How to control weeds in arable farming?
Analysis of technical drivers in a national demonstration farm network
FERMEcophyto

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Sample
- DEPHY FERM Ecophyto network gathering 34 cooperatives
- 290 farms: 5 500 fields, 30 000 ha
- Technical data are collected every year, from 2010 to 2014

Two scales of study
- Field and annual scale
- Cropping system scale

Performance indicators
- Herbicide Treatment Frequency Index (TFI) : % of regional TFI
- Yield : % of annual local yield
- Gross margin : % of local reference (mechanical costs are not included)
- Mechanical cost (€/ha) and workload (h or min / ha)
- Weed resistance risk: use of group HRAC B herbicides

Field and annual results were analysed with ANOVA test ($\alpha = 5\%$)
Cropping system results were analysed with Pearson test ($\alpha = 5\%$) and Mann-Whitney test ($\alpha = 5\%$)
At annual field scale:
- Lower herbicide TFI on wheat when the preceding crop is a spring crop
- Higher gross margin on wheat when the preceding crop is a spring crop

At cropping system scale:
- Significant negative correlation between Herbicide TFI on wheat and the frequency of spring crops
**Spring crop in crop rotation:**

**impact at cropping system scale**

At cropping system scale:

- Herbicide TFI decreases as the presence of spring crops increases in the crop rotation.
- Gross margin is also higher in cropping systems with spring crops.

→ No information about pedo-climatic context in this analysis: What about the effect of spring crops in difficult regions? (drying soils, no access to irrigation...)

- The same type of relationship is observed between the rate of grasslands and herbicide TFI on other crops (p-value=0.0099; corr=-0.19).
At annual field scale:

- Ploughing before wheat seems to have no significant effect on herbicide TFI.
- There is (almost) no impact on wheat yield and gross margin.
- Mechanical cost is a bit higher on plowed fields: 220€/ha vs 211€/ha (+4%).
- Workload is also higher: 4.45 h/ha vs 4 h/ha (+11%).
- Mechanical cost and workload are no longer different when considered at cropping system scale.

→ What about ploughing at the scale of the crop rotation?
• Ploughing appears to have a positive effect on wheat TFI whatever its position within the crop rotation

• No correlation between ploughing frequency and herbicide TFI at cropping system scale

• BUT a significant difference between CS with and without ploughing:
  
  herbicide TFI = 85% of the local reference vs 97% respectively

→ The reflection around ploughing would gain to be considered at the cropping system scale
Sowing date: impact on winter wheat

At annual field scale:

- Early sowing: technical and economical performances very close to normal sowing
- Late sowing affects herbicide TFI but also yield and gross margin
- In that case, late sowing involves an increase of ALS herbicide use frequency, which are mainly used in early spring

→ Grassweeds infestation is lower in case of late sowing (avoidance strategy)
→ Less time for autumn treatment in case of late sowing = increase of ALS use frequency
False seed bed in intercropping: impact on winter wheat

At annual field scale:

- No effect of false seed bed before winter wheat on technical and economical indicators

At cropping system scale:

- There is no correlation between false seed bed frequency and herbicide TFI

→ Short term effect of false seed bed (less grassweeds in wheat crop) may be not sufficient to have an effect on TFI

→ False seed bed are often associated with glyphosate application: negative effect on TFI?

→ Its effect depends on its technical positioning in line with the production context
e.g. composition of weed community, climatic conditions
Mixed weeding: impact on row crops

- TFI is significantly lower when mixed weeding is performed: -9%

  → ... but this TFI decrease is not so important, considering what is observed in experimental trials (-37%)

  → Technical difficulties?

  → Effect might be variable as a function of the production context

- Mixed weeding has a positive impact on yield and gross margin
- Mechanical costs (not included in gross margin) increase with mixed weeding: +33€/ha

  → Mechanical weeding as a way to diversify weed management strategy and to make it more efficient

  + Airing effect which may benefit to the crop and positively affects the yield?

Relative Herbicide TFI, yield and gross margin according to weeding method (Réseau FERMEcophyto, 2011-2014)
Mixed weeding on maize: results from FERMEcophyto network

Technical and economical indicators for conventionnal and mixed weeding on maize
(Réseau FERMEcophyto, 2011-2013)

<table>
<thead>
<tr>
<th></th>
<th>Conventional Weeding</th>
<th>Mixed Weeding (chemical + mechanical weeding)</th>
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</thead>
<tbody>
<tr>
<td>Herbicide TFI</td>
<td>1.59</td>
<td>1.65</td>
</tr>
<tr>
<td>Weeding cost (€/ha)</td>
<td>245 b</td>
<td>323 a</td>
</tr>
<tr>
<td>Workload (min/ha)</td>
<td>192 b</td>
<td>258 b</td>
</tr>
</tbody>
</table>

Mann-Whitney test: NS
Mann-Whitney test: HS
Mann-Whitney test: HS

At cropping system scale:
The difference of mechanical cost and workload we observed is no longer perceptible at cropping system scale! (n=158)
Technical and economical indicators for conventionnal and mixed weeding on maize

(19 trials, 2010-2012)

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<th></th>
<th>Conventional Weeding</th>
<th>Mixed Weeding (chemical + mechanical weeding)</th>
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<tbody>
<tr>
<td>Maximal efficacy (%)</td>
<td>94 a</td>
<td>90 a</td>
</tr>
<tr>
<td>Herbicide TFI</td>
<td>1,53 a</td>
<td>0.95 b</td>
</tr>
<tr>
<td>Weeding cost (€/ha)</td>
<td>87 a</td>
<td>76 a</td>
</tr>
<tr>
<td>Weeding workload (min/ha)</td>
<td>6 b</td>
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Mixt weeding on maize:
experimental results
Conditions of success for mixed weeding in maize: Multiple Correspondence Analysis (MCA) Classification Methods

Group 1 (46%)

- High herbicide TFI
- Medium weed pressure
- Preceding crop: spring crop
- Weeding program: residual herbicide / foliar herbicide / hoeing
- Number of hoeing: 1
- Region: Centre-West
- Lot of: perennial dicots, annual grassweeds and dicots
- Incorporation of nitrogen with hoeing

Groupe 2 (42%)

- Low or medium herbicide TFI
- Low weed pressure
- Preceding: winter crop
- Weeding program: residual herbicide / hoeing or foliar herbicide / hoeing
- Number of hoeing: > 2
- Region: Centre-East, Rhône Valley
- Few or no perennial dicots, annual grassweeds and dicots
- No incorporation of nitrogen with hoeing

→ To have a positive impact on TFI, mechanical weeding must be integrated in weeding program
→ Every conditions of success must be brought together: few weeds, many hoeing, no incorporation on nitrogen...
Conclusion and Outlook

• Working at annual field AND cropping system scale is necessary to fully assess the interest of a weed management strategy

• Some agronomic practices do not have the expected effect on herbicide reliance at field scale or system scale. There could be various explanations:
  • A decrease of weeds pressure does not mean necessarily a decrease of herbicide use
  • The interest of these agronomic practices depends on their technical positioning. This information is quite complex and not available yet
  • These agronomic practices may have a long term effect rather than short term
  • Their effects depend on the production situation and may be different from one context to another

• Some other agronomic practices have the expected effect: crop rotation as a main way to control weeds, ploughing, but also to a lesser extent: late sowing and mixed weeding

• The effect of Integrated Weed Management relies on the consistence between a set of agronomic practices: Necessity to catch the variety of technical combinations at the cropping system scale and study their effects considering the diversity of production contexts
Thank you all for your attention