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Average yields and levels of yield variability in low-input and organic systems

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Meta-analyses assessing the effects of input reductions on yields

- Effects of Organic systems vs. Conventional systems
- Effects of Low-input systems vs. High-input systems
- Effects of legume preceding crops on low-input cereal yields

(2012)

Meta-analyse des « rendements bio » / « rendements conventionnels » dans le monde

Ponisio et al., 2015

Base de données sur les légumineuses dans le monde
(Cernay et al. 2016)

AH : *Arachis hypogaea*,
CA : *Cicer arietinum*,
CC : *Cajanus cajan*,
GM : *Glycine max*,
LAl : *Lupinus albus*, LAn : *Lupinus angustifolius*,
LC : *Lens culinaris*,
LL : *Lupinus luteus*,
Ol : oléagineux,
PS : *Pisum sativum*,
PV : *Phaseolus vulgaris*,
VF : *Vicia faba*,
VM : *Vigna mungo*,
VR : *Vigna radiata*,
VSa : *Vicia sativa*,
VSu : *Vigna subterranea*,
VU : *Vigna unguiculata*.

Ratios moyens de rendement en grains estimés pour des céréales cultivées après différentes espèces de légumineuses à graines

What about variability?

- Variability across experiments
- Within-trial variability across years
- Yield mean - Yield variance relationship

Objective

Compare yields of organic and conventional crops, and analysed their variability across experiments and years.

Data

- 84 papers selected
- 82 experimental sites
- 318 experimental comparisons
- 636 yield ratios
- Data were obtained for 34 countries and 47 crop species

- 75% of the data were collected for eight species;
  tomato (30%), potato (12%), apple (9%), spinach (7%), bean (6%), lettuce (5%), carrot (4%) and onion (3%)

- Most represented countries: USA (36%), Italy (11%), Switzerland (8%), Germany (7%), Turkey (7%), France (4%), and India (5%)

- Three sites were localized in South or Central America, five in Asia or Oceania, and only one in Africa (Tunisia).

Statistical analysis

- Mixed-effect models
  - Response variable: log yield ratio
  - Explanatory variables: crop species, countries, climate, types of organic and conventional systems
  - Random site effect
  - Estimation: REML with weighted data
- Estimation of yield ratio (Organic *vs.* Conventional)
- Comparison of variability (Organic *vs.* Conventional)
  - Variability across years
  - Variability across replicates

Estimated mean ratio of standard deviations of organic and conventional yields:

0.98 (95% confidence interval [0.82–1.18])

Conclusion of Lesur et al. (2017)

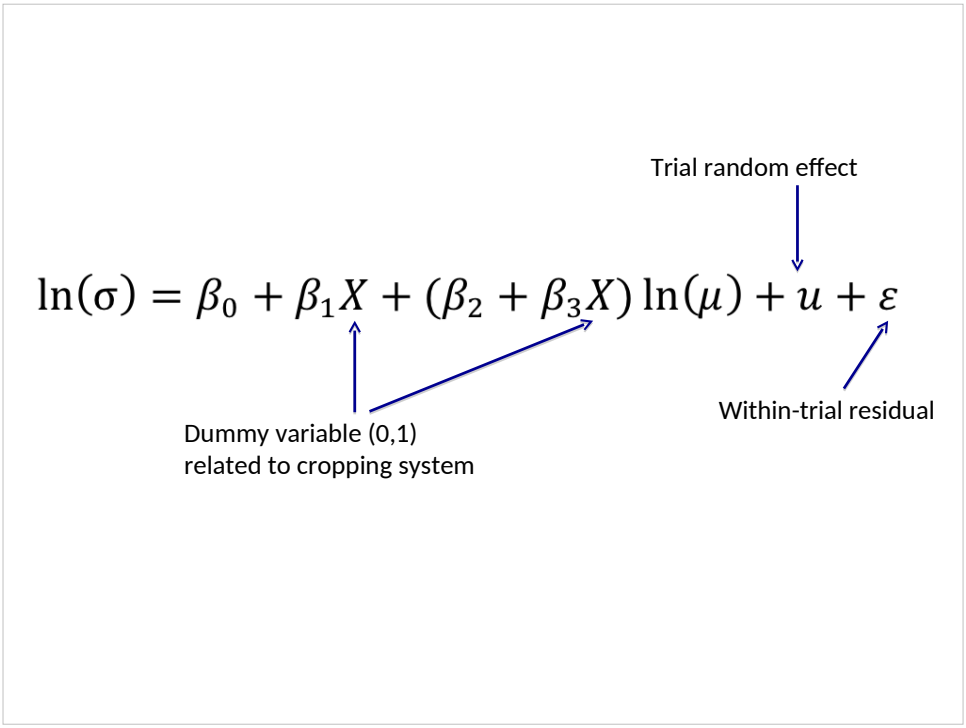
- Yields in organic horticulture were on average 20 to 24% lower than yields in conventional horticulture
- Strong variability of organic vs. conventional yield ratios across experimental sites.
  - The probability to get an extremely high yield loss in organic systems was small: yield loss has only 10% chance to exceed 50% compared to conventional yield.
  - Organic yield has 20% chance to exceed conventional yield.

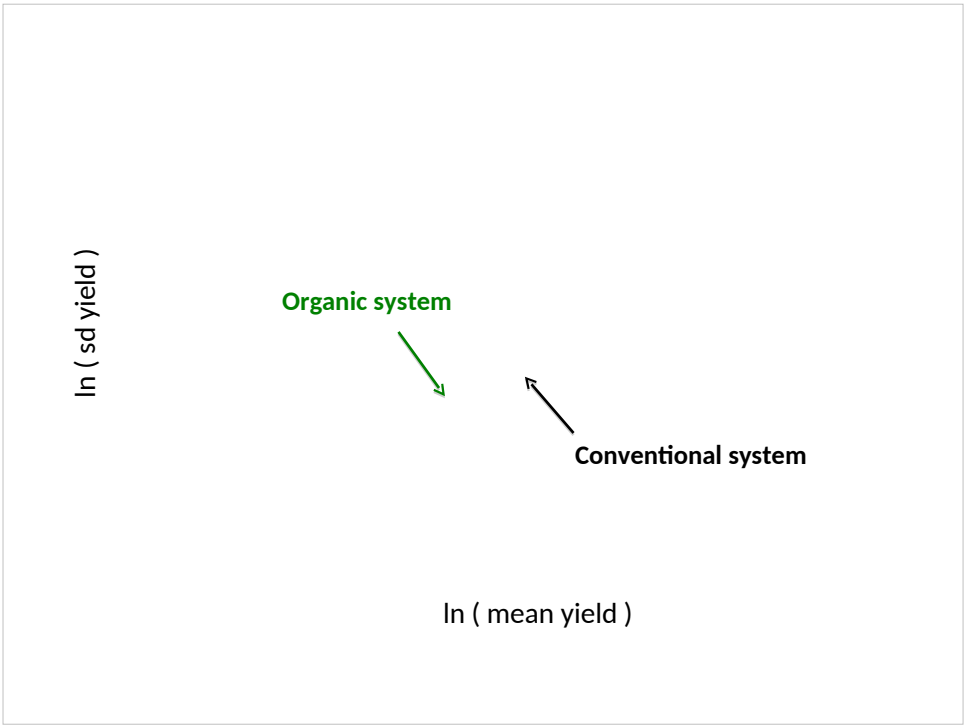
  → Agronomists should not focus on average yield loss only, but analyse the whole yield ratio distribution when studying the productive capacity of organic farming.
- We did not identify any covariates affecting significantly the magnitude of the yield loss.
- We did not find any difference between organic and conventional horticulture yield variances across replicates and years.

Yield mean – Yield variance relationship

Taylor's law: $\sigma^2 = a\mu^b$

- Does such a relationship exist for inter-annual crop yield variance?
- Does it depend on cropping systems?


Trial random effect
$\ln(\sigma) = \beta_0 + \beta_1 X + (\beta_2 + \beta_3 X)\ln(\mu) + u + \varepsilon$
Dummy variable (0,1)
related to cropping system
Within-trial residual


ln (sd yield)
Organic system
Conventional system
ln (mean yield)

Perspectives

- Check with economists whether this kind of results could be useful for them

- Study a range of « diversified » cropping systems:
  - ✓ Systems based on (long) rotations
  - ✓ Intercropping systems
  - ✓ Cover crops
  - ✓ Agroforestry
- Extract results of c.a. 100 meta-analyses performed on these topics
- Assess quality of these meta-analyses
- Post-doc starting on Jan. 2018 (EU project DiverIMPACT)