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**DIRECTORATE-GENERAL FOR AGRICULTURE AND
RURAL DEVELOPMENT
CIVIL DIALOGUE GROUP ARABLE CROPS**

**Integrated Pest Management: principles and practical
implementations in annual crops**



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**IS IT POSSIBLE TO
PRODUCE GOOD
AGRICULTURAL
PRODUCTS
KEEPING/IMPROVING
FARMERS' NET INCOME
BY SIGNIFICANTLY
REDUCING PESTICIDE
USE?**

TWO WAYS

**1) USING PESTICIDES ONLY
WHERE/WHEN IS NEEDED = IPM
(Integrated Pest Management)**

**2) USING OTHER (NON-CHEMICAL)
EFFECTIVE STRATEGIES (=IPM)
WHEN/WHERE A ECONOMIC
POPULATION OCCURS**

IPM THE KEY TOOL

IPM ACCORDING TO DIRECTIVE 2009/128/EC

1. Before any decision on pest control is taken, harmful organisms must be monitored with adequate methods and tools, where available; tools should include observations in the field as well as scientifically sound warning, forecasting and early diagnosis systems.
2. Crops may only be treated when and where the assessment has found that levels exceed set economic thresholds.

Prophylactic use of insecticides is strongly against IPM

1. When economic thresholds are exceeded, agronomic solutions, mainly rotation, should be considered to prevent crop damage, as tillage timing, choice and changing of sowing dates, and crop rotation interfere with newly established pest populations.

IPM ACCORDING TO DIRECTIVE 2009/128/EC

4. When economic thresholds are exceeded and no agronomic solutions are available, biological control, physical treatment or another non-chemical pest control method should be considered as a replacement for chemical treatment.
5. When economic thresholds are exceeded and no agronomic solutions, biological controls, physical treatments or other non-chemical pest control methods are available, chemical treatments should be selected from options that pose the lowest risk to the environment and human health. It should be used so that the risk of pest resistance is minimised

CONDITIONS NEEDED

A) LOW COST STRATEGIES

B) NON-TIME CONSUMING TOOLS

C) SUSTAINABLE TECHNICAL
TOOLS

ESSENTIAL FOR ARABLE CROPS

A) LOW INCOME CROPS

B) LOW MANPOWER AVAILABILITY

C) GENERAL LOW TECHNICAL KNOWLEDGE

D) DIFFERENTLY FROM
ORCHARDS/VINEYARDS (LONG TRADITION)
LITTLE TRADITION/EXPERIENCE ABOUT
MONITORING AND IPM

TO HAVE LOW COSTS TWO PHASES

- 1) AREA-WIDE LEVEL (e.g.
monitoring, risk
assessment, geostatistics,...)
- 2) COMPLEMENTARY LIMITED IN
FIELD EVALUATION

WHICH PESTICIDES?

1) HERBICIDES

2) FUNGICIDES

3) SOIL INSECTICIDES

4) FOLIAR INSECTICIDES

IS IT ACTUALLY FEASIBLE IPM?

CRITERIA TO ASSESS IPM FEASIBILITY

- 1) WHAT IS THE RISK LEVEL (RISK ASSESSMENT)?
 - 1a) ARE PEST POPULATIONS LEVELS ABOVE CRITICAL THRESHOLDS EVERYWHERE AND ARE TREATMENTS NEEDED ON ALL FIELDS OR ONLY ON A FEW OF THEM?
 - 1b) ARE MONITORING SYSTEMS IN PLACE AND THRESHOLDS KNOWN?
- 2) ARE ALTERNATIVE MANAGEMENT STRATEGIES TO PESTICIDES (AGRONOMIC AND/OR BIOLOGICAL AND/OR MECHANICAL OR ANY OTHER NON-CHEMICAL SOLUTIONS) AVAILABLE?

MAIZE CASE STUDY

HERBICIDES

CAN INTEGRATED WEED MANAGEMENT BE IMPLEMENTED?

1. What is the risk level? **High**
2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic and/or biological alternatives)? **Yes, there are very effective non-chemical methods alternative to herbicides**

BAND APPLICATION IN PRECISION FARMING



1



2



3



4



5

HERBICIDE REDUCTION > 80%!!!!

FUNGICIDES

FUNGICIDES

1. What is the risk level? long-term experiments showed that fungicide treatment is not always essential; minor part of fields had rotten seedlings or young plants; fungicide should not be used prophylactically in order to limit the risk of resistant fungi populations developing
2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic and/or biological alternatives)? Yes, risk factors and monitoring methods available; consequent practical guidelines to be established; promising microbial consortia (mainly antagonists like *Trichoderma*) as biological treatments

SOIL INSECTICIDES

MAIZE PESTS AT EARLY STAGES

VIRUSES TRANSMITTED BY INSECTS



Neonics effective but diseases have low incidence, hybrids are usually resistant – resistant hybrids as effective as neonicotinoids

Furlan L, Chiarini F, Balconi C, Lanzasova C, Torri A., Valoti P, Alma A, Saladini MA, Mori N, Davanzo M, Colauzzi M (2012) Possibilità di applicazione della difesa integrata per il controllo delle virosi nella coltura del mais, Apoidea, 1-2, 39 – 44.

OTHER ANIMALS

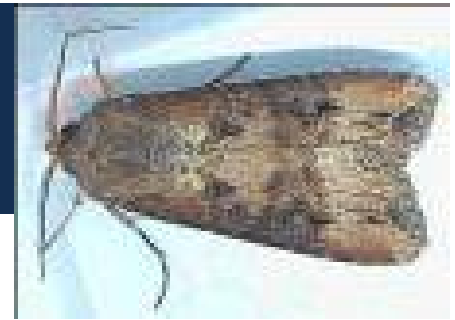


Other solutions

INSECTS AND OTHER ARTHROPODS



BLACKCUTWORMS



- *Agrotis ipsilon* – migrant, most important, *Agrotis segetum*
- OCCASIONAL ATTACKS
- LOW ECONOMIC DAMAGE
- ATTACKS NOT PREDICTABLE at sowing
- NEGLIGIBLE CONTROL BY SOIL INSECTICIDES (ALSO AS SEED COATING) WHEN NEEDED
- BCW ALERT PROGRAMME (Pheromone traps monitoring and DD accumulation – **AREA WIDE LEVEL**) PREDICTS WHERE AND WHEN POST-EMERGENCE TREATMENTS MAY BE NEEDED (HERE SCOUTING TO DECIDE - **COMPLEMENTARY LIMITED IN FIELD EVALUATION**)



UNJUSTIFIED AT SOWING TREATMENTS

BLACK CUTWORMS: CAN IPM BE IMPLEMENTED?

1. What is the risk level? **Low, < 1%**
2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic [and/or biological alternatives)? **Yes, black cutworm alert programme producing accurate results in Italy since 1991**

WCR - DIABROTICA

- POPULATIONS BELOW ECONOMIC THRESHOLD IN MOST OF THE EUROPEAN MAIZE FIELDS
- ROTATION THE ONLY FULL EFFECTIVE STRATEGY (provisions of directive 128/2009/CE give solution)
- ROTATION MAY BE EFFECTIVE EVEN AS “SOFT” MODALITY (1 YEAR OUT OF 3 OR MORE YEARS)
- AVAILABLE SOLUTIONS FOR ROTATION THAT DO NOT REDUCE GROSS MARGIN OF LIVESTOCK/BIOGAS FARMS
- TREATMENTS AT SOWING DO NOT SIGNIFICANTLY AFFECT WCR POPULATION DYNAMICS
- POSSIBILITY OF INSECTICIDE FAILURE WHEN POPULATIONS ARE REALLY HIGH

UNJUSTIFIED AT SOWING TREATMENTS

WCR - DIABROTICA

**THRESHOLD 6 beetles/trap/day
over a 3 – 6 week period**

WCR - diabrotica

KEY QUESTION: IS IT POSSIBLE IPM?

- 1) WHAT IS THE RISK LEVEL? **LOW**
- 2) ARE IPM STRATEGIES (MONITORING METHODS, RISK ASSESSMENT, THRESHOLDS FOR KEY PESTS, AGRONOMIC (FIRST OF ALL ROTATION) – NON CHEMICAL SOLUTIONS,.....) AVAILABLE?

**It can be kept below economic threshold by “soft” rotation
ROTATION IS THE FIRST OPTION FOR IPM BASED ON
DIRECTIVE 2009/128/CE IPM OF DIABROTICA ONLY
MEANS THE IMPLEMENTATION OF RATIONAL ROTATION
WITHOUT ANY CHEMICAL TREATMENTS (AT SOWING
OR LATER AGAINST BEETLES)**

WIREWORMS

AVAILABLE TOOLS FOR IPM

- A) RISK FACTORS
- B) PHEROMONE TRAPS
- C) BAIT TRAPS
- D) AGRONOMIC STRATEGIES
- E) BIOCIDAL PLANTS AND MEALS
- F) OTHER BIOLOGICAL TREATMENTS

PLANTING CROPS WHERE
AND WHEN THERE IS NO
SERIOUS ECONOMIC
DAMAGE RISK

1) AREA-WIDE LEVEL – A) RISK FACTORS

1. **HIGH SOIL ORGANIC MATTER CONTENT (> 5%)**
2. **CONTINUOUS PLANT COVER**
(meadow, double crops as rye grass-maize, canola-soybean,...);
3. **LANDSCAPE** with high incidence of uncultivated zones like grasses, forest and fields with continuous cover as above....
4. **Prevalent species (e.g. *A.brevis* harmfulness > *A.sordidus* >>> *A.ustulatus*) information using pheromone traps (Yf)**
5. **Poor drainage (USDA definition)**
6. **Cover-crops**
7. **Sowing date (late)**

AREA-WIDE LEVEL

B) PHEROMONE TRAPS YATLORf

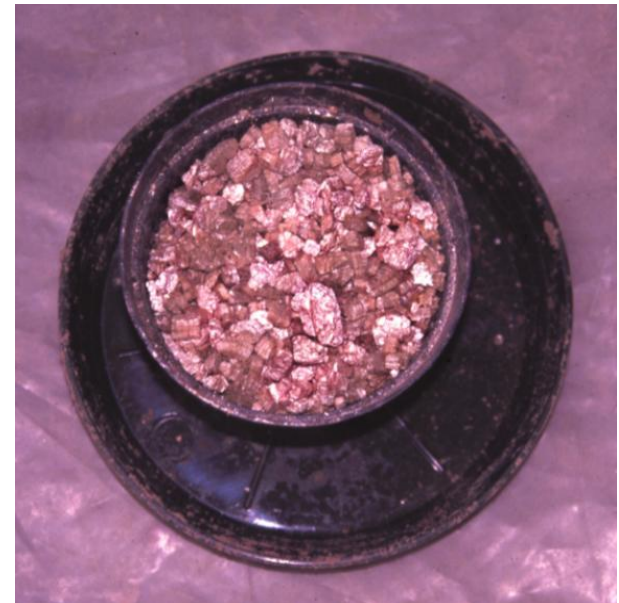
- **RELIABLE (NON SATURABLE)**
- **FEW INSPECTIONS**
- **EASY, QUICK MANAGEMENT**
- **LOW COSTS**
- **MULTIBAITED (MORE SPECIES MONITORED AT THE SAME TIME BY ONE TRAP)**



2) BAIT TRAPS FOR COMPLEMENTARY LIMITED IN FIELD EVALUATION

**a) IF AND WHERE THERE IS A RISK
OF ECONOMIC POPULATIONS
PLACING BAIT TRAPS**

**b) EVALUATION OF
LARVAL THRESHOLDS**



wireworm species	wireworm catches (larvae/trap)	sampled fields	fields with yield reduction (maize)	%
<i>Agriotes ustulatus</i>	0-1	64	0	0,0
	1,01-2	7	0	0,0
	2,01-5	9	0	0,0
	5,01-10	9	1	11,1
	>10,01	5	2	40,0
<i>Agriotes brevis</i>	0-1	54	0	0,0
	1,01-2	6	2	33,3
	2,01-5	7	4	57,1
	> 5,01	3	1	33,3
<i>Agriotes sordidus</i>	0-1	113	0	0,0
	1,01-2	10	0	0,0

Furlan, L. (2014) IPM thresholds for *Agriotes* wireworm species in maize in Southern Europe. J Pest Sci , DOI 10.1007/s10340-014-0583-5.

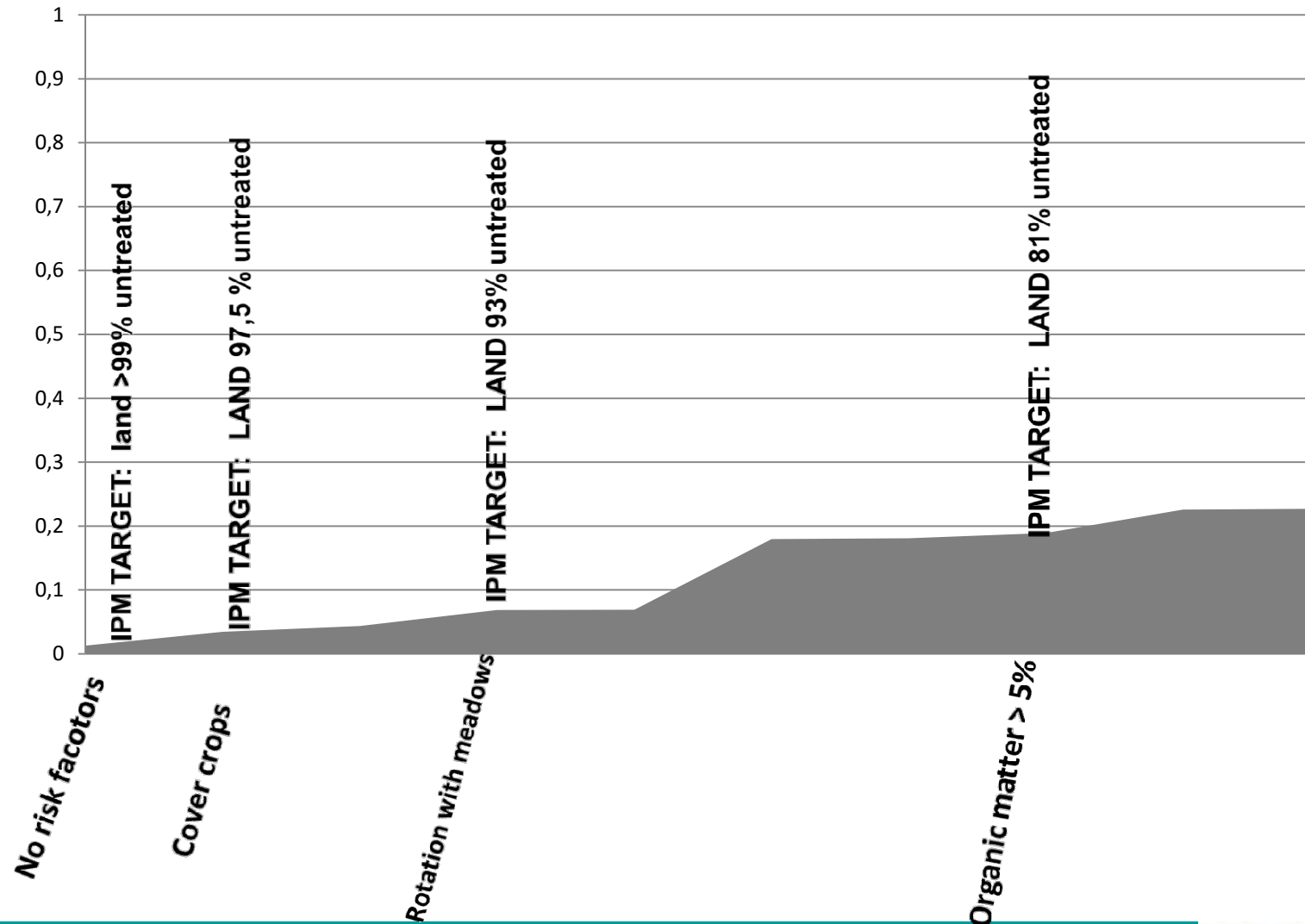
WIREWORMS: CAN IPM BE IMPLEMENTED?

1. What is the risk level? **Low**
2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic and/or biological alternatives)? **Yes**

WHAT THE ACTUAL SOIL PEST RISK FOR MAIZE?

A 30 Ys DATA SET (NORTH EAST ITALY) MAKES CLEAR
THAT A RISK OF YIELD REDUCTION OCCURS IN LESS
THAN 4% OF THE CULTIVATED LAND
(Confirmations in other Italian Regions and Europe; see
<http://www.reterurale.it/apenet> and <http://www.pure-ipm.eu/project>)

AN EXAMPLE: Estimated *damage probability* based on multifactorial risk assessment analysis for *A. sordidus* and targets for IPM



**WHEN RISK IS LOW THE INSURANCE
APPROACH IS CONVENIENT FOR
FARMERS AND MUCH SAFER FOR
PEOPLE & THE ENVIRONMENT
(INCLUDING BEES)**

**A INSURANCE APPROACH MUCH BETTER
THAN INSECTICIDES**

INSURANCE APPROACH vs PESTICIDE APPROACH

ASSUMPTIONS (prudential) for 100 ha of arable crops: 1) Mutual fund cost (MF) 5 €/ha; 2) soil insecticides cost 40 €/ha; 3) the highest damage cost 500 €/ha on 4 ha out of 100; 4) **soil insecticides efficacy 100%**

STRATEGY	MF (ha)	soil insecticides (ha)	IPM COST (€)	MF COST (€)	insecticide cost (€)	damage cost (€)	TOTAL COST (€)	COST DIFFERENCE MF vs insecticides	Effects on humans/ environment	compliance with directive 2009/128/CE	Syntetic general evaluation (1 to 5 stars)
Mutual funds only	100	0	0	500	0	2000	2500	-1500	no	yes	*****
IPM with mutual funds based on risk factors	100	20	100	500	800	0	1400	-2600	reduced	partial	***
IPM with mutual funds based on risk factors + monitoring	100	10	1000	500	400	0	1900	-2100	very reduced	yes	****
soil insecticides (prophylactic use)	0	100	0	0	4000	0	4000	=	yes	no	*

PRACTICAL IMPLEMENTATION



CONDIFESA
VENETO

CONDIFESA FVG



**AGRIFONDO
MUTUALISTICO**

Associazione Mutualistica Dei Condifesa
Del Veneto E Friuli V.G.
(PRIVATE ASSOCIATION OF FARMERS)



**MAIZE
MUTUAL FUND
SINCE 2014**



MUTUAL FUND

Instrument **managed by collective of farmers**
aimed to create a compensation and to balance the risk trough an interregional distribution of risks

No profit, vehicle of innovation with transparency rules



Compensation commensurate with the financial resources of the Fund

Fund stock increased by savings in forecast costs

Solutions that are not offered by the traditional insurance market

RISKS COVERED	<ul style="list-style-type: none"> • Insufficient plant density (stand) due to adverse weather conditions (i.e. drought, flooding, freezing cold) • Insufficient plant density (stand) due to soil pests (e.g. wireworms, black cutworms), or diseases, such as Fusarium spp. (rotten roots, seedlings) • Diabrotica (WCR) damage
TARGET	Members of farmer consortia
OBLIGATIONS	<ul style="list-style-type: none"> • Contract to be signed before sowing; • Implementation of good cultivation practices; • Implementation of Directive 128/2009/EC; • Connection and implementation of suggestions in “Arable Crops Bulletin”
COSTS	€ 5/ha all inclusive (including flooding [excessive rain], freezing cold, drought); pest risk alone is covered with less than € 5/ha
COMPENSATION	<p>Up to € 500/ha including:</p> <ul style="list-style-type: none"> • Resowing (up to € 250/ha) if stand below 4 pls/m² • Yield reduction (up to € 250/ha) based on sowing delay, crop change • up to € 1000/ha for WCR damage

RESULTS 2015

- 1) 53.000 ha with MF cover
- 2) **COST:** 3,5 €/ha (TEN TIMES LESS THAN A SOIL INSECTICIDE)
- 3) **TOTAL REVENUE** TO COVER DAMAGE BY
WIREWORMS, DIABROTICA, WILD FAUNA AND OTHER MINOR
PITFALLS 188.000 €
- 4) TOTAL DAMAGE PAID 80.500 € (25.000 € for wireworm damage)
- 5) SIGNIFICANT INCREASE OF **MF STOCK** FOR NEXT YEARS

RESULTS

**DETAILED STUDY OF A REPRESENTATIVE AREA (450 HA)
INCLUDING RISK FACTORS WITH a) UNTREATED
MONITORED FIELDS OR b) WITH UNTREATED AND
TREATED STRIPS WHERE SIGNIFICANT PEST
POPULATIONS HAD BEEN FOUND (2014-2015)**

Hectares with economic damage: 2014: 0,56% - 2015: 0,00 %

Value of yield reduction: 2014: 700 €/100 ha - 2015: 0,00 %

Value of yield reduction average 2014 – 2015

350 €/100 ha

ADVANTAGES OF MUTUAL FUNDS

1. Reduces costs/ha;
2. Covers risks due to mistakes or difficulties in IPM implementation (e.g. delay in black cutworm treatments);
3. Covers other risks, e.g. flooding and drought, not covered by insecticides;
4. Reduces health risk for farmers, as there is no contact with insecticides;
5. No negative impact of insecticides on soil beneficials;
6. No pollution risks for soil and water tables;

ADVANTAGES OF MUTUAL FUNDS

7. No risk to bees and other wild pollinators; more generally, reduces risk to fauna;
8. Covers weather risks, including weather causing soil insecticides to fail (Furlan *et al.* 2011, Ferro and Furlan, 2012, Furlan *et al.* 2014).

Furlan L., Benevegnu' I, Cecchin A., Chiarini F., Fracasso F., Sartori A., Manfredi V, Frigimelica G., Davanzo M., Canzi S., Sartori E., Codato F., Bin O., Nadal V., Giacomel D, Contiero B (2014) *Difesa integrata del mais: come applicarla in campo*. L'Informatore Agrario, 9, Supplemento Difesa delle Colture, 11-14.

Furlan L., Cappellari C., Porrini C., Radeghieri P., Ferrari R., Pozzati M., Davanzo M., Canzi S., Saladini M.A., Alma A., Balconi C., Stocco M. (2011) *Difesa integrata del mais: come effettuarla nelle prime fasi*. L'Informatore Agrario, 7, Supplemento Difesa delle Colture: 15 – 19.

Ferro G., Furlan L. (2012) *Mais: strategie a confronto per contenere gli elateridi*, 42, L'Informatore Agrario, 42, Supplemento Difesa delle Colture: 63 – 67.

SOME SUCCESSFUL LONG TERM CASE STUDIES IN SINGLE FARMS

Az. Moizzi Luciana, Eraclea (Venice)

Cultivated land: 145 ha
Reclaimed soil (1920, below sea level)
Silty loam soil, 2-3% organic matter

Conventional tillage
Rotation: winter wheat, maize, soybean
(small surface with sugar beet, 10-15 ha,
same fields every 10-12 years)

SOME SUCCESSFUL CASE STUDIES

Az. Moizzi, Italy: Results

A. brevis: negligible populations;

A. litigiosus: negligible populations;

A. sordidus: low populations (beetles < 300; larvae 0 to 0.2/tr);

A. ustulatus: 10% of the surface with high beetle-population > 1500 beetles/season; wireworm density above threshold in 3 years, total 9 ha.

SOME SUCCESSFUL CASE STUDIES

Az. Moizzi Luciana, Eraclea (Venice)

Monitoring each year 1984 - 2015

Soil sampling in the first few years

Bait traps (larvae) from 1992

Pheromone traps (adults) from 1996

SOME SUCCESSFUL CASE STUDIES

Az. Moizzi, Italy: Results

1. More than 1,600 hectares of maize untreated, i.e. no soil insecticide, (1984-2015);
1. 9/1600 ha (0.56%) with economic populations (solution: replace maize with other crops);
2. Seed/plant damage always below 5% (usually 0.1% to 2.5%);
1. No economic damage: 96% of fields with high stand ($> 90\%$ of sown seeds). Some cases of stand reduction ($< 5 \text{ pp/m}^2$), mainly due to bird damage;
1. More than € 55,000 saved, no threat to worker health, and no environmental impact.

VENETO AGRICOLTURA OPEN FARMS - OPEN PROTOCOLS

2009 – 2015

No soil insecticides

600 ha land /y farmed for 7 years

180 ha maize /y for 7 years

> 1300 ha maize farmed over 7 years

No economic damage by soil insects

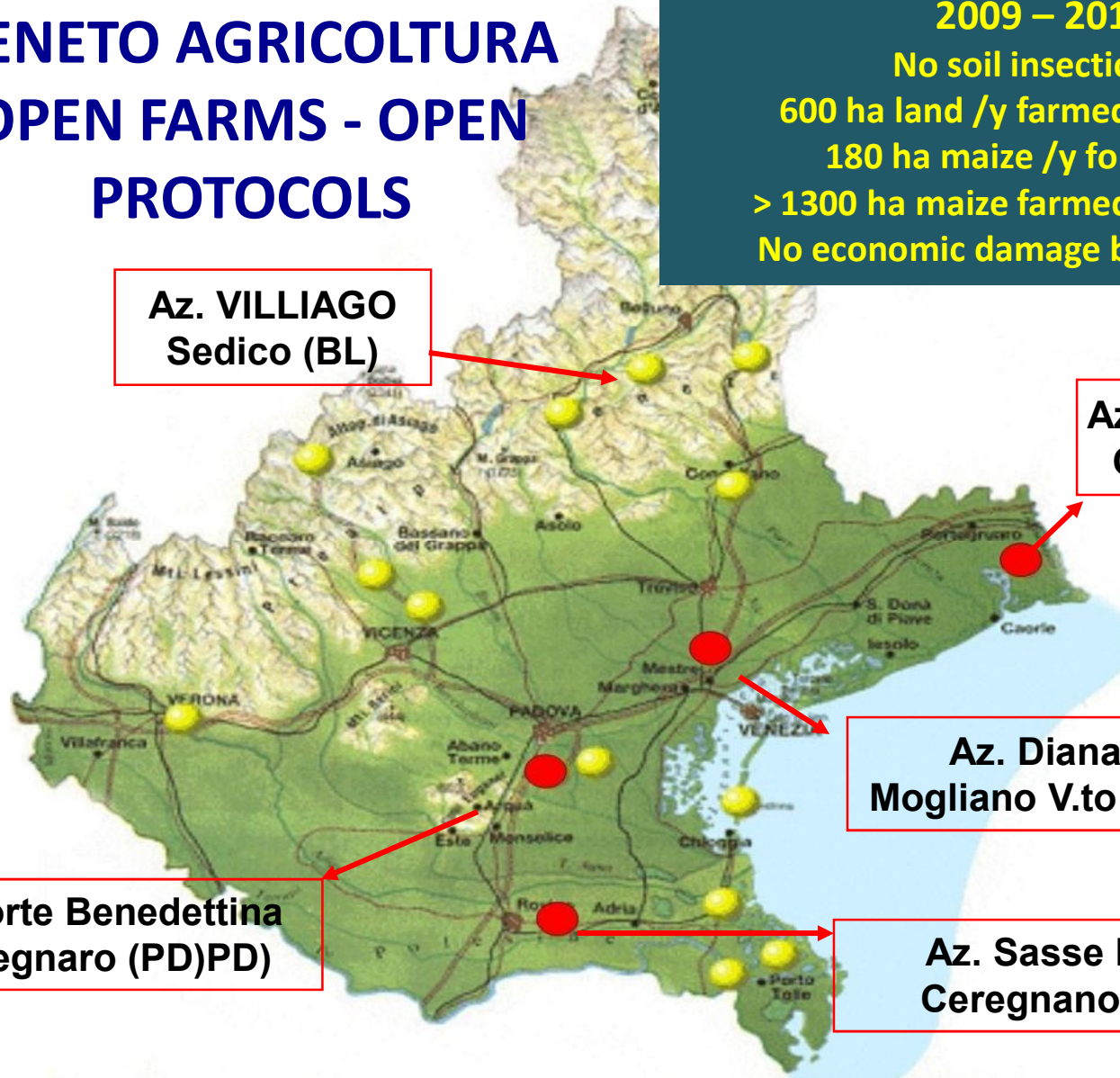
**Az. VILLIAGO
Sedico (BL)**

**Az. Vallevecchia
Caorle (VE)E**

**Az. Diana
Mogliano V.to (TV)**

**Corte Benedettina
Legnaro (PD)PD)**

**Az. Sasse Rami
Ceregno (RO)**



WHAT CAN GOVERNMENT INSTITUTIONS DO TO MAKE EFFECTIVE IPM IMPLEMENTATION?

- 1) SUPPORT RISK ASSESSMENT STUDIES FOR ALL THE CROPS TO IMPROVE IPM STRATEGIES AND COST EVALUATION FOR MUTUAL FUNDS
- 2) GIVE PRECISE TARGETS FOR IPM (e.g. maximum % of cultivated land that may be treated with soil insecticides in each MS or region)
- 3) GIVE FEASIBLE CONTRIBUTIONS TO MUTUAL FUNDS IN ORDER TO “TURN THE KEY” IMMEDIATELY
- 4) SUPPORT INDEPENDENT ADVISORY SYSTEM
- 5) SUPPORT APPLIED RESEARCH FOR PRACTICAL SOLUTIONS AND KNOWLEDGE TRANSFER – A DRAMATIC CHANGE IS IMMEDIATELY POSSIBLE – JUST A QUESTION OF WILLINGNESS

WHICH OTHER CROPS WITH THIS APPROACH?

Sunflower
canola
Winter wheat,.....

**AND WHAT ABOUT OTHER CROPS
WITH MEDIUM/HIGH RISK PESTS???**

**MUTUAL FUNDS TO COVER THE RISK
OF IPM IMPLEMENTATION**

SPECIFIC PROTOCOLS UNDER STUDY