An interactive web-based application for mapping herbicide resistant weed

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Why monitoring and mapping the diffusion of resistance?

• *No much time to discuss this...*
• The earlier, the cheaper, the more updated and accurate, the faster is efficiently disseminated the better it is
• Obviously the end result is a compromise
• Users: farmers, advisors, researchers, national and local decision makers as well as the agrochemical industry
**GIRE®: Italian herbicides resistance working group**

**WHO:** Multi-stakeholders group involving academy, public research, agrochemical industry and advisors dealing with herbicide resistance in Italy

**WHAT:**
- Regular update of the herbicide resistance status in all cropping systems and throughout the country
- Improve resistance management by encouraging a responsible use of herbicides as well as cooperation and communication between public and private researchers
- Devise and disseminate general and specific guidelines for resistance management

**HOW:**
- Complaint monitoring
- Collect R fields history
- Robust and standardized whole plant greenhouse bioassays to test herbicide resistance

... In 1997...
Complex situation continuously evolving:

- 35 resistant biotypes
- Involving 22 species (14 monocots)
- 13 regions interested
- GIRE estimates that more than 200,000 ha are infested
- Several cropping system are involved: rice, wheat, maize, soybean/tomato, lucerne and perennial crops
- More than 1,800 populations in the GIRE database

Need for a better system to create and view maps of resistance...

... In 2009...

**www.resistenzaerbicidi.it**

- Comprehensive information on herbicide resistance in Italy and on the main biological traits of the weeds involved
- resistance management guidelines (general and specific)
- all literature on Italian herbicide resistant cases
- News and highlights
- **maps of the resistant cases (and list of municipalities involved)**

... Now ...

![Graph showing the evolution of herbicide resistance in Italy](chart.png)

- Cumulated no. of R biotypes
- Cumulated no. of R species
- EPSPS inhib.
- ALS inhib.
- ACCase inhib.
- PSII inhib.

GIRE database...
iMAR: Interactive MApping of Resistance

Based on open source software
The map-generation process

It involves sequential steps with several different software components interact with each other, under the coordination of PHP software-code specifically developed.
The most important software elements of the new system

• **The logic of the system**
  The data flow and the site structure is based upon PHP software code, developed within the CodeIgniter software platform

• **mySql db of resistant populations**
  Most relevant stored information:
  - Populations description (resistant species, crops involved, herbicides tested, HRAC groups, resistance level)
  - Geographic localization (Italian region and municipality)
  - Accessory information

• **mySql db of geometrical data**
  It contains the geometrical information (delineations) of regions and municipalities

• **OpenLayers**
  It is an open source JavaScript library for displaying map data in web

• **OpenStreetMap (OSM)**
  It is a collaborative project to create a free editable map of the world. In our context it provides the base layer maps
Most important tables and relations of the databases

**Resistance db (mySql)**
- **Active_ingredient**
  - id
  - id_HRAC
  - id_chemical_family
  - active_ingredient
- **Type_of_resistence**
  - id
  - id_population
  - id_active_ingredient
  - id_HRAC
  - date
  - resistance
- **HRAC_group**
  - id
    - HRAC_code
    - type_of_resistence
    - action_mechanism
    - group_acronym
- **Population**
  - id
    - id_weed
    - id_cropping_syst
    - id_farm
    - population_code
    - sub_code
    - id_municipality
    - locality
    - population_origin
    - GIRE
    - note
    - coordinates_GM
    - year
    - date
- **Weed**
  - id
    - bayer_code
    - genus_species
    - italian_name
    - english_name
    - link_doc
- **Cropping_system**
  - id
    - botanical_species
    - crop_name
    - description

**Geographic db (mySql)**
- **Geom_municip_Italy**
  - id
    - shape
    - id_region
    - municipality_code
    - name
- **Geom_regions_Italy**
  - id
    - shape
    - region_code
    - name
Example: *Papaver rhoeas*

**Static maps**

A map has to be created for each case of herbicide resistance involving *Papaver rhoeas* in wheat

ALS inhibitors

Synthetic auxins (2,4-D)

ALS inhibitors + Synthetic auxins (2,4-D)

3 maps to describe all cases of HR reported in *Papaver rhoeas*
Dynamic map

All cases of herbicide resistance involving *Papaver rhoeas* are visualized in a unique map.
Example: *Lolium* spp.

**Static maps**

A map has to be designed for each case of herbicide resistance involving *Lolium* spp.

7 maps to describe all cases of HR reported in *Lolium* spp.!!
Dynamic map

All cases of herbicide resistance involving *Lolium* spp. are visualized in a unique map.
Advantages of iMAR compared to the previous mapping systems

- Data are uploaded directly in an online database (not accessible to the public) where every resistant weed population is represented by a string containing various info which identify the population as unique
  → fewer errors of input and transfer of the data

- Users choose the features (type of resistance, weed species, region of interest and cropping system) and the map is automatically generated by the system
  → customized maps

- The system is automatic, easy to use, always updated and cheap because the maps are built using open source software tools
  → rationalization of resources
  → improves the transfer of information
  → already used by stakeholders, including decision makers
THANKS FOR YOUR ATTENTION!