EUROPEAN COMMISSION

GDC CULTURES ARABLES

CÉRÉALES, OLÉAGINEUX + FOURRAGES SÉCHÉS

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Mutual Funds an essential support to Integrated Pest Management (IPM) implementation

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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.

3. 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

AN IMPORTANT CASE STUDY: ARABLE CROPS/MAIZE

IPM ACCORDING TO DIRECTIVE 128/2009/EC ON ARABLE CROPS: A TOUGH CASE

Although most pesticides worldwide are applied to control arable-crop parasites

IPM IS NOT USED EXTENSIVELY ON ARABLE CROPS
(but is widely implemented on other crops, e.g. orchards).

Therefore:

- ARABLE CROPS (e.g. maize) make it tougher to implement Directive 2009/128/EC properly.
- A SPECIAL EFFORT is needed to make the directive work for arable crops.

IPM OF ARABLE CROPS

A REVOLUTION

IPM OF ARABLE CROPS

- Low-income crops;
- Little manpower available;
- General low technical knowledge;
- Little tradition/experience of monitoring and IPM, unlike in orchards/vineyards.

REQUIREMENTS

- Low-cost strategies;
- Time-saving tools;
- Sustainable technical tools.

REQUIREMENTS

Do we have the knowledge to implement IPM of arable crops?

REQUIREMENTS

- Area-wide observations (low cost/ha);
- Complementary limited in-field evaluation, where needed.

REQUIREMENTS AT AREA-WIDE LEVEL

- Mainly semio-chemical based tools;
- Statistical evaluation methods (e.g. Geostatistics);
- Meteorological information / forecasting models;
- Agronomic information.

BASIC STRATEGIES

- Real-time dissemination of area-wide and model information by email/text;
- Technician training.

MAIN MODELS

- **WEED IPM**: ALERTINF EMERGENCE PATTERNS OF THE MAIN WEEDS (PADUA UNIVERSITY);
- **WCR IPM:** WCR EGG AND LARVAL DEVELOPMENT (DAVIS);
- **WCR IPM:** ADULT/FEMALE DEVELOPMENT PATTERNS (NOWATZKY);
- **BLACK CUTWORM ALERT PROGRAMME:** IOWA UNIVERSITY (ADAPTED TO ITALY);
- **ECB:** POPULATION DEVELOPMENT;
- **CROPS:** CROP DEVELOPMENT PATTERNS (CROPSYST);
- **FUSARIUM CEREALS**: DISEASE PATTERNS (BEING DEVELOPED);

PESTICIDES AND HARMFUL ORGANISMS

- Soil insecticides (e.g. wireworms, WCR);
- Herbicides;
- Post-emergence insecticides (e.g. to fight black ECB);
- Fungicides (e.g. seedling diseases, *Fusarium*).

CAN IPM BE USED?

For each combination crop/agronomic-climatic conditions we need to answer the following questions:

1. What is the risk level? Do population levels exceed thresholds everywhere? Is treatment needed in all fields, or just some?

2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic and/or biological alternatives)?

PESTICIDES AND HARMFUL ORGANISMS

- Soil insecticides (e.g. Against wireworms, WCR);
- Herbicides;
- Post-emergence insecticides (e.g. to fight black ECB);
- Fungicides (e.g. seedling diseases, *Fusarium*).

PESTS AT EARLY STAGES

VIRUSES TRANSMITTED BY INSECTS

Neonicotinoids effective, but diseases have low incidence; hybrids are usually resistant. Resistant hybrids are as effective as neonicotinoids.

Furlan L, Chiarini F, Balconi C, Lanzanova 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

PESTS AT EARLY STAGES: insects and other arthropods

- Black cutworms (BCW);
- Diabrotica (WCR);
- Wireworms (WIR);
- Other soil pests, e.g. Diplopods (generally low incidence).

BLACK CUTWORMS

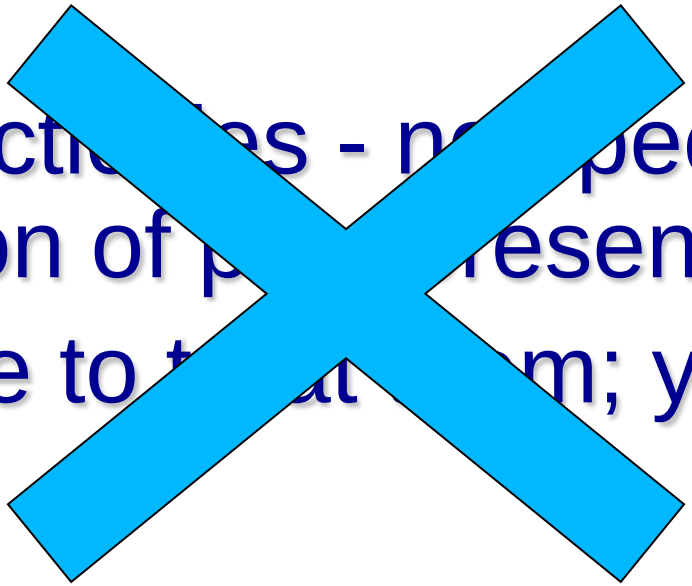
BLACK CUTWORMS (*A. ipsilon*)

- Occasional attacks (last major outbreaks 1971 and 1983);
- Low economic damage;
- Attacks not predictable at sowing;
- Negligible control by soil insecticides when needed (including seed coating);
- Alert programme predicts when and where post-emergence treatments are needed.

TREATMENT UNJUSTIFIED AT SOWING

BLACK CUTWORMS

Traditional (non-IPM) approach



- Soil insecticides - no specific evaluation of presence;
- You have to treat them; you never know!

IPM OF BLACK CUTWORMS

AREA-WIDE LEVEL

- Black cutworm alert programme: moth arrival predicted with pheromone traps (southern winds assessed, formation of harmful instars assessed with a development model);

- Bulletin on population development;
- Possible foliar treatment when fourth instar forms, and scouts forecast an early attack above threshold (5% of plants damaged).

TREATMENT UNJUSTIFIED AT SOWING

IPM OF BLACK CUTWORMS

COMPLEMENTARY LIMITED IN-FIELD EVALUATION

- Scouts sent to monitor at field level only where area-wide monitoring detected moth populations;
- When harmful stage forms (fourth instar, DD accumulation) in an identified area, scouts sent to look for damaged plants;
- Post-emergence treatment implemented when an early above threshold attack occurs (5% of plants damaged);
- Effective insecticides available.

IPM OF BLACK CUTWORMS

YEAR	FIRST CAPTURE	FIRST SIGNIFICANT FLIGHT	FLIGHT LEVEL	southern wind	4th INSTAR first larvae	peak of 4th instar larvae	Forecast date for 176 DD	DAMAGE LEVEL
1991	March 6	March 21-26	Medium	not available data	NO larvae found			very low
1992	April 1	April 3-6	low	17 - 22/3; 29/3-2/4	NO larvae found			NO DAMAGE
1993	March 29	April 6	low	13-20/3; 29/3-1/4	NO larvae found			NO DAMAGE
1994	March 4	Marchy 23 - 26	medium	2/3; 22 - 24/3	May 5	May 7-8	May 8-13	medium
1995	March 11	NO	very low	7/3; 27-28/3	NO larvae found			NO DAMAGE
1996	March 18	April 3	medium	5/3; 31/3	May 2	May 6-8	May 9-11	medium
1997	NO	NO	very low	20-22/3; 26-27/3; 30-31/3	NO larvae found			NO DAMAGE
1998	March 16	April 5-12	medium	13-18/3; 28/3-4/4	May 13	May 15-17	May 8-13	medium
1999	March 26	April 6	low	23-25/5; 3-4/4	May 10	May 14	May 5-10	low
2000	March 29	March 29 April 5	medium	20-23/3; 29-31/3	May 4	May 8	May 4-8	low
2001	March 2	March 17	medium	27/2; 15/3	April 29	May 1-2	May 5-9	medium

Table: results of the implementation of the Black Cutworm Alert programme in Veneto over a 11 years.

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.

BLACK CUTWORMS: ACCORDING TO DIRECTIVE 2009/128/EC

1. Treatment may be applied only once pest population levels have been estimated with monitoring and development models: Available

2. Treatment may then be carried out only when and where monitoring has found that levels are above set economic thresholds: Available

3. When economic thresholds are exceeded, agronomic solutions, mainly rotation, should be considered to prevent damage to maize crops: Not available in practice

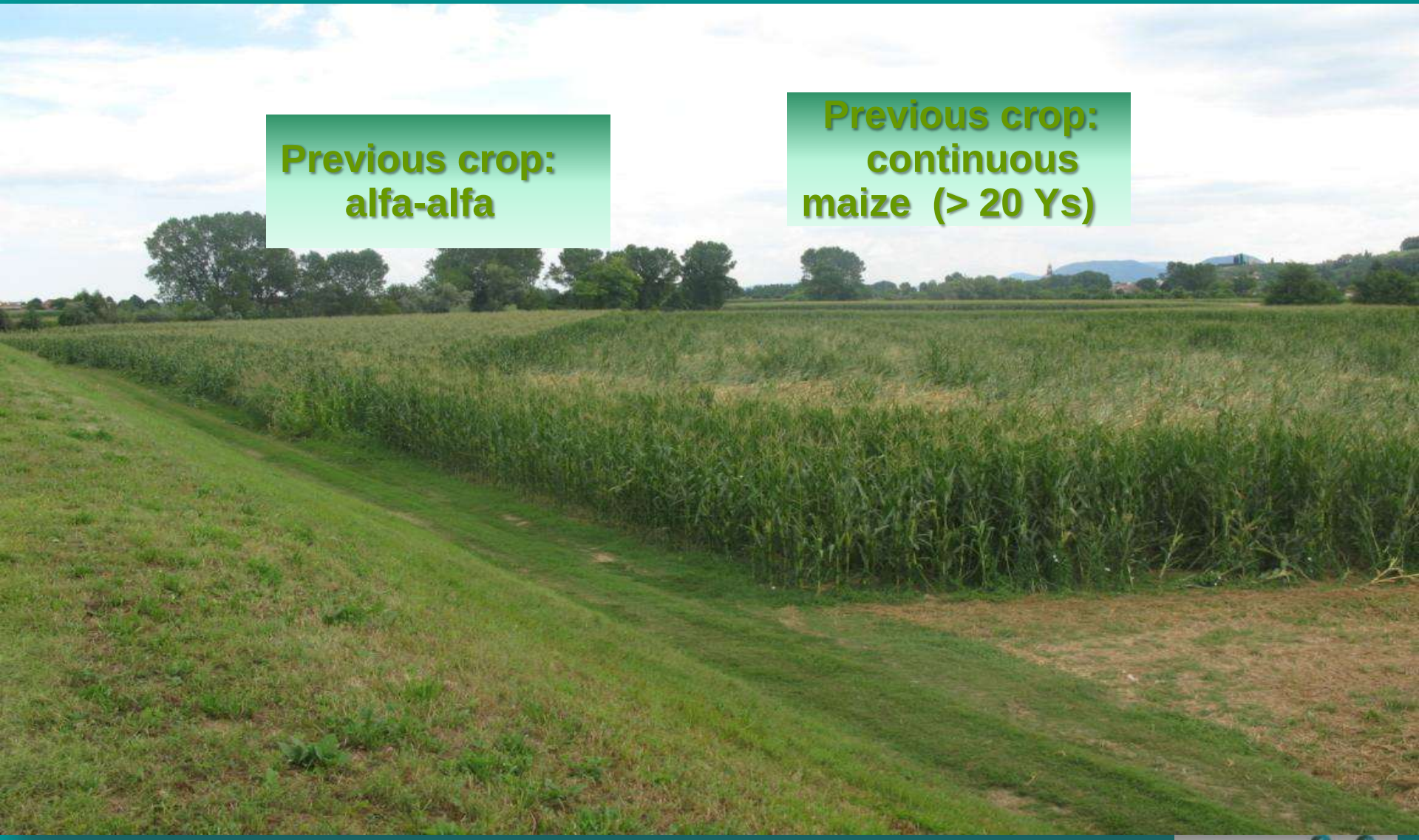
4. When economic thresholds are exceeded and no agronomic solutions are available, biological control, or any other non-chemical pest control method, should be considered as a replacement for chemical treatment: Not available in practice

WCR

IPM OF WCR

- Rotation: the only fully effective strategy (see Directive 128/2009/EC);
- Rotation may be effective even as a ‘soft’ method (every two or more years if implemented on a large scale);
- Some rotation solutions do not reduce the gross margin of livestock/biogas farms;
- Treatment at sowing does not significantly affect WCR population dynamics;
- Biological treatments (entomopathogenic nematodes) available
- Insecticide may fail.

TREATMENT UNJUSTIFIED AT SOWING


Previous crop:
alfa-alfa
Previous crop:
continuous
maize (> 20 Ys)

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

WCR – DIABROTICA: CAN IPM BE IMPLEMENTED?

1. What is the risk level? Low if IPM main strategies implemented

2. Are IPM strategies available (e.g. monitoring methods, risk assessment, key-pest thresholds, agronomic [rotation] and/or biological alternatives)? Available good monitoring methods, WCR can be kept below economic thresholds by rotation, the most effective IPM type according to Directive 2009/128/EC – Annex III: IPM of Diabrotica involves implementing rational rotation without chemical treatment (at sowing, or later, against beetles) entomopathogenic nematodes available

WCR – DIABROTICA: IPM ACCORDING TO DIRECTIVE 2009/128/EC

1. Treatment may be applied only once pest population levels have been estimated with monitoring and development models: Available.

2. Treatment may then be carried out only when and where monitoring has found that levels are above set economic thresholds: Available.

3. When economic thresholds are exceeded, agronomic solutions, mainly rotation (the only fully effective, low-impact strategy), should be considered to avoid damage to maize crops: Available.

4. When economic thresholds are exceeded and no agronomic solutions are available, biological control or any other non-chemical pest control method, should be considered as a replacement for chemical treatment: Available (entomopathogenic nematodes).

WIREWORMS

WHAT IS IPM AGAINST WIREWORMS?

IMPLEMENTATION
OF SAMPLING/MODELS/THRESHOLDS:
treatments only after pest assessment.

WIREWORMS

A CASE STUDY OF ITALY

FIELDS DAMAGED BY WIREWORMS
(over 30 years of observations in Italy)

visible damage (plants with attack symptoms common): < 5.0%

high damage (> 30% of plants damaged): < 1.0

WIREWORMS
(Apenet 2010 – a major survey in the Po Valley)

ITALIAN REGIONS	MONITORED FIELDS	WITH RISK FACTORS (*A.brevis, A.sordidus*)	WITH RISK FACTORS (*A.litigiosus, A.ustulatus*)	*A. brevis* mean (e.s., min-max)	*A. sordidus* mean (e.s., min-max)	*A. litigiosus* mean(e.s., min-max)	*A. ustulatus* mean (e.s., min-max)	PLANT STAND pp/m^2 HEALTHY (*mean, min, max*)	media (pp sane % of heakthy plants out of total sown seeds)	Plants damaged by wireworms % of emerged plants (mean, min, max)	Fields with visible damage on plants – no economic damage (up to 10% of damged plants) (n°)	Fields with economic damage
VENETO	51	6	6	76 (18.3, 0.0- 691)	523 (53.1, 91- 2129)	n.r.	548 (88,4, 0,00- 2786,00)	6,46 (0.07, 5.30- 7.38)	90.3	1.14 (0.024, 0.0- 7.0)	2	0
EMILIA ROMAGNA	105	7	4	n.r.	245 (26.44, 4.00- 2201)	253 (24.3, 6.0- 1141)	n.r.	n.r.	n.r.	n.r.	1	0
LOMBARDY	10	2	1	n.r.	983 (244, 189 - 2349)	629 (202, 63- 2087)	n.r.	6.48 (0.06, 4.80 – 7.3)	93.2	0.17 (0.071, 0.10- 0.81)	1	0
PIEDMONT	6	1	0	n.r.	1091 (290, 123- 2311)	243 (52, 46- 549)	n.r.	7.00 (0.12, 6.40- 7.40)	94.6	5.8 (0.017, 0-12)	1	0
FRIULI	11	2	0	169 (19.7, 86 - 323)	335 (66.6, 59-763)	12 (6.41, 0.00- 52.0)	n.r.	6.63 (0.05, 6.35 – 6.90)	90.7	0.059 (0.01, 0.05- 0.1)	0	0
TOTAL	183	18	11								5	0
(%)											2.7	0

PURE PROJECT (7TH FRAMEWORK PROGRAMME) 2011 - 2014

- Three on-station experiments - France, Hungary and Italy (long-term) to investigate different IPM strategies.

- Fifteen on-farm experiments (France, Germany, Hungary, Italy and Slovenia).

WIREWORMS
WHAT ABOUT OTHER MEMBER STATES?

Fifteen on-farm experiments were conducted with commercially available equipment in:

- **a Southern European climate (five sites in Italy and two in France);**
- **a Central European climate (two sites in Germany);**
- **an Eastern European climate (four sites in Hungary and two in Slovenia).**

Thirty-one experiments in two years on untreated fields/plots, or on alternate treated/untreated strips found

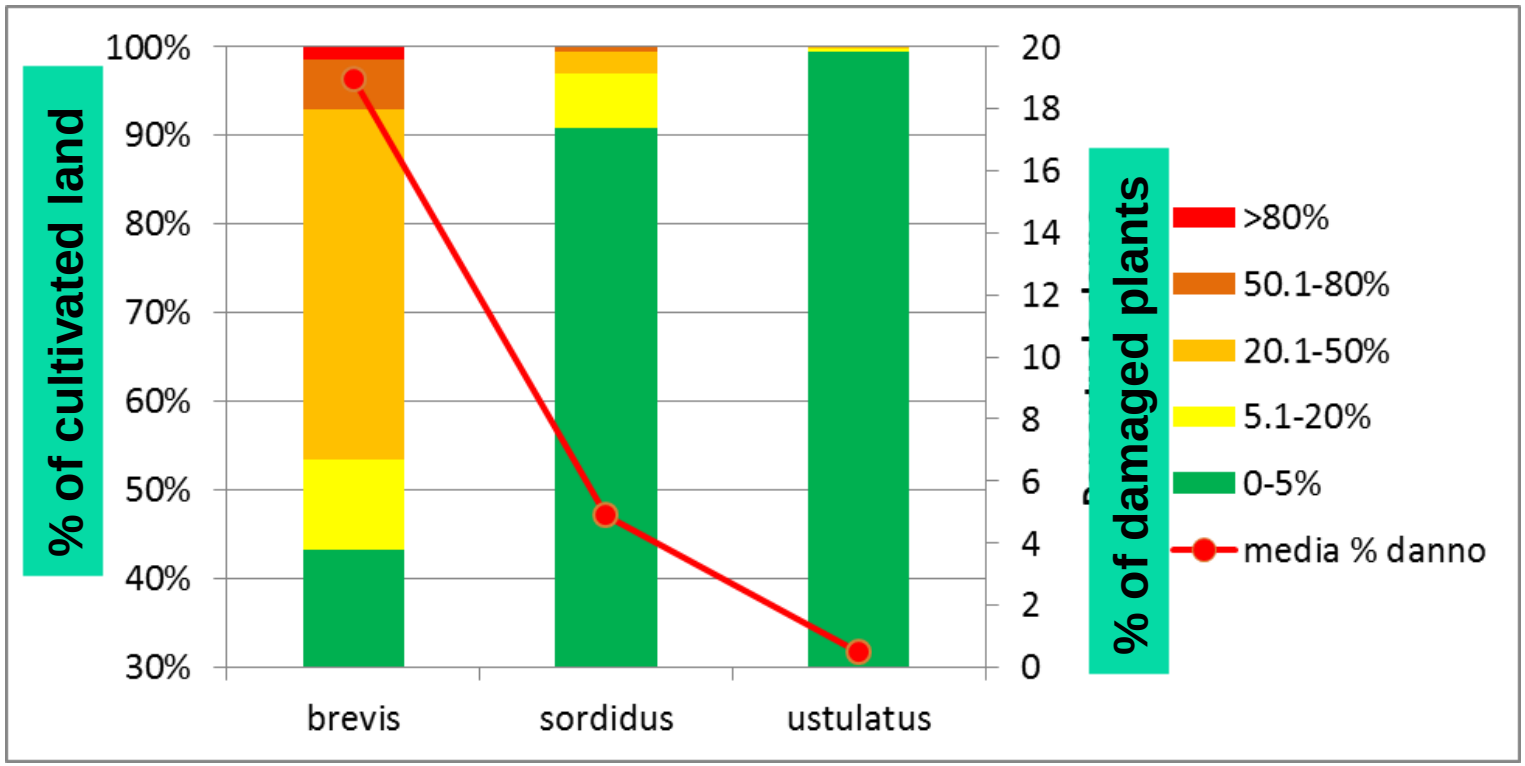
NO ECONOMIC WIREWORM DAMAGE

CURRENT IPM TOOLS

- Risk factors
- Pheromone traps
- Bait traps
- Agronomic strategies
- Biocidal plants and meal
- Other biological treatments

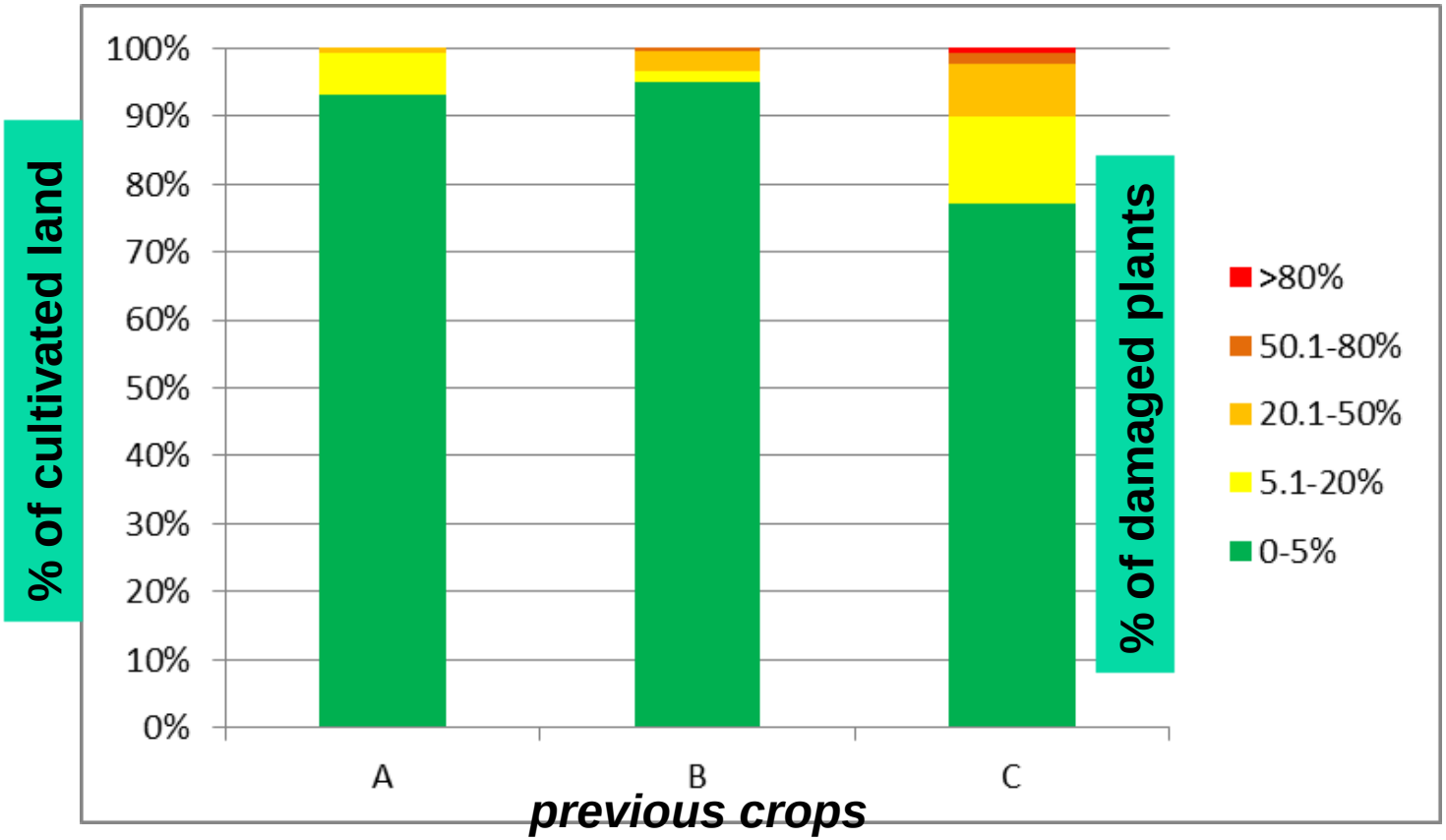
CROPS PLANTED WHEN AND WHERE THERE IS NO SERIOUS RISK OF ECONOMIC DAMAGE

RISK FACTOR: WIREWORM SPECIES



Agriotes species

RISK FACTOR: PREVIOUS CROPS



A: maize
B: rotation without meadow or double crops
C: meadows and/or alfa alfa and/or double crops over 4 ys before

AREA-WIDE LEVEL AGRONOMIC RISK FACTORS

- Continuous plant cover (meadow, double crops, e.g. rye grass/maize, oilseed rape/soybean);
- Peat soils (high organic matter content);
- Previous damage (high beetle captures with Yf and/or high incidence of uncultivated zones, e.g. grasses);
- Irrigation (constant supply of water keeping soil moisture high);

AREA-WIDE LEVEL
YATLORf PHEROMONE TRAPS

- Reliable (non-saturable);
- Few inspections;
- Quick, easy management;
- Low costs;
- Multi-baited (one trap monitors several species at the same time).

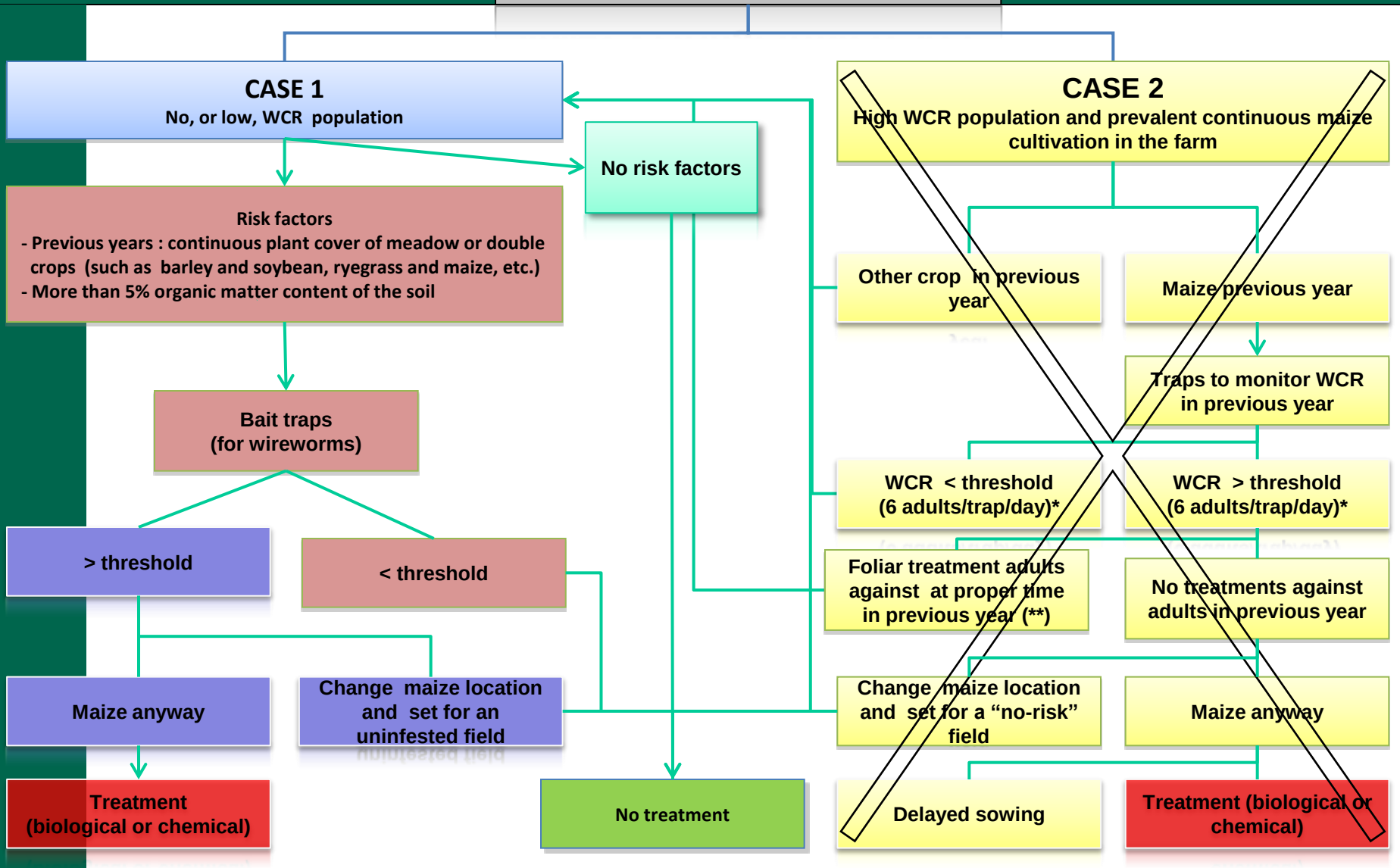
BAIT TRAPS FOR COMPLEMENTARY LIMITED IN-FIELD EVALUATION

- Place bait traps when and where there is a risk of economic populations;
- Assess larval thresholds.

wireworm species	wireworm catches (larvae/trap)	sampled fields	fields with yield reduction (maize)	%
Agriotes ustulatus	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**
Agriotes brevis	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**
Agriotes sordidus	0-1	113	0	0.0
	1.01-2	10	0	0.0
	> 2.01	**10**	**3**	**30.0**

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

Maize sowing: what to do?



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, and MUTUAL FUNDS may allow IPM to be implemented rapidly.

WIREWORMS: IPM ACCORDING TO DIRECTIVE 2009/128/EC

1. Treatment may be applied only once pest population levels have been estimated with monitoring and development models: Available.

2. Treatment may then be carried out only when and where monitoring has found that levels are above set economic thresholds: Available

3. When economic thresholds are exceeded, agronomic solutions, mainly rotation, should be considered to prevent damage to maize crops: Partially available.

4. When economic thresholds are exceeded and no agronomic solutions are available, biological control, or any other non-chemical pest control method, should be considered as a replacement for chemical treatment: Available.

SOME SUCCESSFUL CASE STUDIES

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

More than 1,600 hectares of maize untreated, i.e. no soil insecticide, (1984-2015);

9/1600 ha (0.56%) with economic populations (solution: replace maize with other crops);

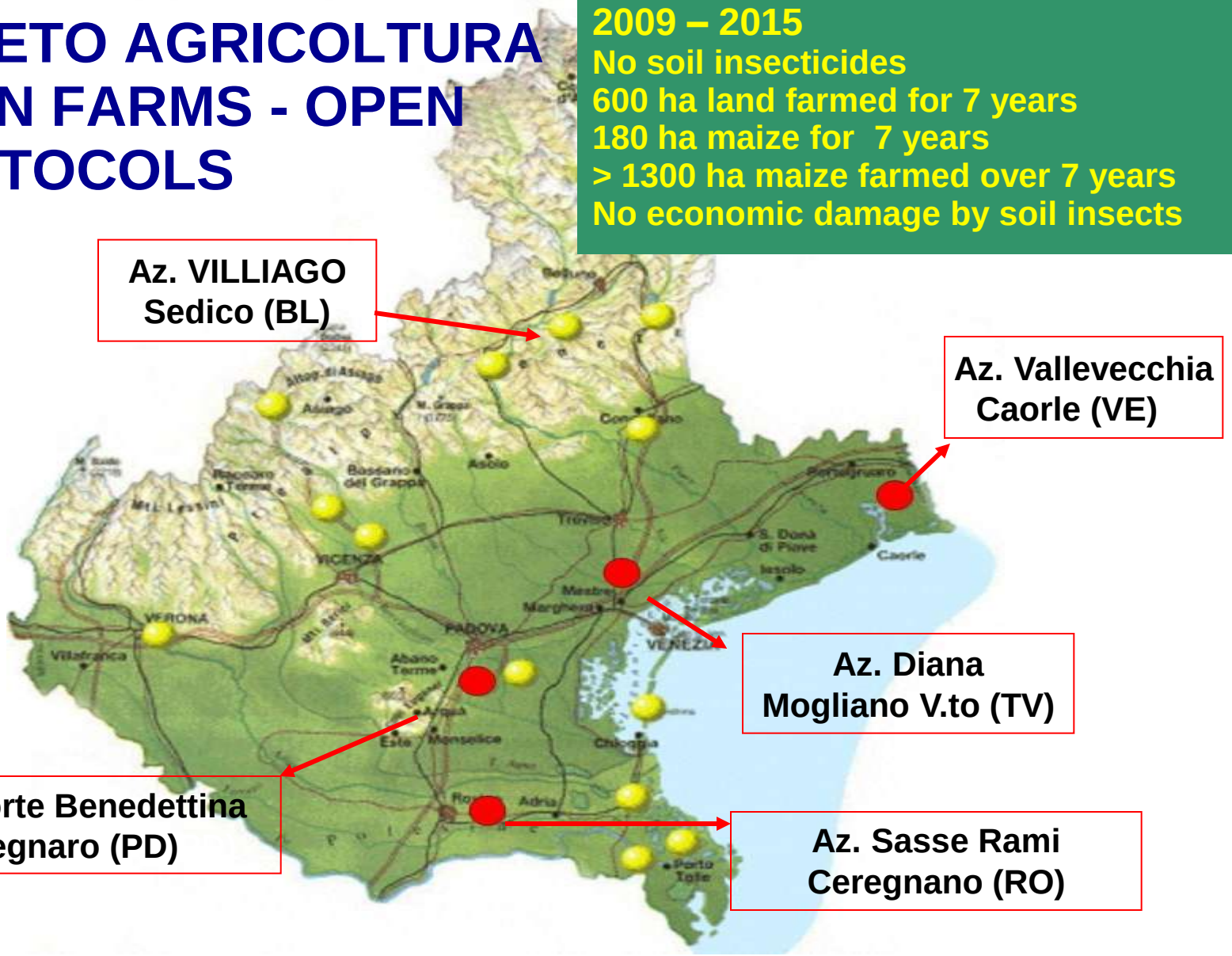
Seed/plant damage always below 5% (usually 0.1% to 2.5%);

No economic damage: 96% of fields with high stand (> 90% of sown seeds). Some cases of stand reduction (< 5 pp/m^2), mainly due to bird damage;

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 farmed for 7 years
180 ha maize for 7 years
> 1300 ha maize farmed over 7 years
No economic damage by soil insects



A NEW "INSURANCE" APPROACH

MUTUAL FUNDS INSTEAD OF INSECTICIDE TREATMENTS

WHEN RISK IS LOW, THE INSURANCE APPROACH IS AFFORDABLE AND MUCH SAFER FOR PEOPLE & THE ENVIRONMENT (INCLUDING BEES)

MUTUAL FUNDS TO ALLOW RAPID AND EFFECTIVE IMPLEMENTATION OF IPM

RISKS COVERED	• 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)
TARGET	Members of farmer consortia
OBLIGATIONS	• 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 FOR FARMERS (without EU contribution)	€15/ha (7 €(ha if with hail insurance) all inclusive (including flooding [excessive rain], freezing cold, drought); pest risk alone is covered with less than €15/ha
COMPENSATION	Up to € 500/ha including: • Resowing (up to € 250/ha) if stand below 4 pls/m^2 • Yield reduction (up to € 250/ha) based on sowing delay, crop change
COMPENSATION LIMITS	According to farm size: •Up to 10 ha: €2,000 limit; •Between 11 and 20 ha: €4,000; •> 20 ha: 10 times the total cost, or €50,000

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.

RESULTS 2014

450 hectares carefully sampled (entirely untreated or with untreated and treated strip/plots in all the fields with high wireworm populations);

hectares with economic damage: 1,13%

Value of yield reduction: 700 € out of 100 ha

RESULTS 2015

(70.000 hectares covered by the Maize Mutual Fund)

450 hectares carefully sampled (entirely untreated or with untreated and treated strip/plots in all the fields with high wireworm populations);

hectares with potential economic damage: 0,18%

Value of yield reduction (estimation): 100 €/100 ha

RESULTS average 2014-2015

450 hectares sampled (entirely untreated or with untreated and treated strip/plots in all the fields with high wireworm populations);

hectares with potential economic damage: 0,66%

Value of yield reduction (estimation): 400 €/100 ha

MUTUAL FUNDS vs PROPHYLACTIC USE OF INSECTICIDES

EVALUATION OF EUROPEAN SCENARIOS

ASSUMPTIONS (prudential)

Mutual fund cost (MF): 15 €/ha (without any EU contribution)

- ✓ soil insecticides COST 40 €/ha
- ✓ the highest damage cost 500 €/ha on 4 ha out of 100
- ✓ soil insecticides efficacy 50%

STRATEGY (100 ha)	MF (ha)	soil insecticides (ha)	IPM management cost (€)	MF COST (€)	insecticide cost (€)	damage cost (€)	TOTAL COST (€)	COST DIFFERENCE MF vs insecticides	Effects on humans, environment , beneficials	compliance with directive 2009/128 /CE	Syntetic general evaluation (1 to 5 stars)
Mutual funds (MF) only	100	0	0	1500	0	2000	3500	- 1500	no	yes	*****
IPM with mutual funds based on risk factors	100	20	0	1500	800	1000	3300	- 1700	reduced	partial	****
IPM with mutual funds based on risk factors + monitoring	100	10	500	1500	400	500	2900	- 2100	very reduced	yes	*****
soil insecticides (prophylactic use)	0	100	0	0	4000	1000	5000	=	yes	no	*