COST EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

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IPM FOR WEED CONTROL: THE THRESHOLD CONCEPT

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INTRODUCTION

Very ambitious measures!!

People pay increasing attention in choosing safe foods

European Food Safety Authority

EUROPEAN COMMISSION

Brussels, 20.5.2020
COM(2020) 381 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

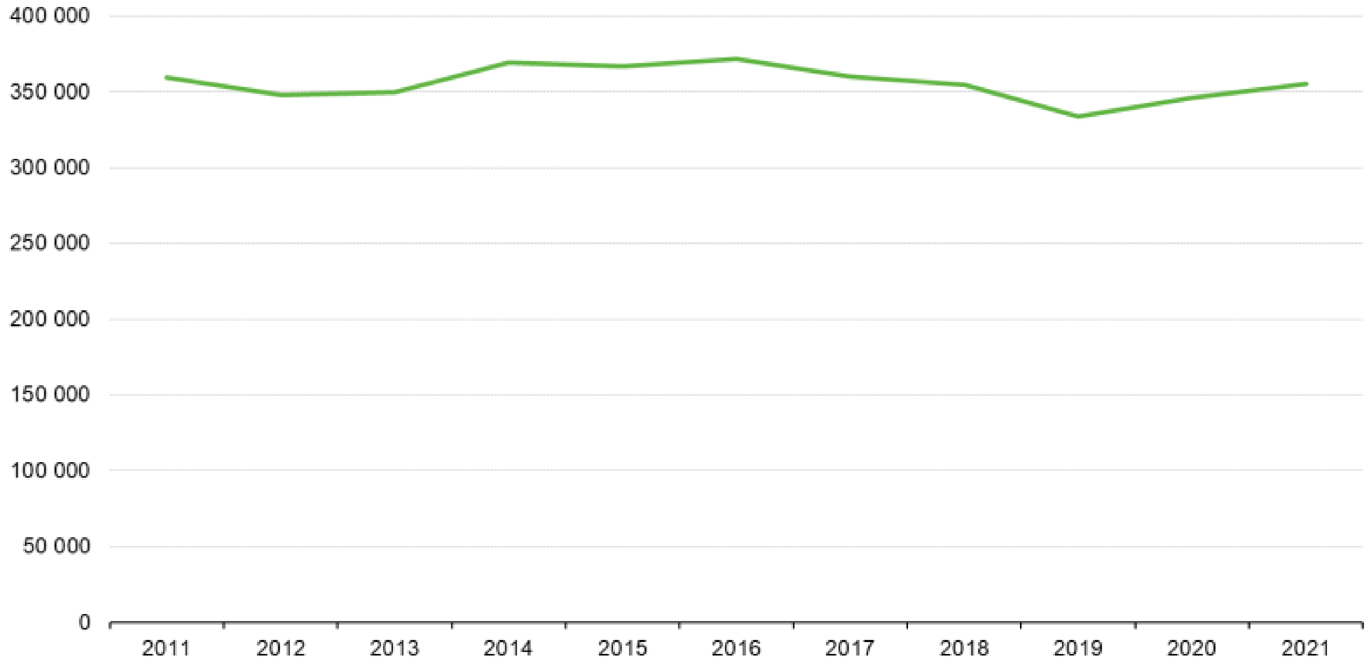
A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system

The use of **chemical pesticides** in agriculture contributes to soil, water and air pollution, biodiversity loss and can harm non-target plants, insects, birds, mammals and amphibians. The Commission has already established a Harmonised Risk Indicator to quantify the progress in reducing the risks linked to pesticides. This demonstrates a 20% decrease in risk from pesticide use in the past five years. The Commission will take additional action to reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides[13] by 50% by 2030. To pave the way to alternatives and maintain farmers' incomes, the Commission will take a number of steps. It will revise the Sustainable Use of Pesticides Directive, enhance provisions on **integrated pest management** (IPM) and promote greater use of safe alternative ways of protecting harvests from pests and diseases. IPM will encourage the use of alternative control techniques, such as crop rotation and mechanical weeding, and will be one of the main tools in reducing the use of, and dependency on, chemical pesticides in general, and the use of more hazardous pesticides in particular. Agricultural practices that reduce the use of pesticides through the CAP will be of paramount importance and the Strategic Plans should reflect this transition and promote access to advice. The Commission will also facilitate the placing on the market of pesticides containing biological active substances and reinforce the environmental risk assessment of pesticides. It will act to reduce the length of the pesticide authorisation process by Member States. The Commission will also propose changes to the 2009 Regulation concerning statistics on pesticides[14] to overcome data gaps and promote evidence-based policymaking.

INTRODUCTION

- **Protection against pests is an essential component of agroecosystem management** and prevents large scale yield losses (Oerke, 2006).
- Since the 1950s, pest control has relied on **chemical pesticides** which have led to numerous benefits, but also to considerable negative effects on human health and the environment.
- However, after the input reduction measures came into effect (i.e. Directive 2009/128/EC, 2009), to date, pesticide use has not been significantly reduced.

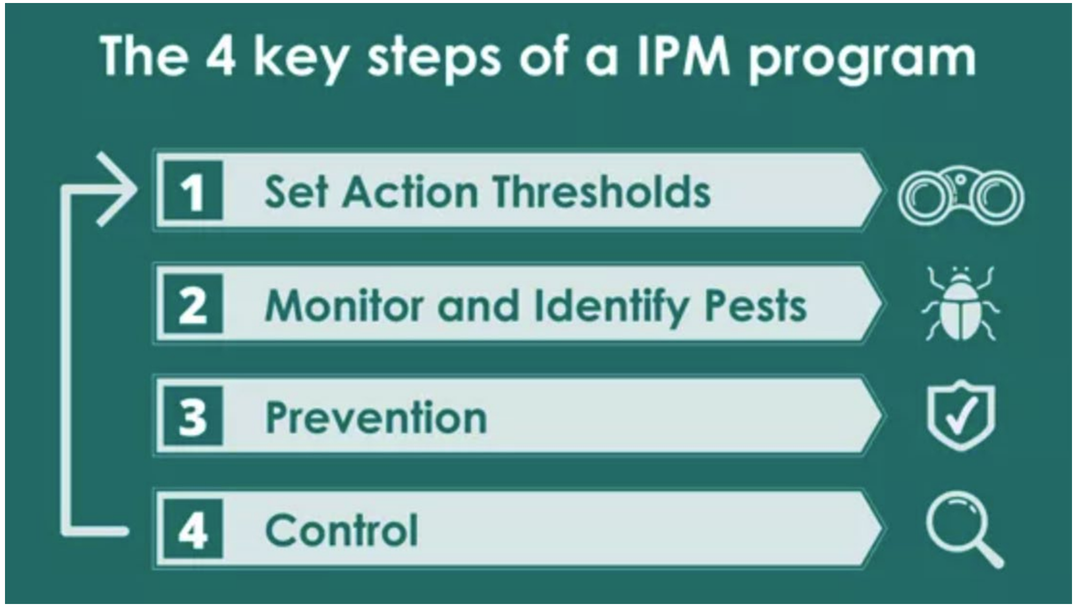
Sales of pesticides
(tonnes, EU, 2011-2021)

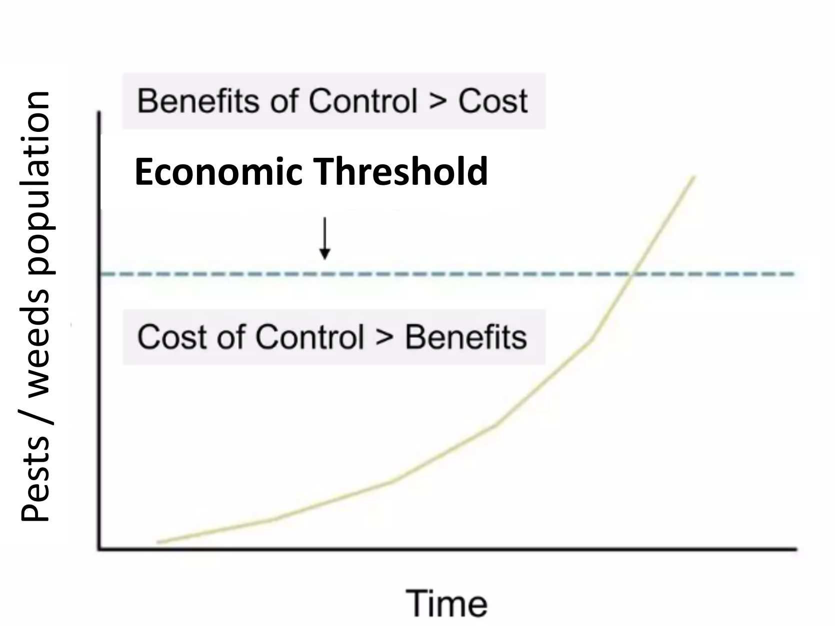


Note: EU estimate for 2021 includes 2020 data for BE. EU data do not take into account confidential values, which represent < 1 % of the total sales over the entire time series.
Source: Eurostat (online data code: aei_fm_salpest09)

eurostat

INTEGRATED PEST MANAGEMENT (IPM)





4 BASIC PILLARS:

1. Set an **action threshold**, a point at which pest/weed populations indicate that pest/weed control action must be taken → a treatment is "justified" only if the **benefits of control** is greater than the **cost of control**

2. **Monitor and identify** pests/weeds accurately → an appropriate control decisions can be made in combination with action thresholds.
→ This stage avoids the possibility of using treatments when they are not really needed.

3. IPM programs work to manage the crop and the farms area to **prevent pests/weeds** from becoming **a threat.**

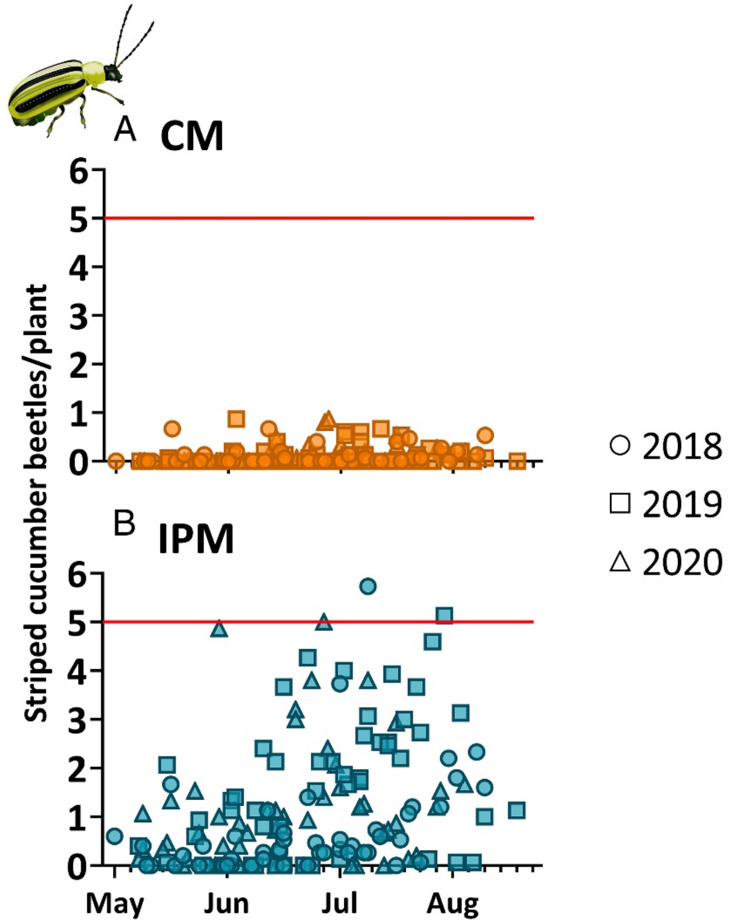
4. if the previous steps indicate that pest/weed control is needed, IPM programs evaluate the appropriate **control** method for both effectiveness and risk.

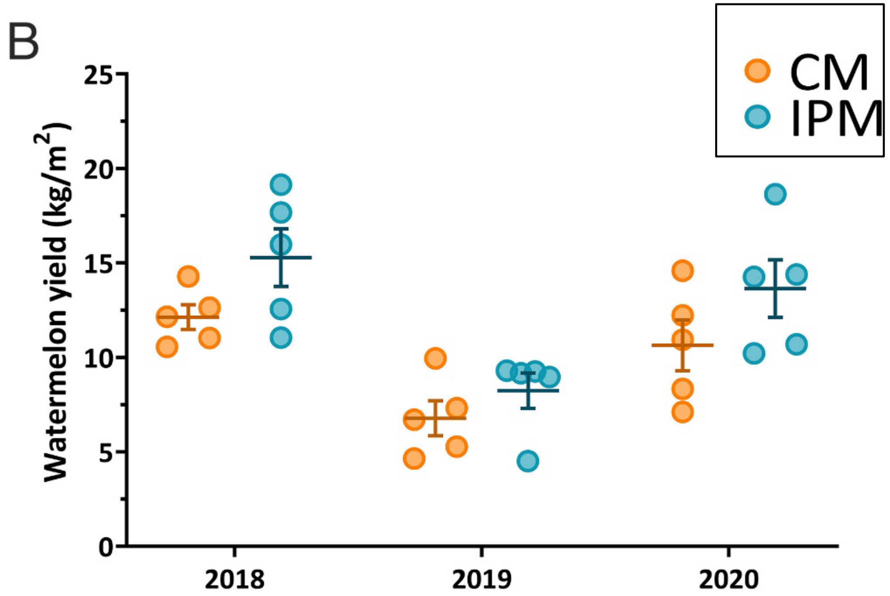
- **IPM** is best described **as a continuum** and not a single pest control method → to be effective, all the 4 pillars must be applied
- Scientific literature is rich in strategies developed to monitor and minimize pests' competition, **BUT** it's also difficult **to get farmers** to use all appropriate IPM techniques.

→ Possible alternatives are **effective**, **inexpensive** and «**ready to be used**» solutions, such as the **pesticides**

Conventional Management (CM)
5 sites * 3 years =
77 insecticide applications

Integrated Pest Management (IPM)
5 sites * 3 years =
4 insecticide applications

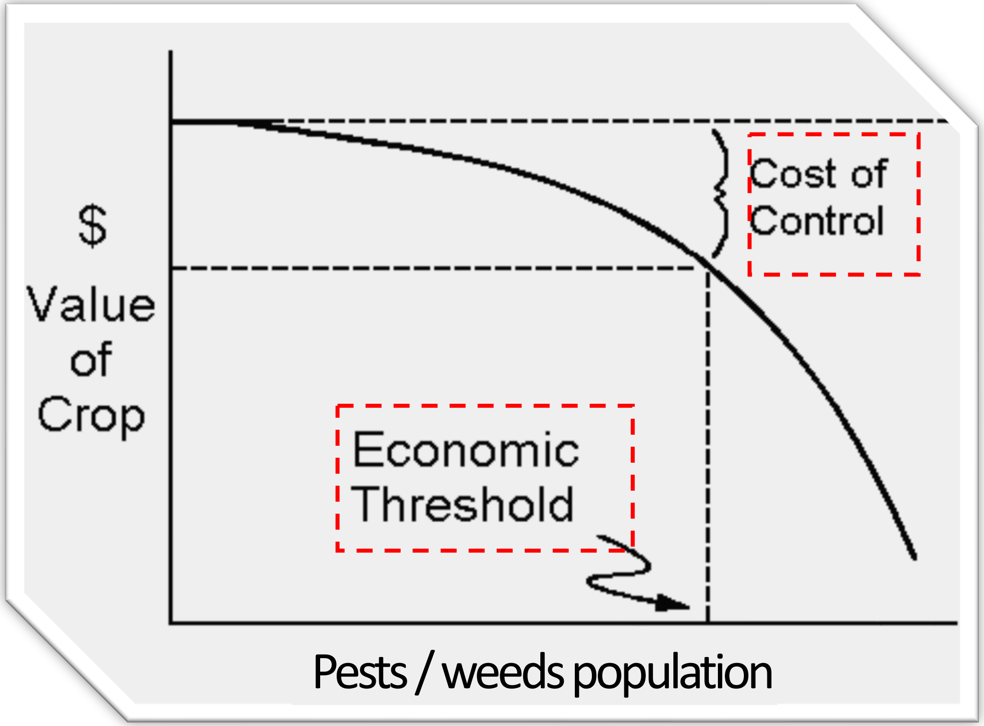




Watermelon yield was 25.7% higher in IPM (9.91 ± 0.84 kg/m2) than in CM (7.88 ± 0.63 kg/m2) fields

Pecenka *et al.*, (2021). IPM reduces insecticide applications by 95% while maintaining or enhancing crop yields through wild pollinator conservation. **PNAS**, 118 (44) e2108429118

INTEGRATED PEST MANAGEMENT (IPM)



For many important insect pests and plant disease **IPM has been reached remarkable results**

Common wheat cultivation

ITALIAN IPM GUIDELINES

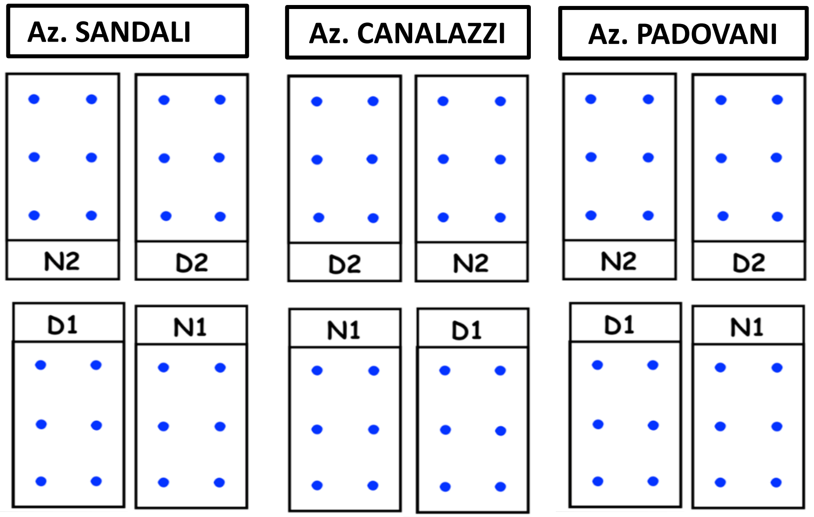
- insects and diseases: economic thresholds
- weed: list of active ingredients and maximum doses that can be applied

Provide a simple model and technical support, to avoid calendar-based herbicide applications, especially for weeds that don't warrant treatments

MATERIALS AND METHODS:

- **3 farms** located in Po Valley (Emilia Romagna Region, Northern Italy);
- **Two growing seasons** (2019/2020 and 2020/2021);
- The farms belong to the supply chain of a major Italian food company that produces pasta and baked goods.
- Data on **yield, protein content, % of impurities** in the harvested wheat **were collected**.
- **Costs of the herbicide treatments** will be used to verify the accuracy of the **predicted economic threshold.**

MATERIALS AND METHODS:



D=Treated ; N= Not treated

- A **randomized complete block design** with **2 replicate blocks**, comparing the herbicide treatment factor (treated and no-treated) was adopted;

- **At BBCH 23-30**, in **10 areas (1 m^2)** within **each experimental plot,** a **visual assessment** of weed species was realized

→ Type of weed

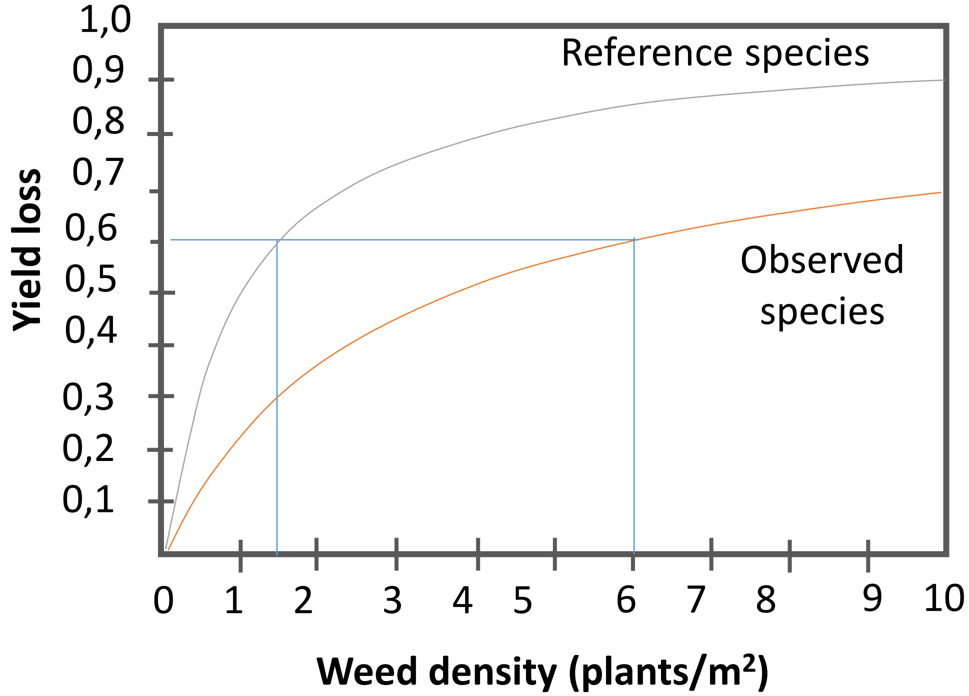
→ Number of plants for each type of weed

Weed species in wheat	**i**	**a**
Avena sterilis L. subsp. *ludoviciana*	0,013	0,372
Bromus sterilis	0,006	0,700
Galium aparine	0,029	0,650
Capsella bursa-pastoris	0,005	0,134
Lolium multiflorum	0,004	0,920
Papaver rhoeas L.	0,005	0,134
Veronica hederifolia L.	0,005	0,134

For weed, the **loss in yield** is estimated based on the ***a*** and ***i*** coefficients available for the main weed species (Berti *et al.,* 2001).

→ **i** and **a** are specific to a given crop-weed combination

MATERIALS AND METHODS:



(1) $$Y_L = \frac{i * D}{1 + \frac{i * D}{a}}$$

Y_L: predicted relative yield loss; **D:** weed density; ***i*** and ***a***: competitive index

(2) $$Deq_t = \sum \frac{i_i * D_i}{1 + i_i * D_i * \left(\frac{1}{a_i} + 1\right)}$$

Deq_t: total density equivalent, choosing a hypothetical specie as **reference** with *i* and *a* index equal to 1

(3) $$Y_L = \frac{Deq_t}{1 + Deq_t}$$

(4) $$E_L = Y_{WF} * P * Y_L$$

E_L : predicted economic loss; **Y_{WF}** : Yield weed free; **P:** sale price; **Y_L** : predicted relative yield loss

RESULTS – SANDALI 2020

VISUAL ASSESSMENT (20/02/2020)	HERBICIDE TREATED PLOTS - N plants/m²	NO TREATED PLOTS - N plants/m²
Avena spp.	1,11	1,15
Veronica spp.	6,25	4,05
Papaver rhoeas	0,00	0,10

TOTAL DENSITY EQUIVALENT (Deq_t)	**0,045**
PREDICTED RELATIVE YIELD LOSS (Y_L)	3,2 %

TREATMENT 22/02/2020	Floramix ™ (DowDuPont)
control a broad spectrum of mono- and dicotyledonous weeds by inhibiting the ALS enzymes (triazolopyrimidines) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	NO TREATED PLOTS
YIELD	7,5 ± 0,8 t/ha	7,5 ± 0,3 t/ha
PROTEIN CONTENT	12,7 ± 0,2 g/100g	13,1 ± 0,1 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	194 €/t	194 €/t

TREATED *vs* NO TREATED YIELD	**--**

PREDICTED ECONOMIC LOSS	**- 48 €/Ha**
COST of HERBICIDE TREATMENT	**69 €/Ha**
OBSERVED ECONOMIC DIFFERENCES	**-- €/Ha**

RESULTS – CANALAZZI 2020

VISUAL ASSESSMENT (20/02/2020)	HERBICIDE TREATED PLOTS - N plants/m^2	NO TREATED PLOTS - N plants/m^2
Avena spp.	0,15	0,00
Veronica spp.	3,4	1,60
Papaver rhoeas	1,00	0,20
Capsella bursa-pastoris	0,45	0,30
Lolium multiflorum	0,00	0,05
Galium aparine	0,00	0,05

TOTAL DENSITY EQUIVALENT (Deq_t)	**0,01**
PREDICTED RELATIVE YIELD LOSS (Y_L)	**- 3,7 %**

TREATMENT 22/02/2020	Floramix ™ (DowDuPont)
control a broad spectrum of mono- and dicotyledonous weeds by inhibiting the ALS enzymes (triazolopyrimidines) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	NO TREATED PLOTS
YIELD	8,2 ± 0,7 t/ha	7,8 ± 0,2 t/ha
PROTEIN CONTENT	11,2 ± 0,2 g/100g	11,3 ± 0,3 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	194 €/t	194 €/t

TREATED *vs* NO TREATED YIELD	**- 4,1 %**

PREDICTED ECONOMIC LOSS	**- 63 €/Ha**
COST of HERBICIDE TREATMENT	**69 €/Ha**
OBSERVED ECONOMIC DIFFERENCES	**- 68 €/Ha**

RESULTS – PADOVANI 2020

VISUAL ASSESSMENT (26/02/2020)	HERBICIDE TREATED PLOTS - N plants/m^2	NO TREATED PLOTS - N plants/m^2
Avena spp.	0,80	1,60
Veronica spp.	0,85	0,60
Papaver rhoeas	0,30	0,45
Alopecurus myosuroides	0,05	0,05
Senecio vulgaris	0,10	0,00

TOTAL DENSITY EQUIVALENT (Deq_t)	**0,03**
PREDICTED RELATIVE YIELD LOSS (Y_L)	**- 2,5 %**

TREATMENT (11/03/2020)	CELIO ® (Gowan)+ BIATHLON 4D ® (BASF)
CELIO: control of monocotyledonous weeds (clodinafop); BIATHLON 4D: control of dicotyledonous weeds (tritosolfuron) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	NO TREATED PLOTS
YIELD	8,9 ± 0,2 t/ha	8,1 ± 0,6 t/ha
PROTEIN CONTENT	12,4 ± 0,9 g/100g	11,7 ± 0,2 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	194 €/t	194 €/t

TREATED *vs* NO TREATED YIELD	**- 4,1 %**

PREDICTED ECONOMIC LOSS	**- 42 €/Ha**
COST of HERBICIDE TREATMENT	**67 €/Ha**
OBSERVED ECONOMIC DIFFERENCES	**- 161 €/Ha**

RESULTS - SANDALI 2021

VISUAL ASSESSMENT (02/03/2021)	HERBICIDE TREATED PLOTS - N plants/m²	NO TREATED PLOTS - N plants/m²
Avena spp.	0,0	0,0
Veronica spp.	4,8	0,0
Papaver rhoeas	1,8	0,2

TOTAL DENSITY EQUIVALENT (Deq_t)	**0,0**
PREDICTED RELATIVE YIELD LOSS (Y_L)	**0 %**

TREATMENT 02/03/2021	**FLORAMIX TM (DOWDUPONT) + WETTING PLUS**
control a broad spectrum of mono- and dicotyledonous weeds by inhibiting the ALS enzymes (triazolopyrimidines) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	NO TREATED PLOTS
YIELD	6,1 ± 1,4 t/ha	6,3 ± 0,5 t/ha
PROTEIN CONTENT	14,7 ± 0,6 g/100g	14,0 ± 1,2 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	280 €/t	280 €/t

TREATED *vs* NO TREATED YIELD	**+ 3%**

PREDICTED ECONOMIC LOSS	**0 €/Ha**
COST of HERBICIDE TREATMENT	**77 €/Ha**
OBSERVED ECONOMIC DIFFERENCES	**+79 + €/Ha**

RESULTS – CANALAZZI 2021

VISUAL ASSESSMENT (02/03/2021)	HERBICIDE TREATED PLOTS - N plants/m²	NO TREATED PLOTS - N plants/m²
Avena spp.	0,00	0,00
Veronica spp.	5,20	2,50
Papaver rhoeas	0,20	0,05
Lactuca serriola	0,60	0,00
Galium aparine	0,00	0,05

TOTAL DENSITY EQUIVALENT (Deq_t)	**0,04**
PREDICTED RELATIVE YIELD LOSS (Y_L)	**1,1%**

TREATMENT 02/03/2021	TIMELINE TRIO (ADAMA)
inhibiting the ACCasi and ALS enzymes (triazolopyrimidines) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	NO TREATED PLOTS
YIELD	8,8 ± 0,5 t/ha	8,4 ± 0,1 t/ha
PROTEIN CONTENT	10,9 ± 0,3 g/100g	10,4 ± 0,2 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	210 €/t	210 €/t

TREATED *vs* NO TREATED YIELD	- 5,2 %

PREDICTED ECONOMIC LOSS	- 80 €/Ha
COST of HERBICIDE TREATMENT	84 €/Ha
OBSERVED ECONOMIC DIFFERENCES	-116 €/Ha

RESULTS – PADOVANI 2021

VISUAL ASSESSMENT (02/03/2021)	**HERBICIDE TREATED PLOTS - N plants/m^2**	**NO TREATED PLOTS - N plants/m^2**
Avena spp.	1,50	1,00
Veronica spp.	0,55	0,05
Papaver rhoeas	0,15	0,05

TOTAL DENSITY EQUIVALENT (Deq$_t$)	**0,01**
PREDICTED RELATIVE YIELD LOSS (Y_L)	**-1,3 %**

TREATMENT 04/03/2021	**CELIO ® (Gowan)+ BIATHLON 4D ® (BASF)**
CELIO: control of monocotyledonous weeds(clodinafop); BIATHLON 4D: control of dicotyledonous weeds (tritosolfuron) – NO RESIDUAL ACTIVITY	

	HERBICIDE TREATED PLOTS	**NO TREATED PLOTS**
YIELD	6,13± 0,8 t/ha	5,2 ± 0,3 t/ha
PROTEIN CONTENT	11,3 ± 0,1 g/100g	11,8 ± 0,2 g/100g
% of IMPURITIES	<< 1%	<< 1%
SELLING PRICE OF GRAIN	261 €/t	261 €/t

TREATED *vs* NO TREATED YIELD	**- 4,1 %**

PREDICTED ECONOMIC LOSS	**- 76 €/Ha**
COST of HERBICIDE TREATMENT	**75 €/Ha**
OBSERVED ECONOMIC DIFFERENCES	**- 232 €/Ha**

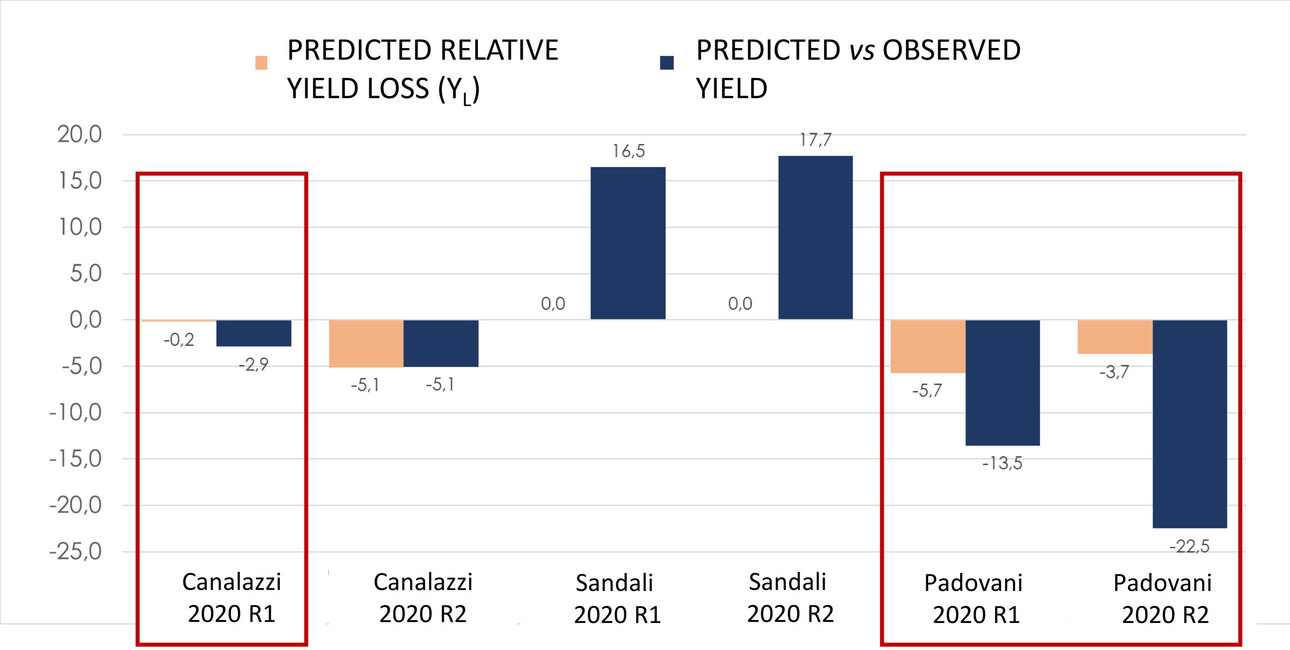
RESULTS - EFFECTIVENESS OF THE PREDICTION MODEL

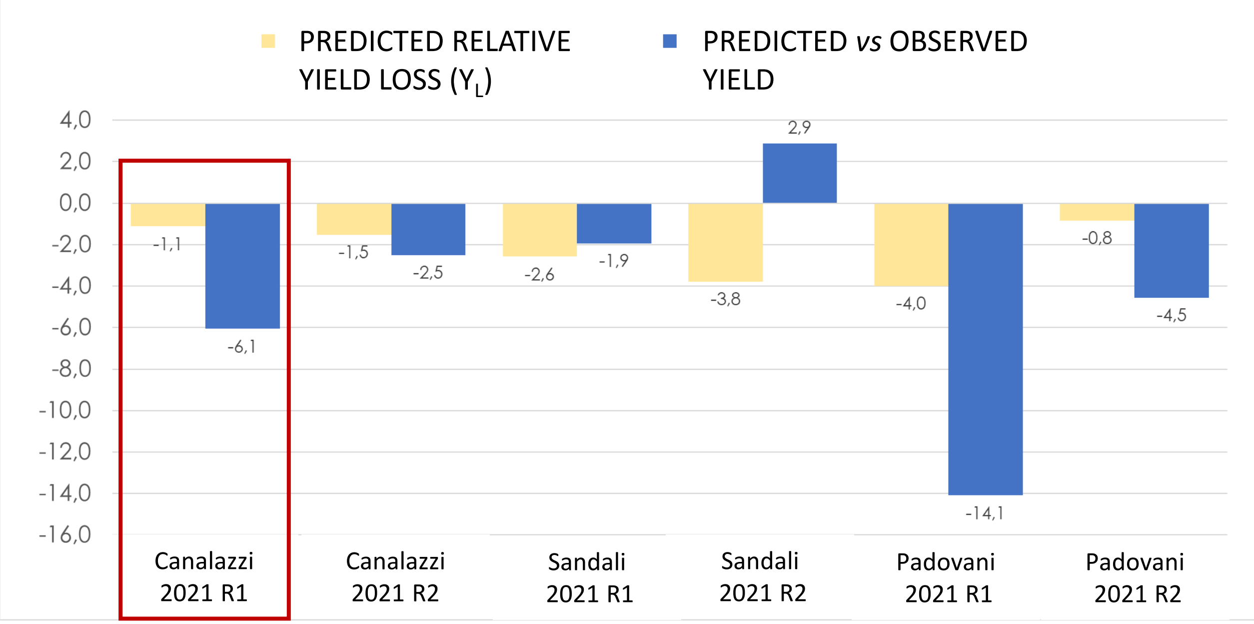
✓ NOT significant differences on impurities, yield and protein content between treated and no-treated theses

	% of impurities (w/w)	**Yield (t/ha)**	**Protein content (g/100g)**
	ns	**ns**	**ns**
Herbicide treated	<1%	7,51	11,7
No-treated	<1%	7,20	11,7

✓ Considering each replication of the field trials (12 in total), the model made **congruent predictions in 8 out of 12** cases; however, in terms of economics, the prediction model did not always match the objectives.

- visual surveys should be carried out shortly before treatment
- pay attention to *Avena* spp. → probably useful to increase the number of sampling





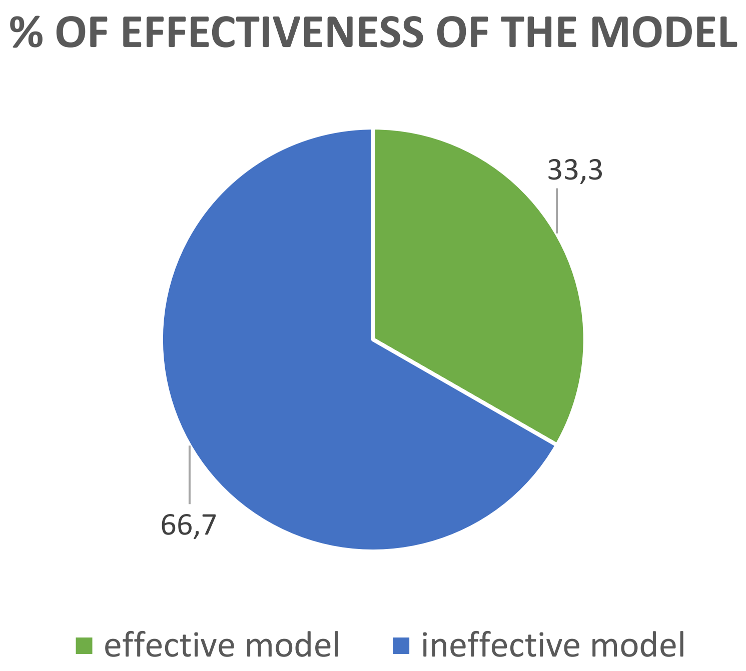
CONCLUSIONS

The model under consideration **provides results that appear promising**

→ **INCREASE DATASET**: observed data **are certainly preliminary** (3 farms examined, and 2 growing season);

→ **UPDATE** i and a coefficient

→ **AUTOMATE** weed survey → very difficult challenge for wheat weeds



- Currently the biggest **obstacle to IPM adoption** is the **excessively low cost of pesticides** → **no farmer accepts a risk for a such little marginality.**
- To make the system sustainable, health and environmental impacts would need to be factored **into the cost of the pesticide products.**
- To be effective, change must involve **farmers** and their **production chain**


Thank you for your attention
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