Agronomic evaluation of IPM strategies in European maize (corn) production

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Arable crops are relatively low value crops

- IPM is not used extensively on arable crops (but is widely implemented on other crops, e.g. orchards).
- Not easy to properly implement Directive 2009/128/EC to arable crops (e.g. maize).
- IPM tools have to be cheap and easy to implement

Experiments in maize and objectives within PURE

- 3 on-station (long-term) to investigate different maize-based systems (MBCS) with different levels of IPM (Italy, Hungary, France)

- 15 on-farm (farm-scale) to test the efficacy of IPM tools in 2011-2012 and 2013-2014 periods against the local conventional approach (Italy, Hungary, Slovenia, Germany, France)
    - IWM strategies for weed control
    - Biological control with *Trichogramma* releases and Bt spraying vs. European corn borer (ECB)

Long term on-station experiments

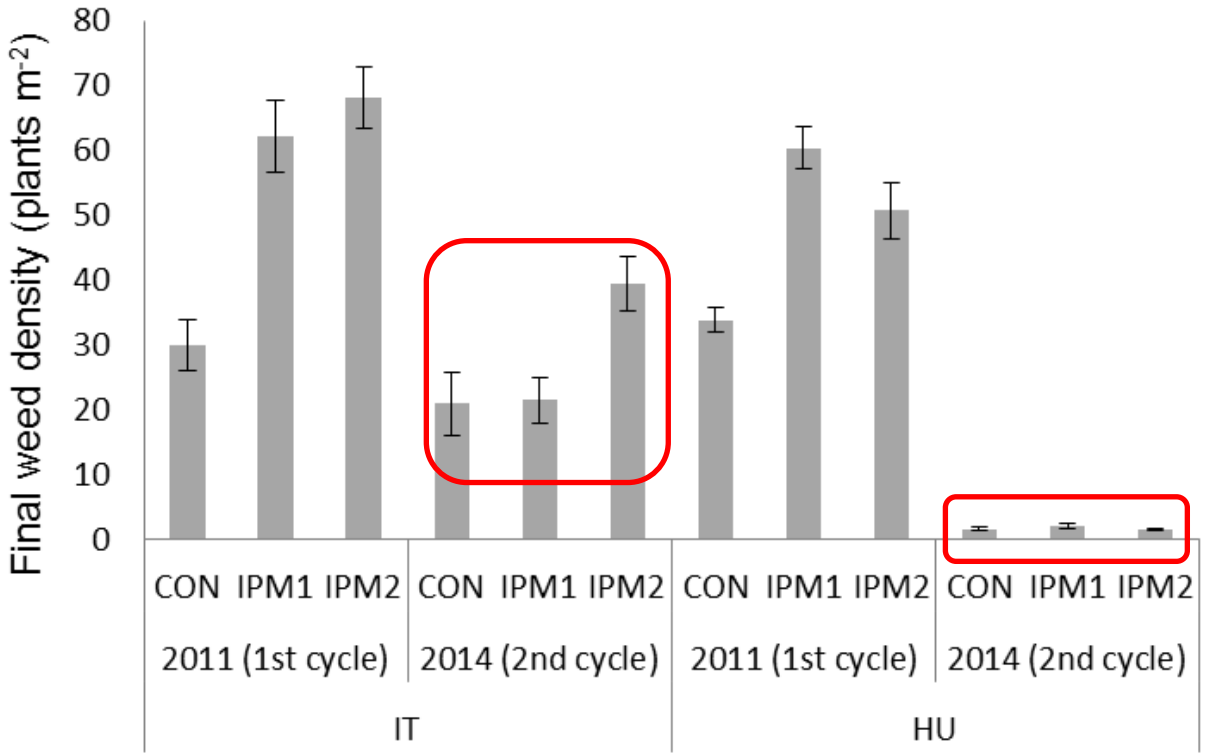
Three maize-based cropping systems (MBCS) with three different IPM levels were compared in in Italy, Hungary and France: rotation as the key element.

1. **CON: conventional system** (common rotation, standard practices)
2. **IPM1: advanced system** (more diverse rotation, practices that exist but not commonly used)
3. **IPM2: innovative system** (more complex rotation, preference in non-chemical methods)

Italy (2011-2014)

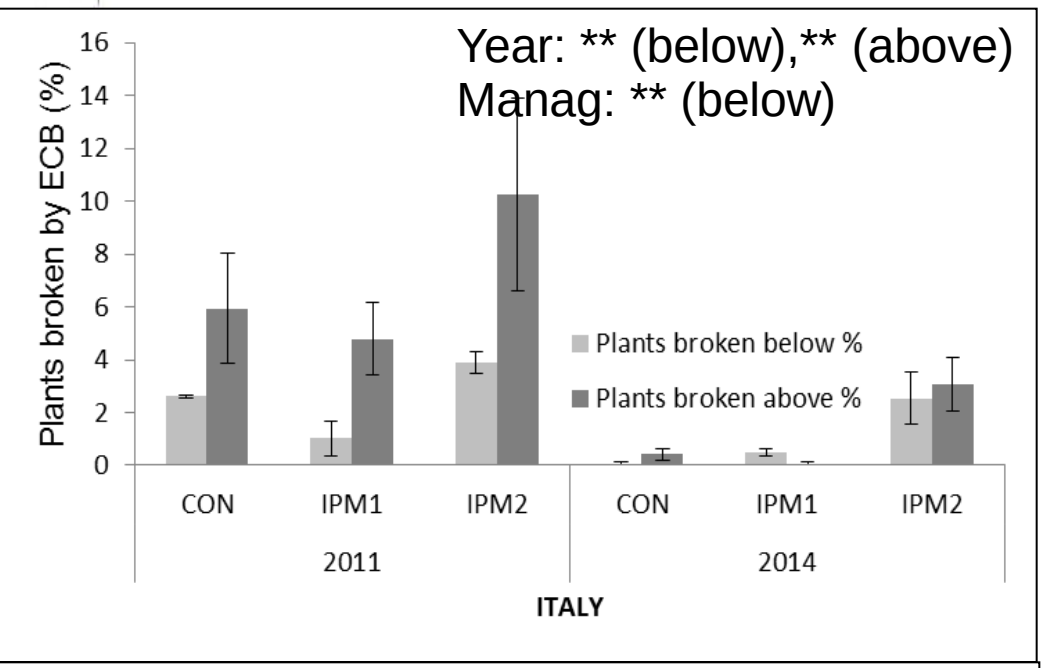
	Conventional	IPM1 (advanced)	IPM2 (innovative)
Cropping sequence	Maize-maize-winter wheat-maize(2nd cycle)	Maize-winter wheat-soybean-maize(2nd cycle)	Maize-winter wheat-CC-soybean-CC-maize(2nd cycle)
Crop protection 2011+2014	**Maize**	**Maize**	**Maize**
Predictive models of weed emergence for post-treatments	NO	YES	YES
Herbicide	Pre-emergence (broadcast) Post-emergence (broadcast)	Pre-emergence (30 cm band) Post-emergence (30 cm band)	Early post-emergence (30 cm band)
Mechanical weeding	Hoeing	Hoeing	Hoeing
Soil insecticides	YES	NO	NO
Monitoring of ECB for insecticide treatments	YES	YES	YES
Insecticide	Broad-spectrum	Selective	Bio-insecticide (*Bacillus thuringiensis*)

IPM vs. CON in maize



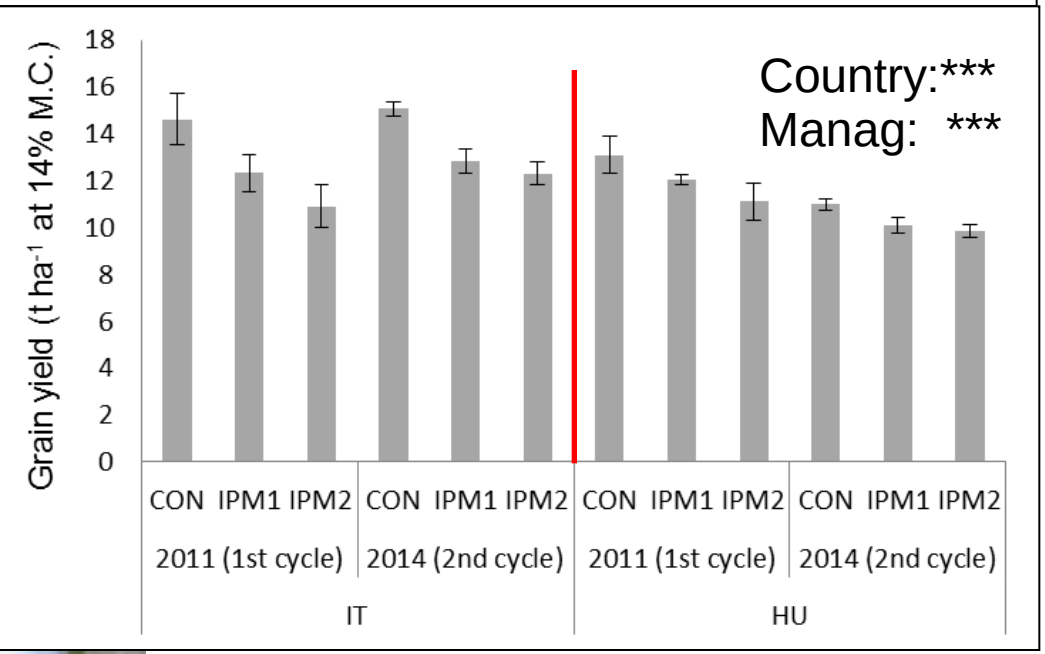
- All main factors and interactions were significant
- In the 2nd cycle maize, weed control in CON and IPM1 was similar,
- Significant reduction in the 2nd cycle maize of IPM1 and IPM2 systems, showing an overall effect of the diversified crop rotation on weed density

IPM vs. CON in maize



In IT, significantly higher no. of plants broken below maize ear in IPM2 (Bt spraying)

No difference in plants broken above ear between management



Overall, CON had significantly higher yield than IPM, whereas IPM levels did not differ between them

Conclusions on IPM vs CON

- Significant reduction on weed density and biomass in the 2nd rotation cycle maize of IPM1 and IPM2, showing an overall effect of the diversified crop rotation
- In the 2nd cycle maize, weed control in CON and IPM1 was similar
- Overall, CON had significantly higher yield than IPM, whereas IPM levels didn't differ between them
- Soil insecticide in CON was not needed since soil insect pressure and damage was always very low

IWM tools tested on-farm in 2011-2012

The IWM tools tested in the different countries were:

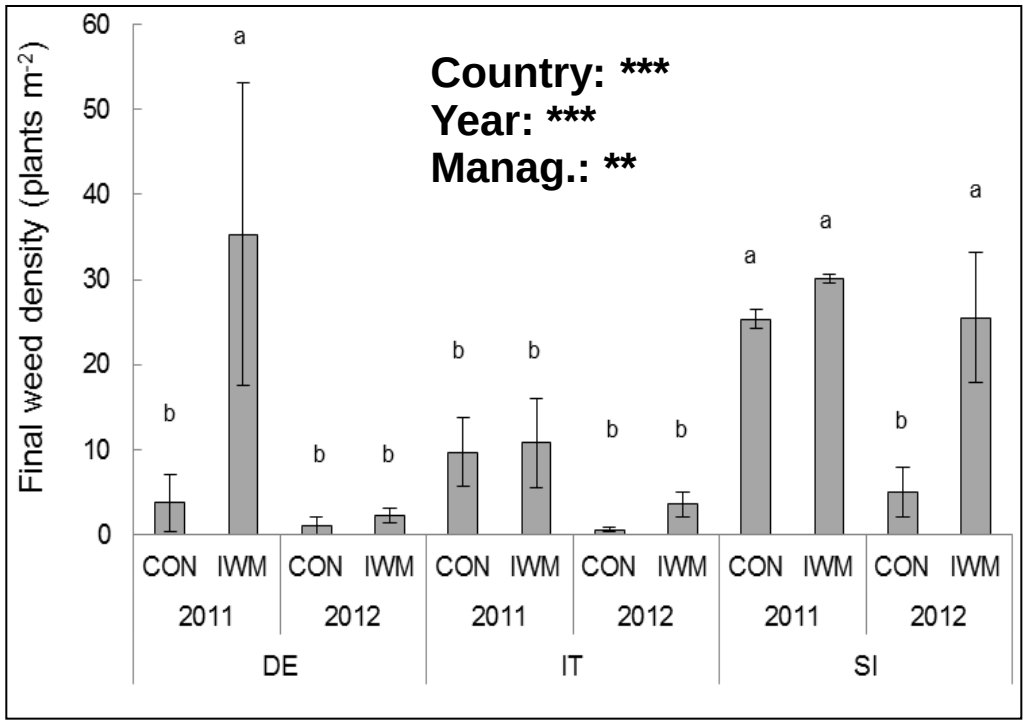
1. the early-post emergence in band application combined with hoeing followed by another hoeing in DE

2. the early-post emergence herbicide in broadcast application when/if scouting and forecasting model (ALERTINF; Masin et al., 2010) indicates followed by hoeing in IT

3. harrowing at 2-3 maize leaves stage and low dose of post-emergence herbicide in SI

In all countries CON consisted of broadcast herbicide application (pre- or post-emergence), plus hoeing in Italy

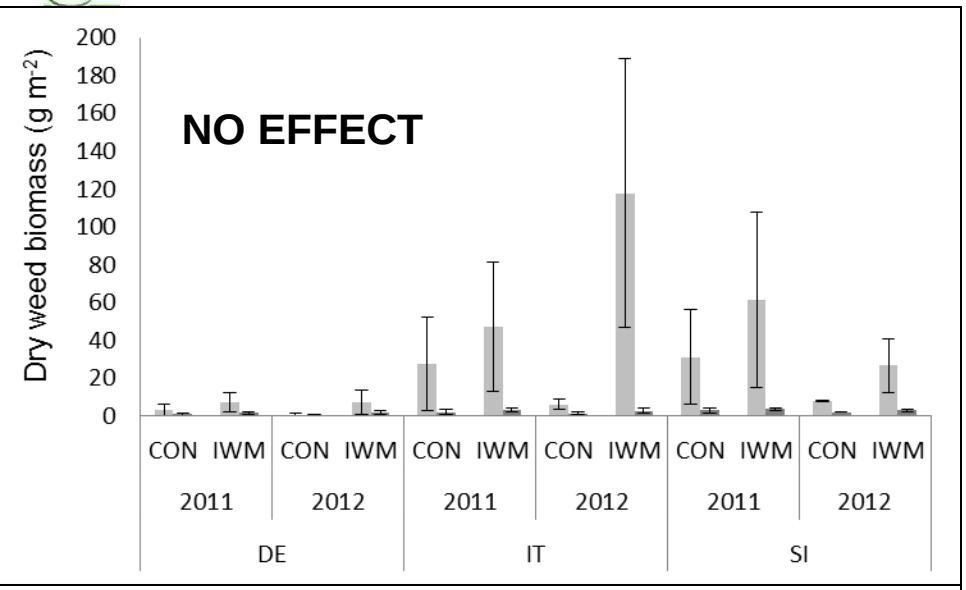
IWM vs. CON in 2011-2012

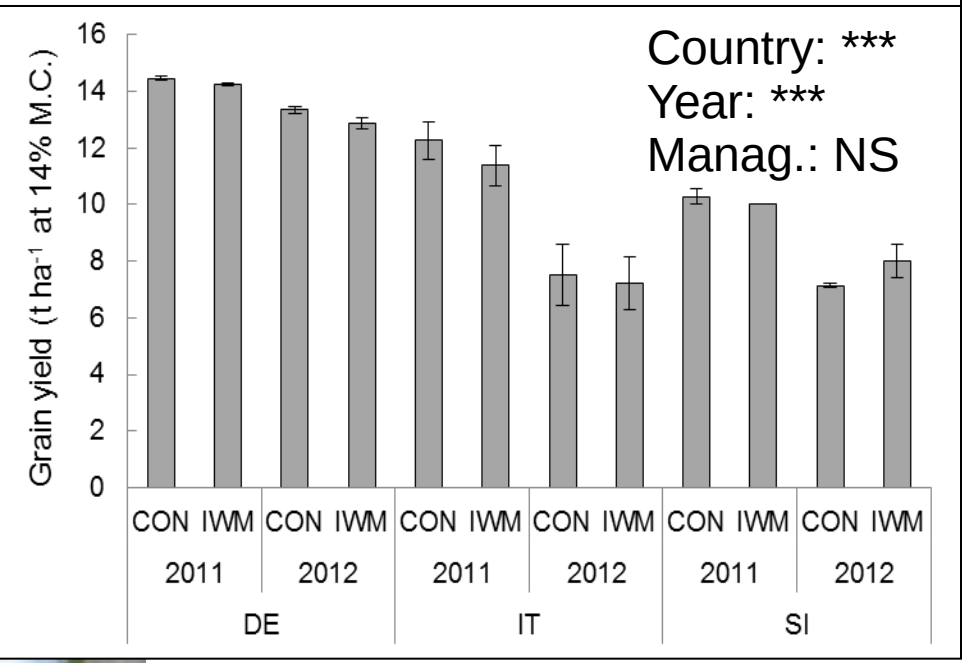


- Final weed density significantly different between weed management, countries, years and interactions

➢ Where: C, Country; Y, Year; WM, weed management; ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$

IWM vs. CON in 2011-2012





- ANOVA showed no difference between management on dry weed biomass (g m^{-2})

➢ light grey columns indicate the raw data means and grey columns with bars the log transformed [log (x + 1)] means and their standard error.

- ANOVA showed only Country and Year difference in yield

IWM tools tested in 2013-2014

1. the early-post emergence in band application combined with hoeing followed by another hoeing in DE;

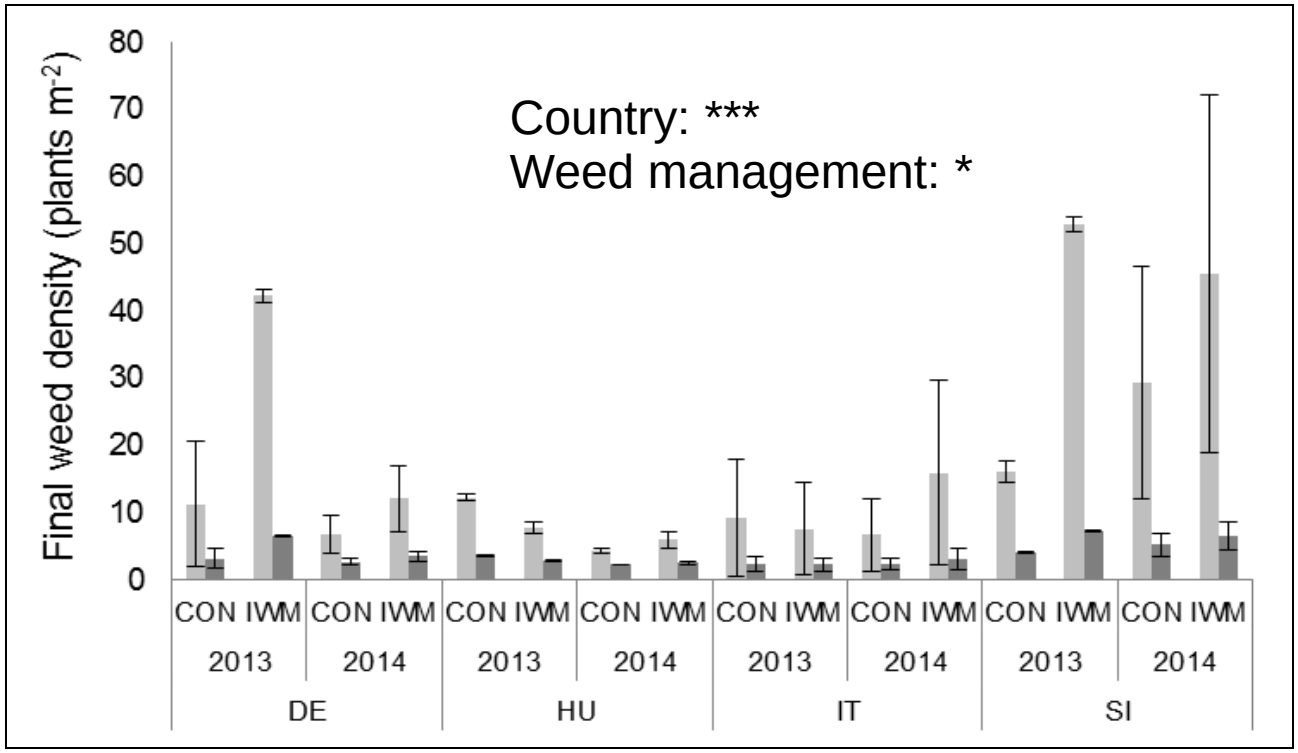
2. early post-emergence herbicide in band application followed by harrowing in HU;

3. pre-emergence herbicide in band application followed by hoeing in IT;

4. early post-emergence herbicide in band application followed by hoeing in SI.

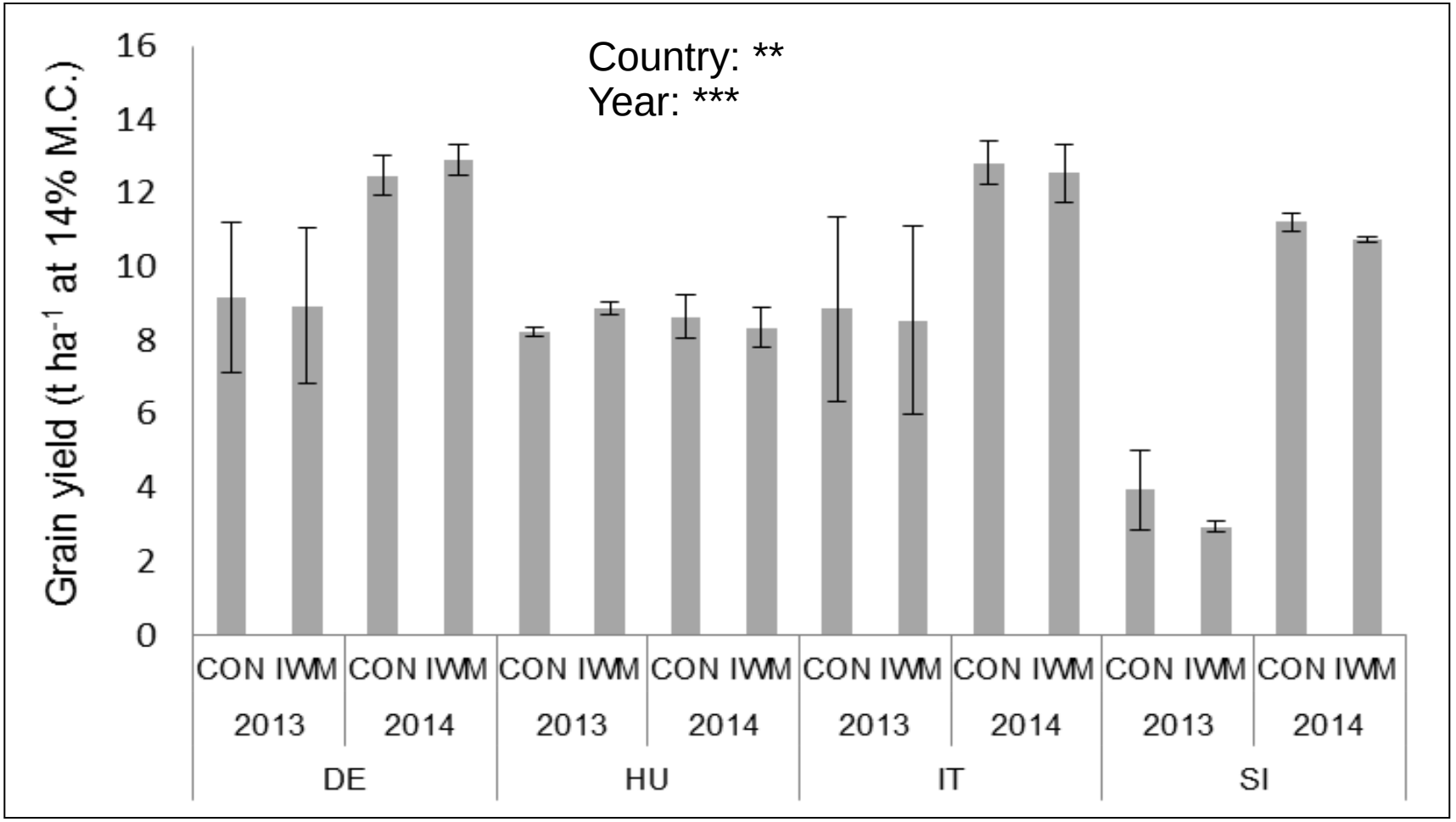
In all countries CON consisted of broadcast herbicide application (pre- or post-emergence), plus hoeing in Italy

IWM vs. CON in 2013-2014



- Final weed density significantly different between IWM tools and CON management, and countries
- ➢ Light grey columns indicate the raw data means and grey columns with bars the square-root transformed [√ (x + 1)] means and their standard error.

IWM vs. CON in 2013-2014

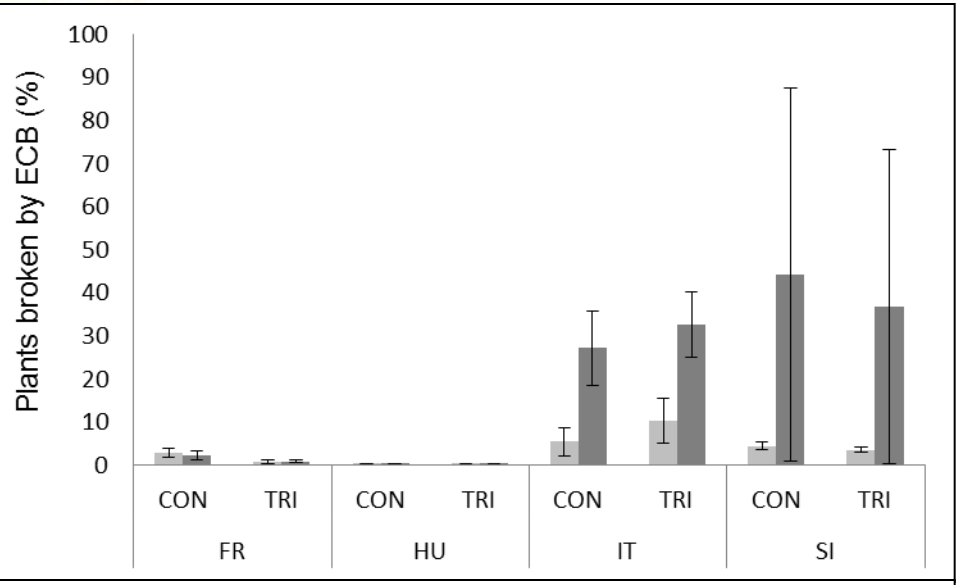


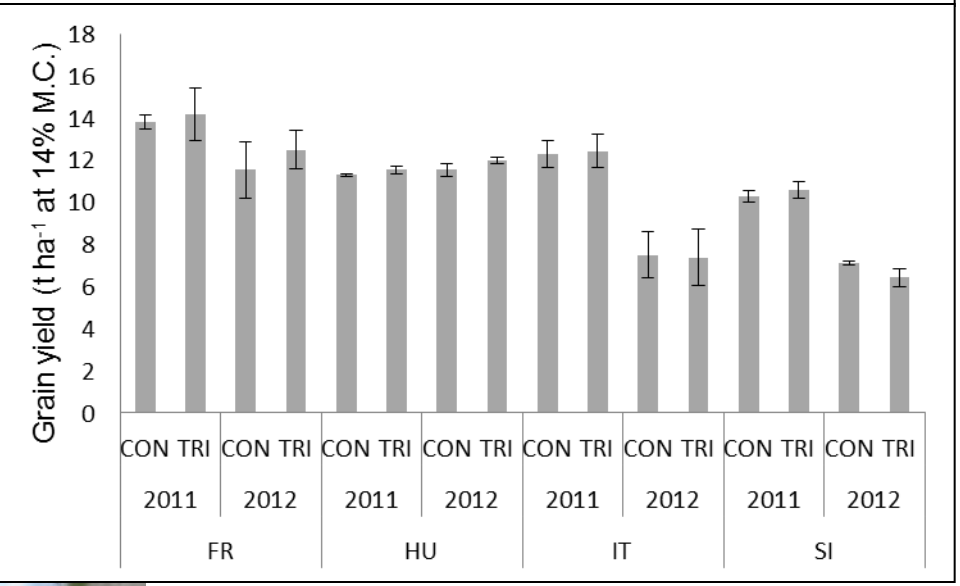
Only country and year differences in yield

Conclusions on IWM vs CON

- Overall, CON had lower final weed densities than IWM in both periods of experimentation
- Weed biomass showed no significant difference between IWM and CON
- Overall no differences in the grain yield among CON and IWM
- IWM tools tested are considered agronomically efficient

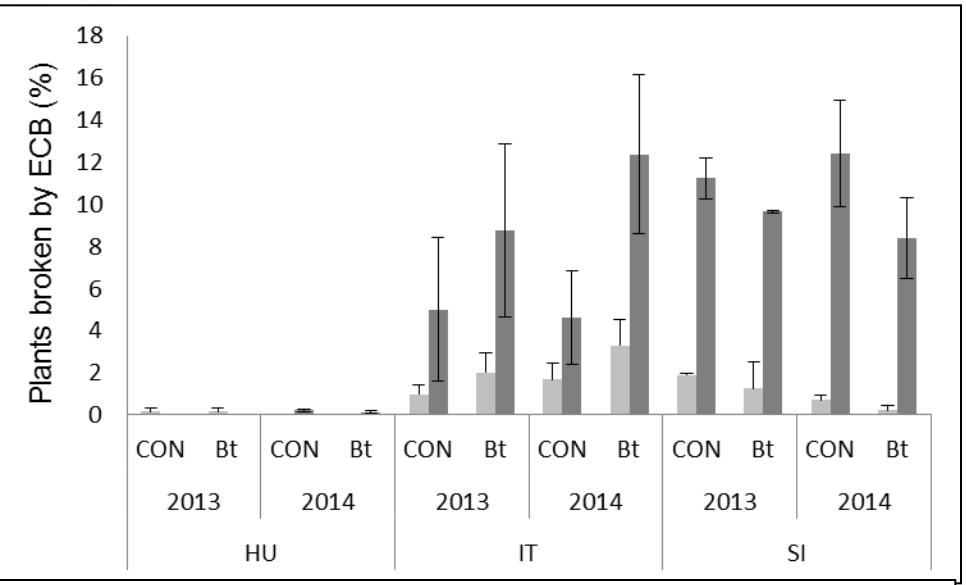
Trichogramma vs. CON in 2011-2012



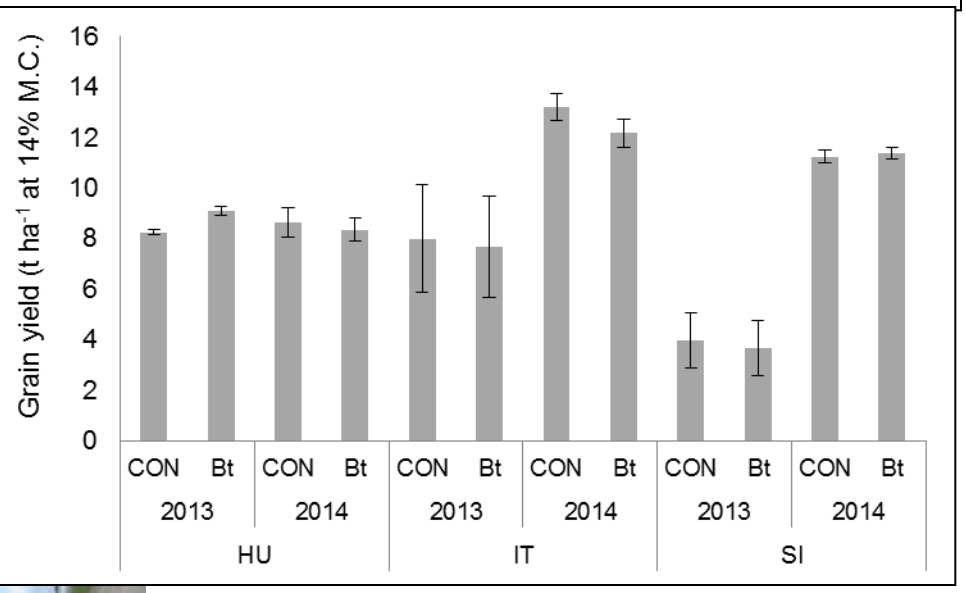


- Light grey columns: maize plants broken below ear; dark grey columns: maize plants broken above ear
- Different ECB pressures between countries with IT highest and HU lowest
- No difference between Trichogramma and CON for both plants broken above or below maize ear
- Grain yield no different between *Trichogramma* releases and CON

Bt vs. CON in 2013-2014



- Light grey columns: maize plants broken below ear; dark grey columns: maize plants broken above ear
- Different ECB pressures between countries with IT highest and HU lowest
- No difference between Bt and CON for both plants broken above or below maize ear



- Grain yield no different between *Bt* spraying and CON

Conclusions on IPM vs. CON

- Both *Trichogramma* and *Bt* spraying showed similar efficacy to CON against ECB
- ECB damage was lower where *Trichogramma* and *Bt* spraying were used.
- Application of these IPM tools depends on ECB pressure
- ECB monitoring crucial for decisions
- Important for Italy that uses insecticides and has medium or high ECB pressures

Overall conclusions or lessons learnt

- Soil insecticides generally no needed because of low pest pressure and damage
- Broadcast herbicide applications can be avoided or reduced
- Decision for application and good efficacy of biological IPM tools (*Trichogramma* and *Bt*) vs. ECB depends on:
  - Pest pressure (monitoring for decision)
  - Right timing of application (monitoring for the right timing to optimize efficacy)

- Agronomic sustainability…… promising…

Thank you for your attention!

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