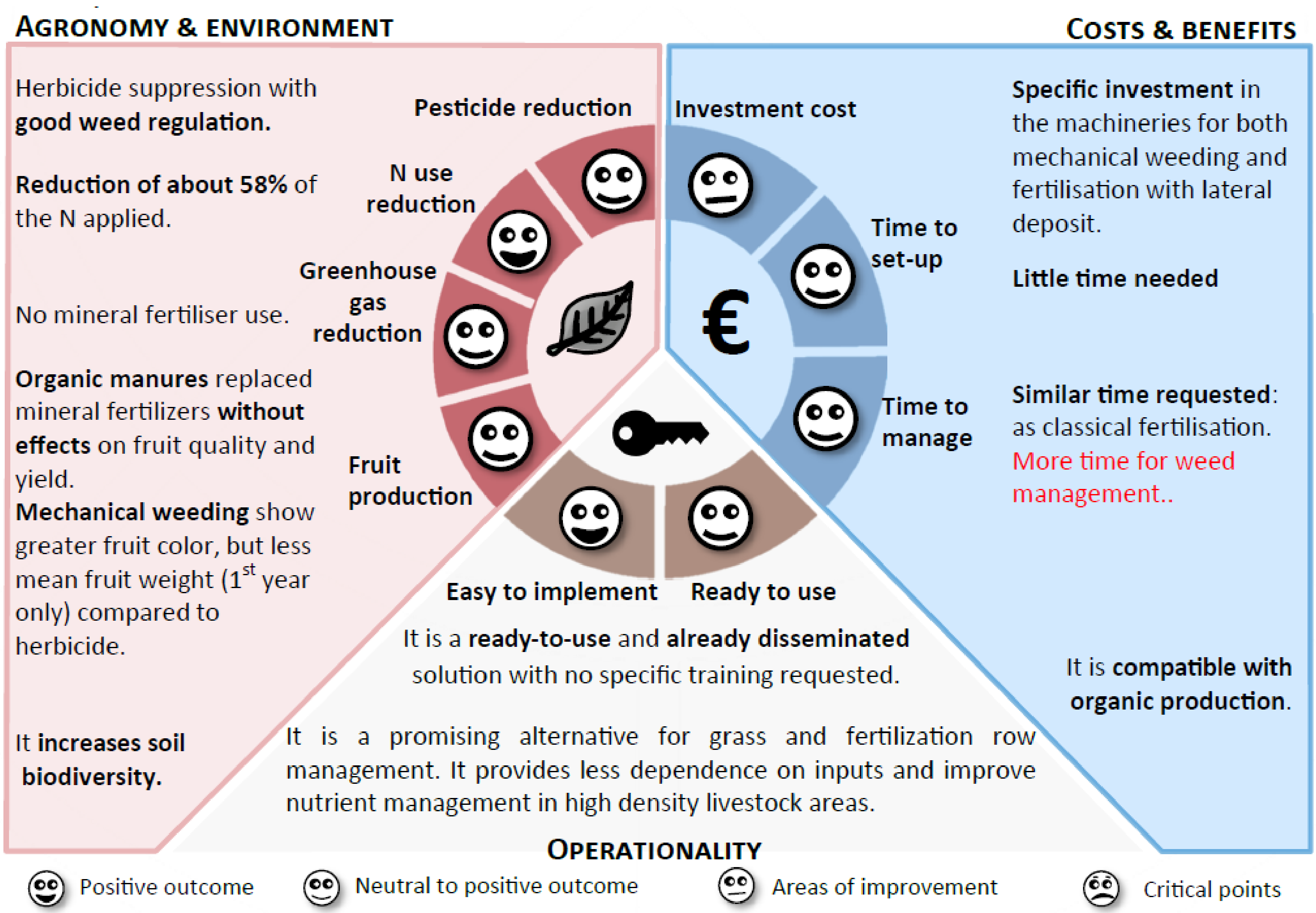
Most positive outcome

- No negative effects on production or quality

Most negative outcome

- Too early to say
- So far no negative outcomes

Practice Performances



Roadmap for transfer– Next steps

Although practice would be readily transferable without any barrier other than availability of organic manure and machinery, the experiment is still ongoing and key data regarding medium term effects on production and quality as well as soil quality is still missing.

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PRACTICES PERFORMANCES & RESULTS

Modelling ecosystem services in apple orchards

G Vercambre, M Moradzadeh, P Valsesia, D Plénet, M Génard, J Borg, M Memah, F Lescourret – INRAE Avignon

01.01.2018 to 31.12.2020

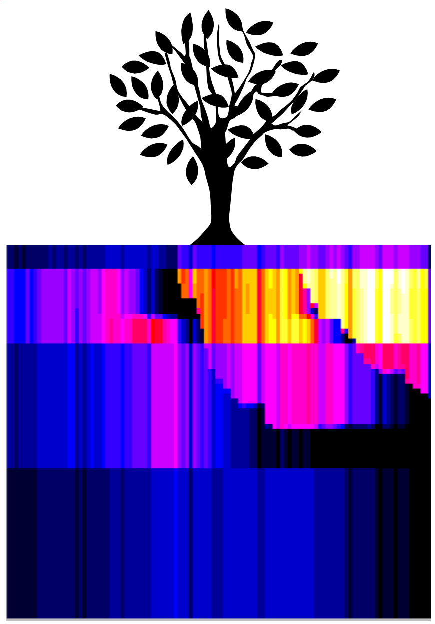
Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

Overview of the objectives

Soil, climate

Cultural practices



Ecosystem services

Fruit production	• Yield • Size, quality (distribution)
Climate regulation	• Prevention of N denitrification • C sequestration
Nitrogen availability in soil	• Concentration of nitrates in horizon 0-30 cm • Yearly variation of organic N
Regulation of water fluxes	• Soil humidity (0 – 30 cm) • Drainage • Prevention of N lixiviation

Tree model

Focuses on growth and fruit quality controlled by environmental conditions and cultural practices

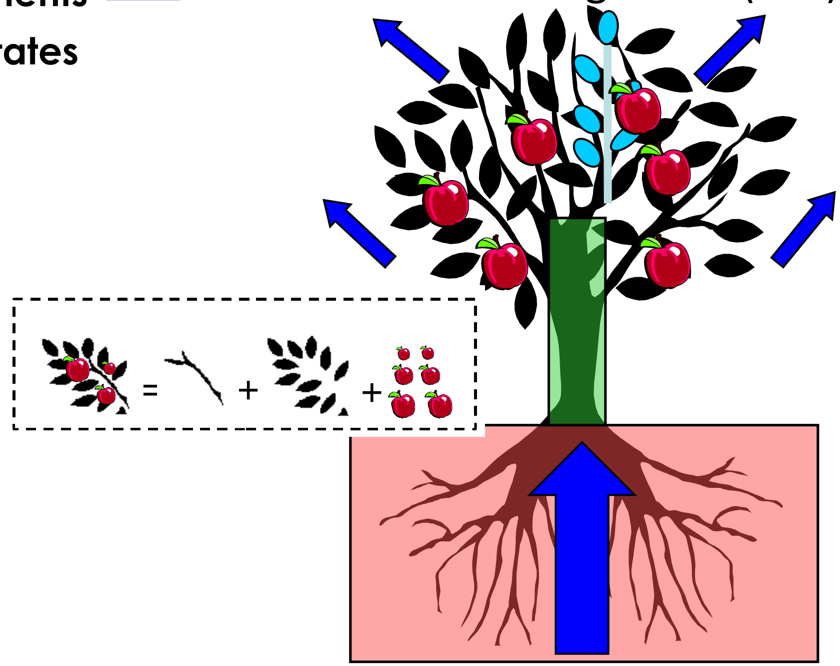
Climate **Irrigation** **Pruning** **Thinning**

The tree is composed of different **compartments**

- Roots :
  - old
  - new
- Old wood
- Watersprouts
- Fruit bearing shoot (FBS)

The represented **processes/physiological states** are:

- Carbon
  - Light interception
  - Photosynthesis
  - Carbon storage and mobilisation
  - Exchanges
  - Respiration
  - Growth
  - Metabolic transformations (sugars)
- Water
  - Energy balance and water transfers
  - Leaf temperature and transpiration
  - Water potentials within the tree



Tree model

Focuses on growth and fruit quality controlled by environmental conditions and cultural practices

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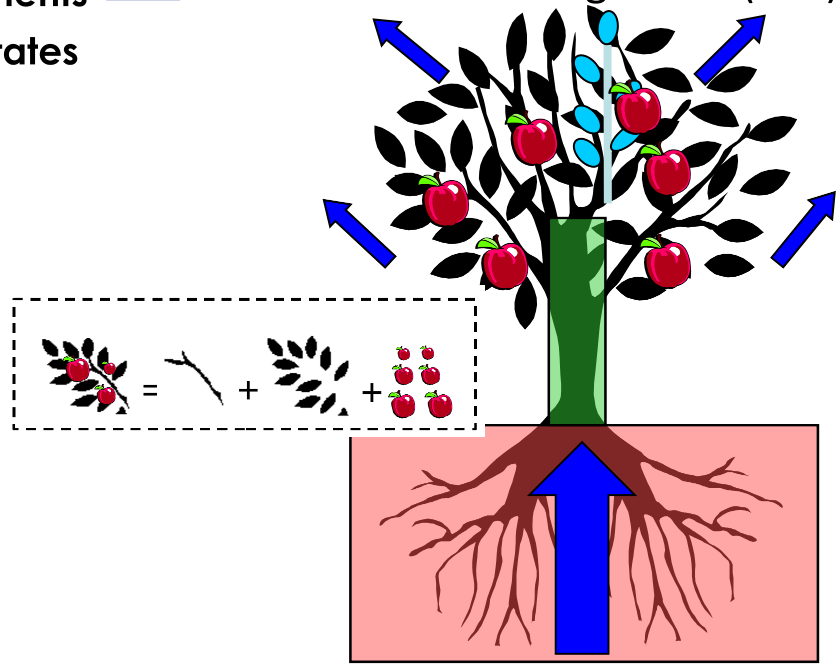
The represented **processes/physiological states** are:

- Carbon
  - Light interception
  - Photosynthesis
  - Storage and mobilisation
  - Exchanges
  - Respiration
  - Growth
  - Metabolic transformations (sugars)
- Nitrogen
  - Absorption
  - Storage and mobilisation
  - Reduction of growth



Soil model

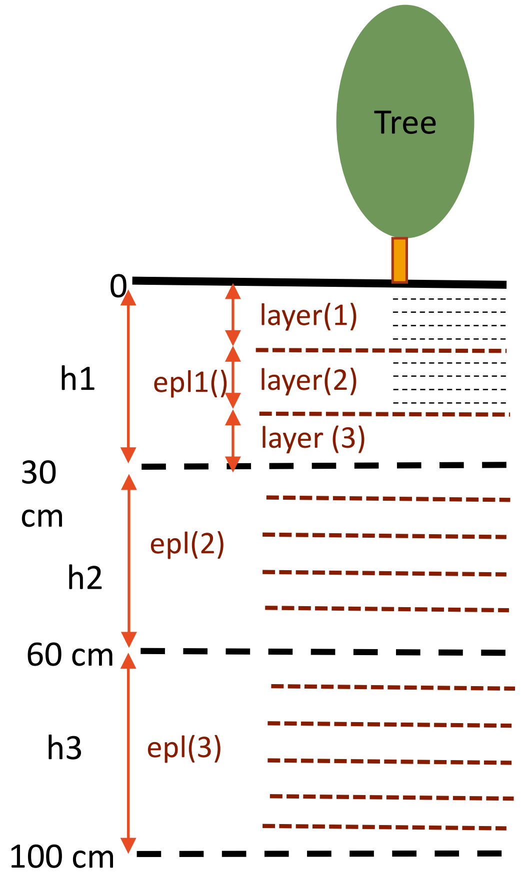
Soil of Stics, a widespread model of annual crops. Focuses on water, N and C processes controlled by environmental conditions and cultural practices

Soil+climate **Irrigation** **Fertilisation**

The soil is **cut into horizons, layers and sub-layers**

The represented **processes/states** are:

- Water
  - Supply and infiltration
  - Soil evaporation
  - Water transfers between layers
  - Water potential/layer (🡐 water content)
  - Collar water potential **(link with the tree model)**
  - Distribution of water absorption by roots
  - Water balance/layer



Soil model

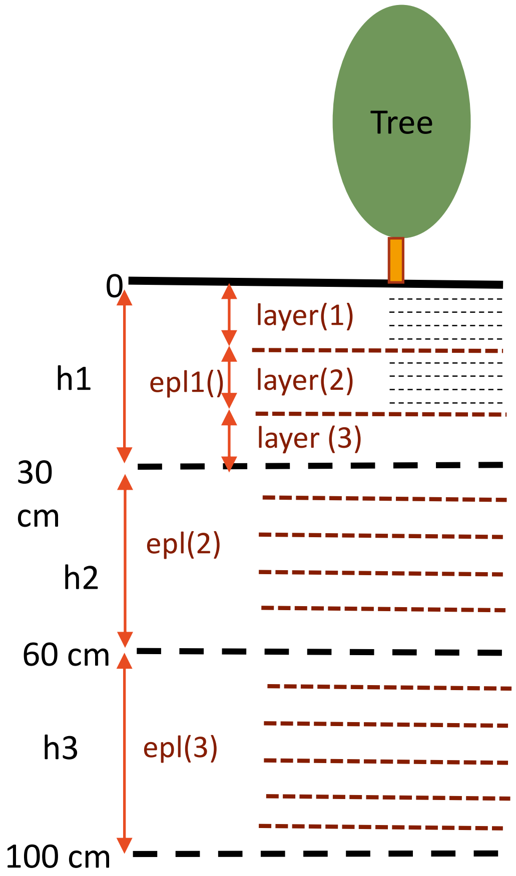
Soil of Stics, a widespread model of annual crops. Focuses on water, N and C processes controlled by environmental conditions and cultural practices

Soil+climate **Irrigation** **Fertilisation**

The soil is **cut into horizons, layers and sub-layers**

The represented **processes/states** are:

- Nitrogen
  - Initialisation
  - Supply
  - Transformation
    - ✓ Immobilisation
    - ✓ Mineralisation
    - ✓ Nitrification
    - ✓ Denitrification
  - Leaching



Soil model

Soil of Stics, a widespread model of annual crops. Focuses on water, N and C processes controlled by environmental conditions and cultural practices

Soil+climate **Irrigation** **Fertilisation**

The soil is **cut into horizons, layers and sub-layers**

The represented **processes/states** are:

- Carbon
  - Initialisation
  - Supply (organic, residues)
  - Transformation
    - ✓ Immobilisation
    - ✓ Mineralisation

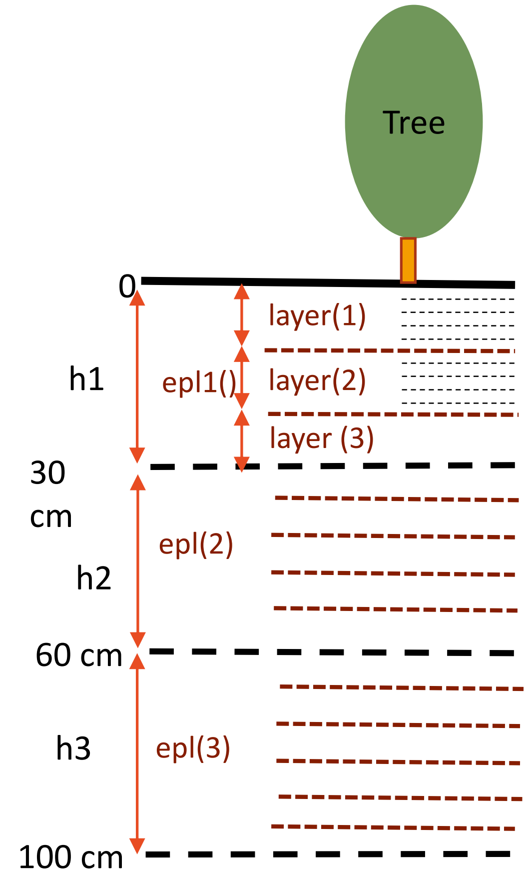
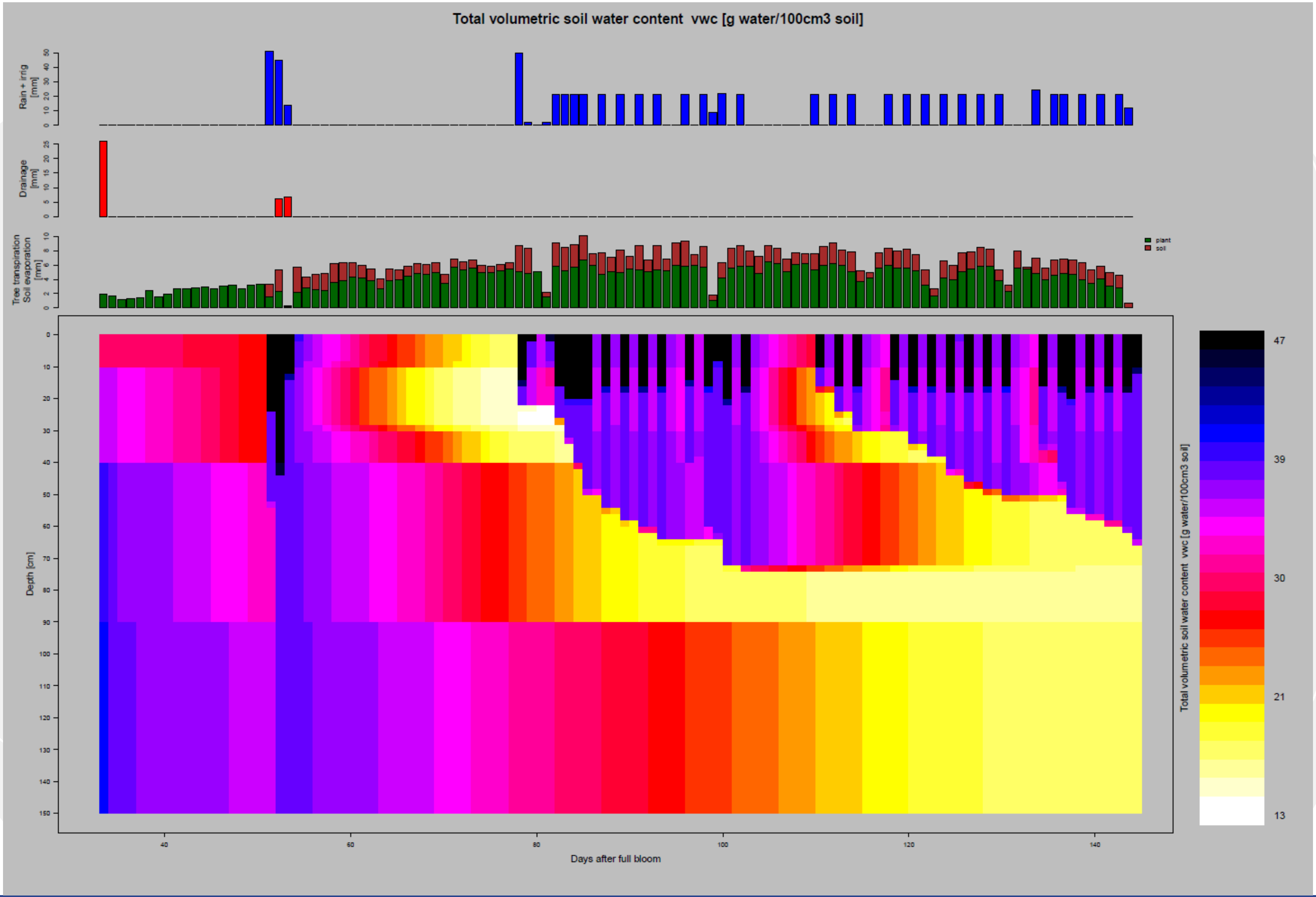


Illustration of intermediate variables

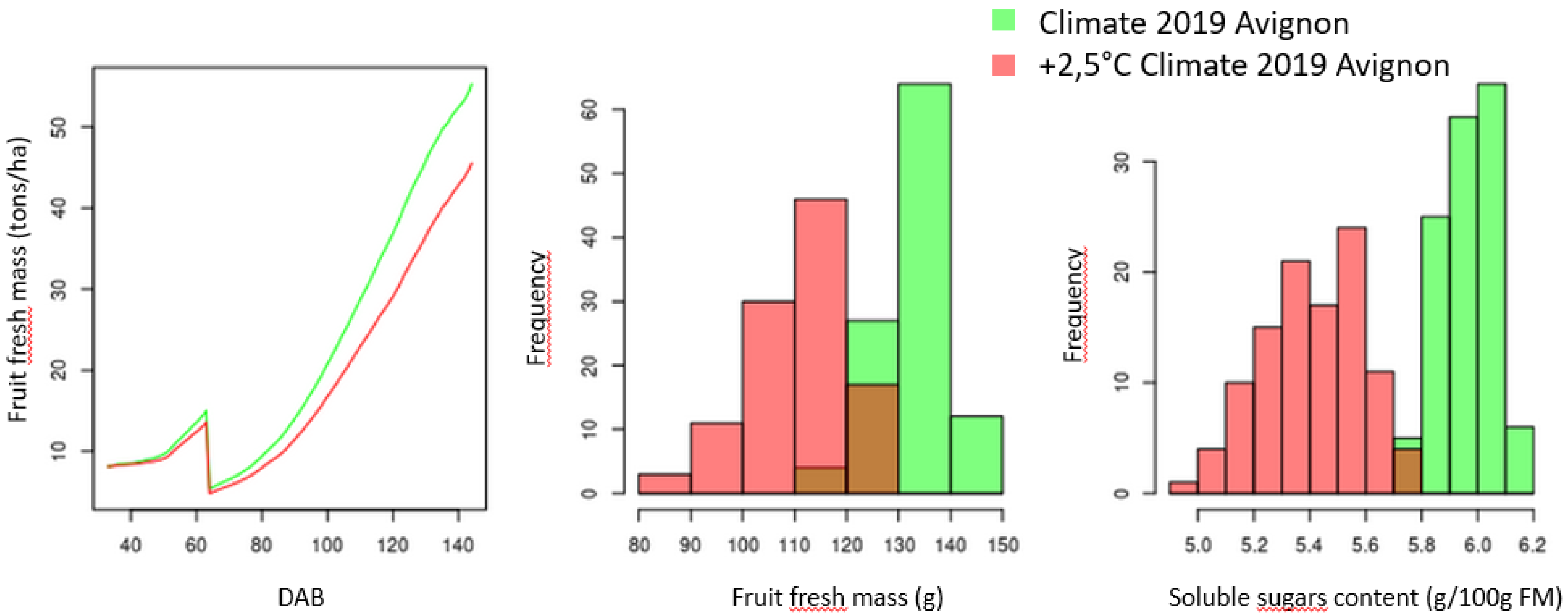


Ecosystem services

Yield (tons of fresh mass/ha)

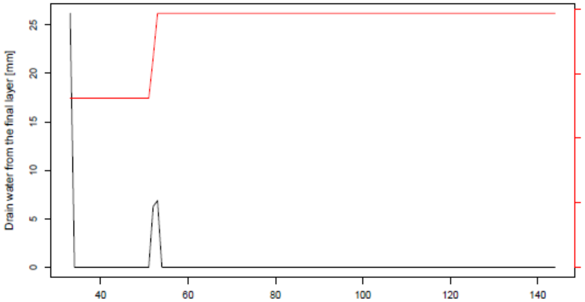
Distribution of fruit sizes at harvest

Distribution of fruit quality (gSS/gFM) at harvest

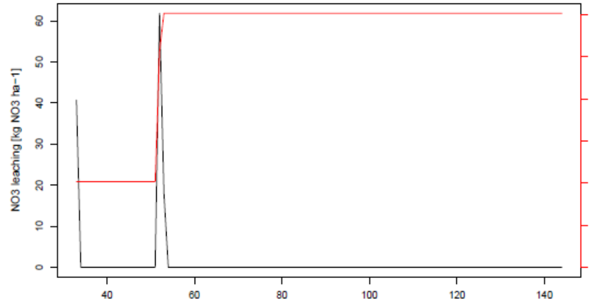


Ecosystem services

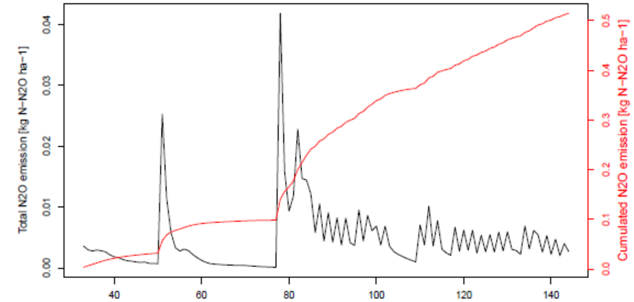
Drain water (mm)



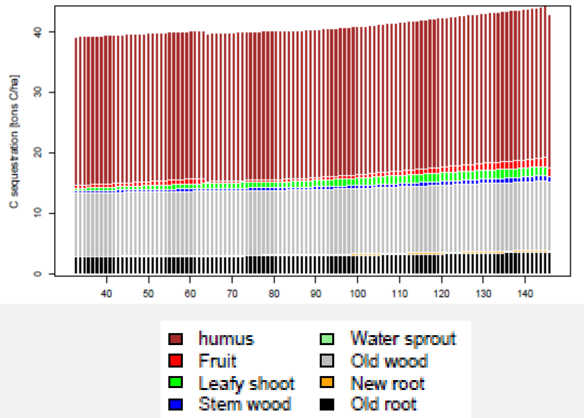
Nitrogen leaching (kg N-NO_3/ha)



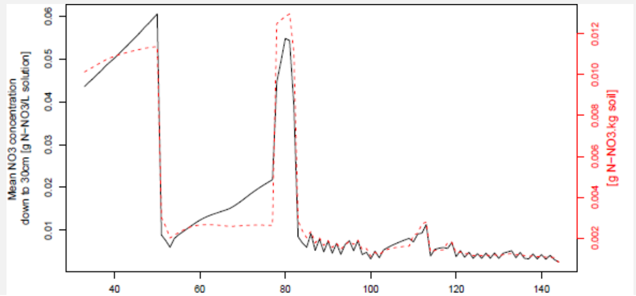
N_2O emission (kg N-N_2O/ha)



Carbon sequestration (tons C/ha)



NO_3 concentration down to 30 cm (g N-NO_3/kg soil)



Interactions with stakeholders
(Ctifl, advisory service, experimental station)

Relevance of indicators?
Which priority?

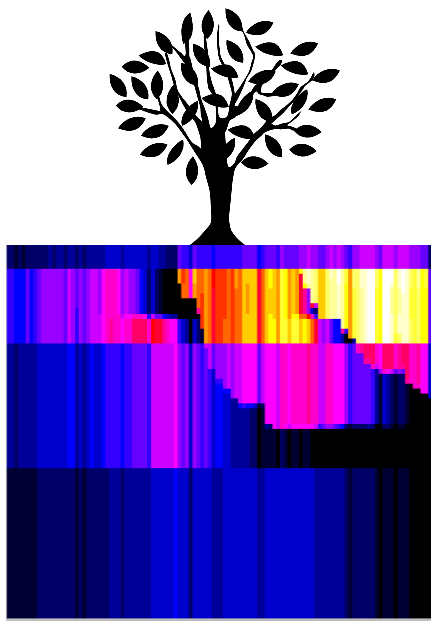
Which scenarios?

Soil, CC

Cultural practices

Soil management (covers, machinery)
N fertilization (forms, timing…)

Respective contributions to output variation



Ecosystem services

Fruit production

Climate regulation

Nitrogen availability in soil

Regulation of water fluxes

Interannual variability
- Yield
- Size, quality (distribution)

- Prevention of N denitrification
- C sequestration

- Concentration of nitrates in horizon 0-30 cm
- Yearly variation of organic N

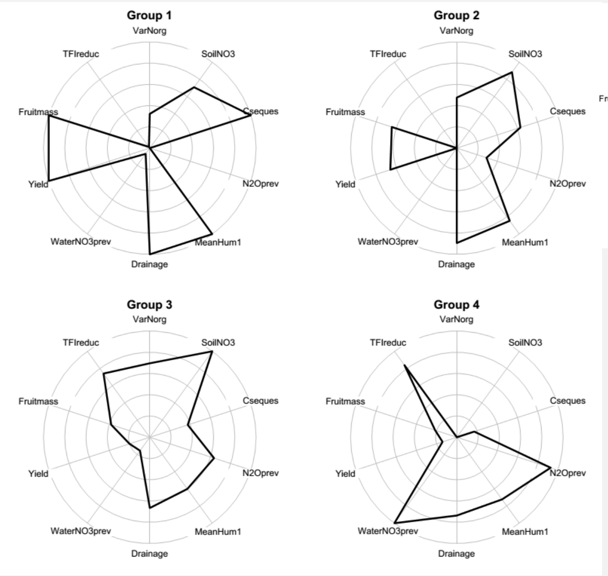
- Soil humidity (0 – 30 cm)
- Drainage
- Prevention of N lixiviation

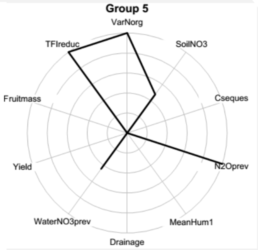
Other services/outputs?
Biodiversity

Take home messages– Next steps

- The first fruit crop model that represents a bundle of ES
- A tool to interact with stakeholders for the multi-functionality and sustainability of fruit growing
- The stakeholders are interested in the whole range of ES studied and suggested interesting scenarios

- To go further
  - ✓ Estimation and tests of the model by confrontation to experimental data have still to be done
  - ✓ Urgent need for modelling ground management (covers, …)
  - ✓ Workshops with stakeholders





Relationships between cropping systems and ES bundles *(Demestihas et al 2019)*

Friendly Fruit

PRACTICES PERFORMANCES & RESULTS

Non chemical soil fumigation in strawberry: the Biofumigation and the ASD techniques

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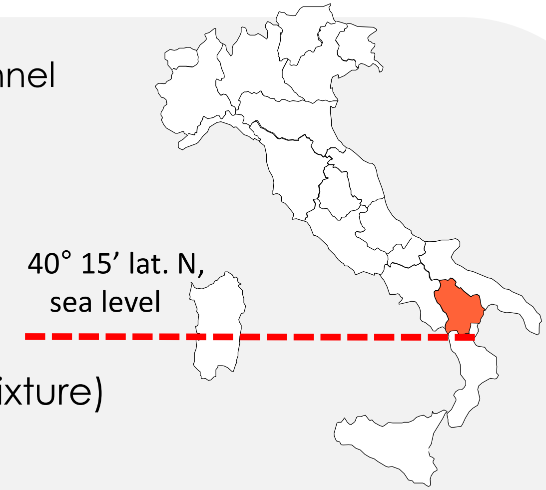
01.01.2018 to 31.12.2020

Supported by: eit Climate-KIC

Climate-KIC is supported by the EIT, a body of the European Union

History of experiments and selection of practice

- ✓ **2 years trials**
  - ✓ 2018/2019 and 2019/2020;
  - ✓ Commercial farm, growing strawberry protected under tunnel
  - ✓ Replanting soil/ chemical fumigation
- ✓ Cultivar: Sabrosa*
  - ✓ Plant material: bare-root plants
  - ✓ harvest period: January-May



TREATMENTS:

1. STANDARD – Chemical fumigation (chloropicrin + 1,3-D mixture)
2. BIOFUM - Biofumigation with biocide plants
3. ASD - Anaerobic soil disinfestation
4. UNTREATED - Non-fumigated soil
5. ASD Variant (simplified application)


Typical multi-span tunnel used in Southern Italy for strawberry

BIOFUMIGATION AND ASD:

- ✓ Easy to apply;
- ✓ applied already in several countries proved promising in containing soilborne pests and diseases;
- ✓ involve incorporation of remarkable amounts organic matter, hence play also a role as soil amendments;
- ✓ commercial products are available=simplified application and more consistent results

Description of the practice selected for the leaflet

What ?

Soil incorporation pre-planting of:

BIOFUMIGATION: defatted seed meals of Brassicaceae plants
(commercial product: 'BioFence' pellets, Nutrien Italia S.p.A);

ASD: organic matter material of vegetable origin
(commercial product: 'Soil Resetting', granular, Thatchtec, NL).

Why ?

To contain soilborne pests and pathogens of previous strawberry planting and minimize replanting syndrome (impacting plant growth, yield quantity and quality) with no use of chemical fumigants

Plant collapses associated with soilborne pathogens

Status ?

BIOFUMIGATION: promising but results need to be confirmed
ASD: almost ready-to-use

Main steps to implement Biofumigation practice

In the interval time between previous strawberry planting removal and new planting:

1. Soil tillage;
2. Incorporation of 'BioFence' pellets (2,5-3,0 t/ha) at a 0-30 cm soil depth;
3. Irrigation to activate hydrolysis of glucosinolates;
4. Preparation of raised beds including the treated soil only; mulching;
5.Planting

Main steps to implement the ASD practice

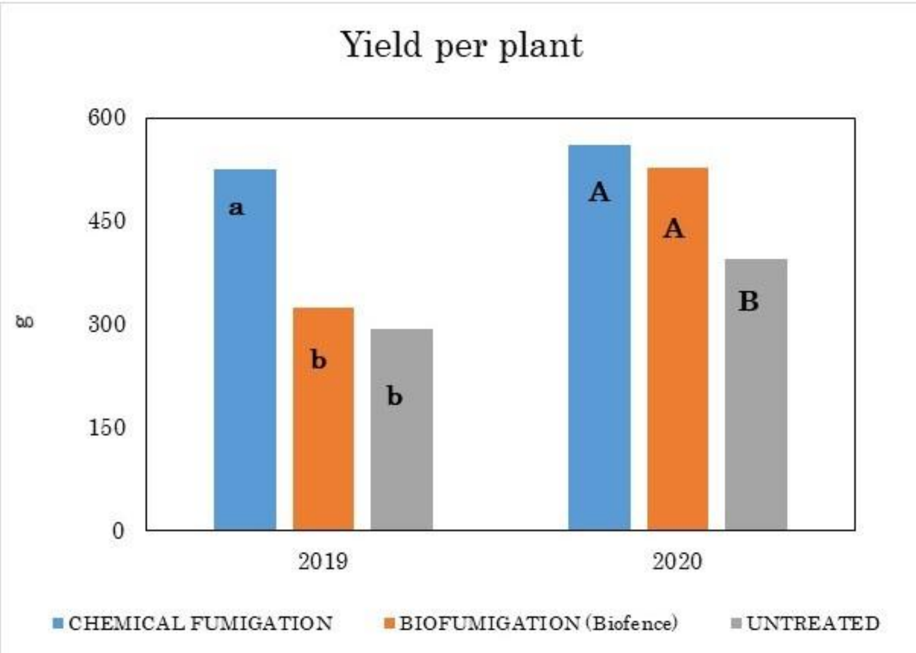
In the interval time between previous crop removal and new strawberry planting:

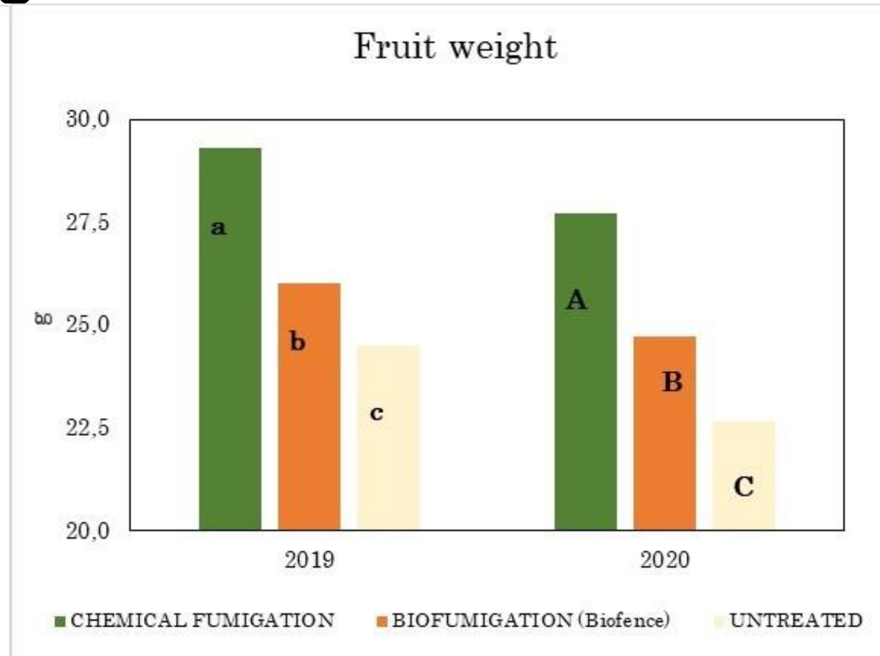
1. Soil tillage;
2. Incorporation of 'Soil Resetting' (8 t/ha) to a 0-30 cm soil depth;
3. Irrigation to initiate product decomposition;
4. Sealing the treated soil with totally impermeable (TIF) film;
5. TIF removal after not less than 3 weeks;
6. Preparation of raised beds including the treated soil only, mulching;
7. Planting

ALTERNATIVE TESTED IN YEAR 2

Expected Key result / Message to take home

Biofumigation

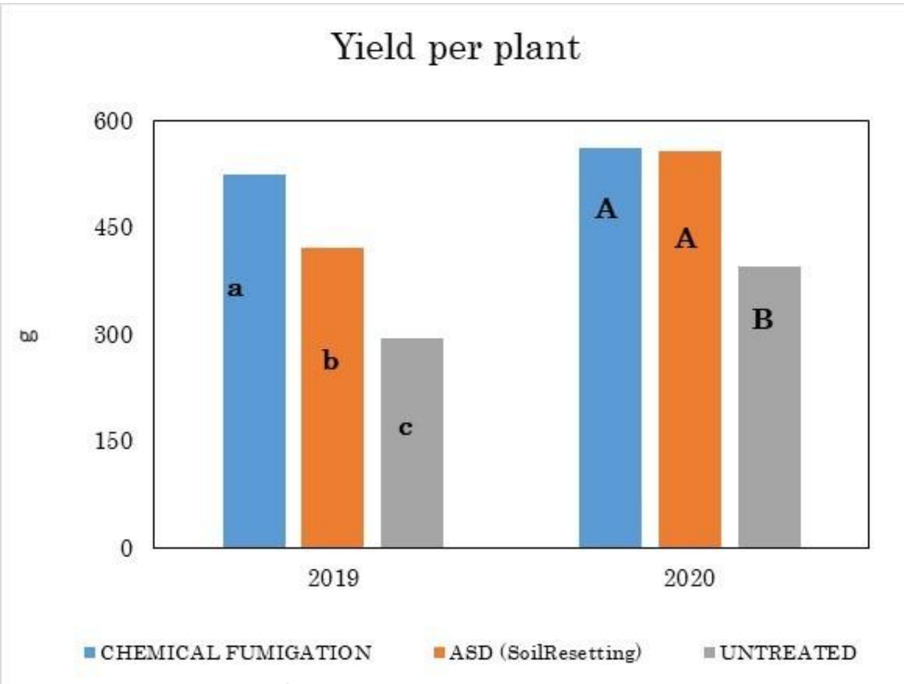


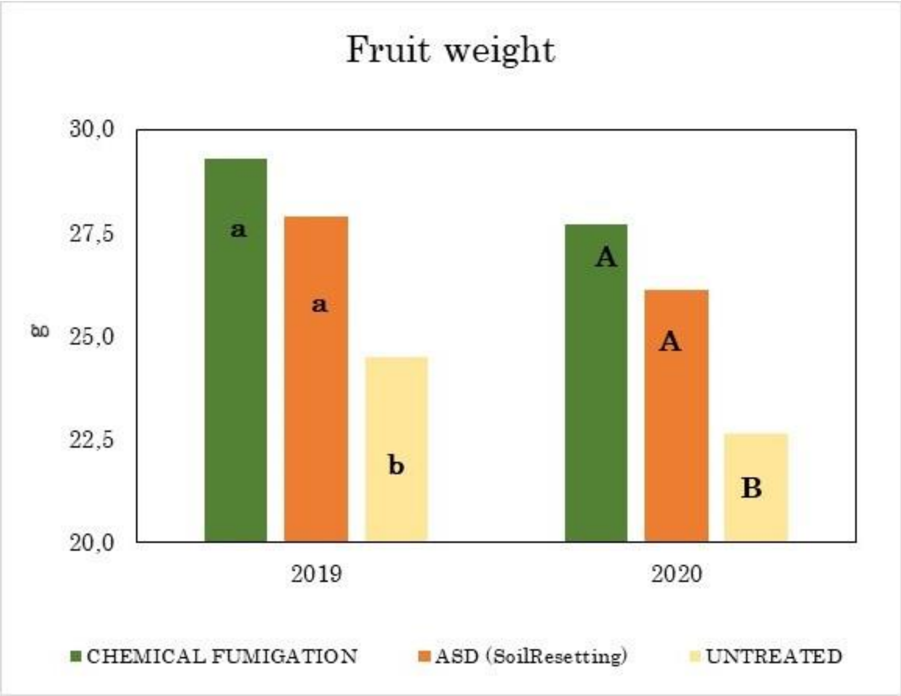


Biofumigation with defatted seed meals of Brassicaceae (commercial product: Biofence®, Nutrien Italia S.p.A) shows potential as an eco-friendly alternative to soil chemical fumigation on strawberry; additional experimentation is needed to optimize conditions and increase efficacy.

Expected Key result / Message to take home

ASD

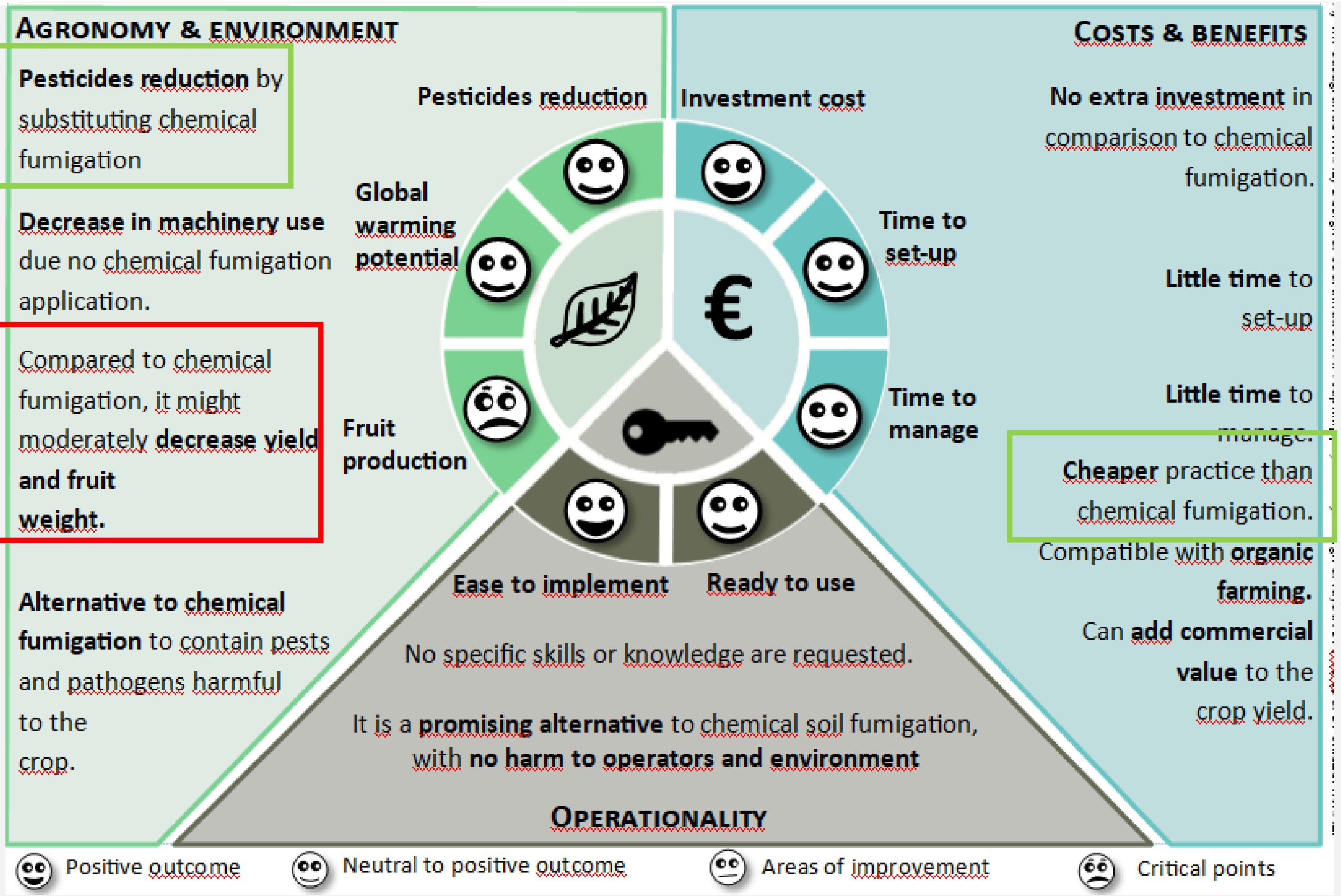




Anaerobic soil disinfestation (commercial product: Soil Resetting®, Thatcthec, NL) added pre-planting is a promising eco-friendly alternative to conventional soil chemical fumigation on strawberry.

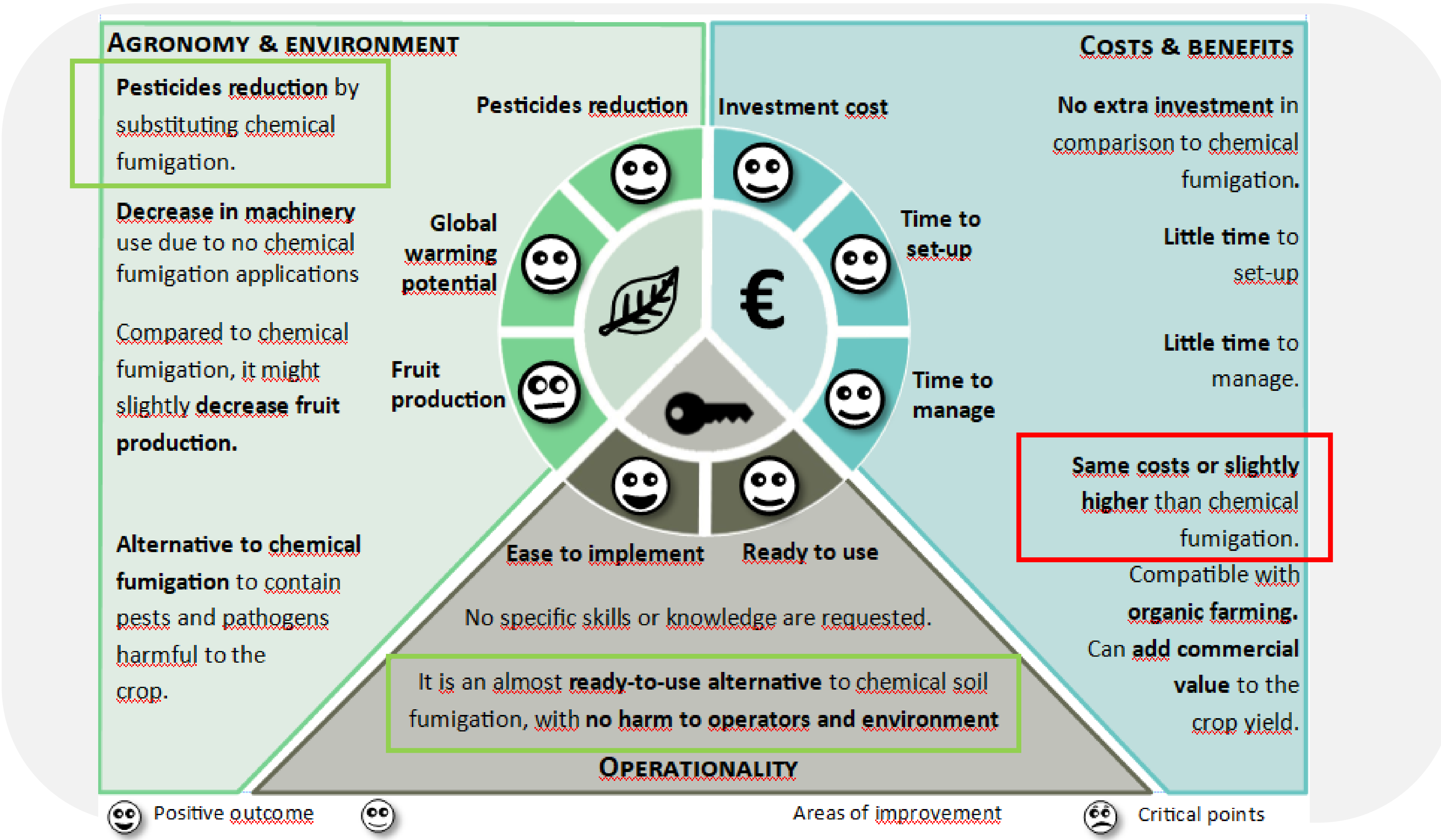
Practice Performances: BIOFUMIGATION

In comparison with chemical fumigation:



Practice Performances: ASD

In comparison with chemical fumigation:



Roadmap for transfer– Next steps

- ✓ Spread the results through technical & dissemination articles (including the Leaflets) or on portals specialized in informing the horticulture/fruit sector; organize seminars/promote events (i.e. open days) dedicated to stakeholders

- ✓ Large scale testing/demostration involving growers associations, including the organic sector, still necessary to move from an experimental phase (although carried out in a commercial farm) to an applicative phase