A meta-regression analysis of Finnish phosphorus fertilization trials of cereals

Elena Valkama, Risto Uusitalo, Eila Turtola

MTT Agrifood Research Finland, Plant production/
Soils and Environment, Jokioinen
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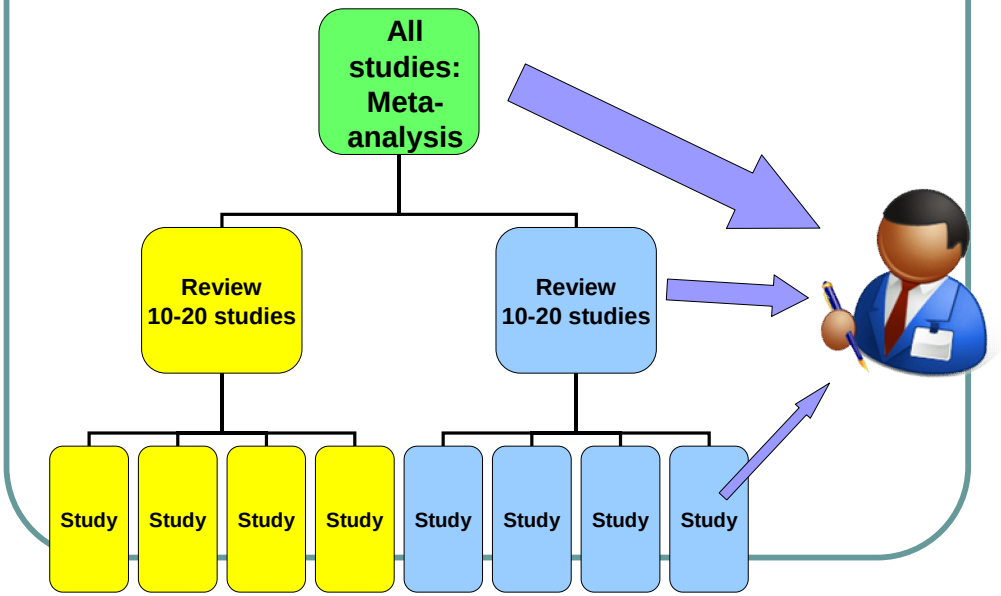
Data for model definition



Yield response models, problems of traditional approach:

- A single fertilizer trial:
  - regression analysis, BUT relevance for other conditions?
- Numerous independent experiments:
  - Methodological diversity
  - Climatic conditions
  - Unequal within-study variances (variance of the sampling errors)
  - Violate the assumptions of regression analysis

What is meta-analysis?

- *The statistical analysis of a large collection of results for the purpose of integrating the findings.*
- Medicine and social sciences: over 40 years.
- Ecology: the past 15 years.
- Agricultural science: currently.

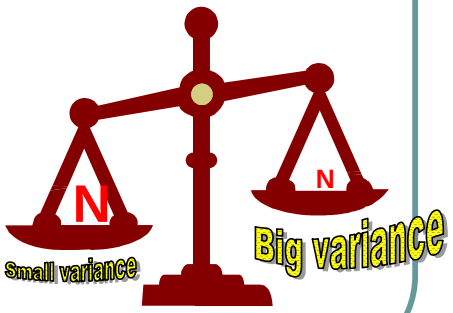
What is meta-analysis?

- An index of effect size, *r:*
  $\ln r = \ln (Yield_{PKN}/Yield_{KN})$

  the results from individual studies can be compared and evaluated.

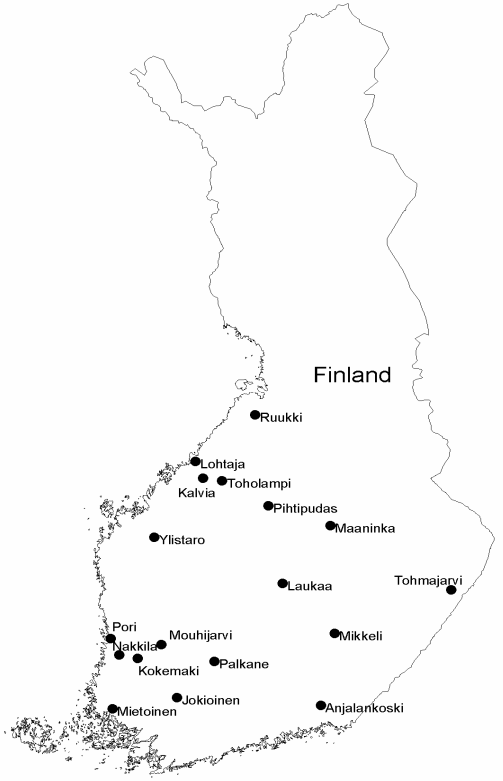
- Meta-regression is an extension of meta-analysis.

- Weighting procedure increases the precision of the combined estimates

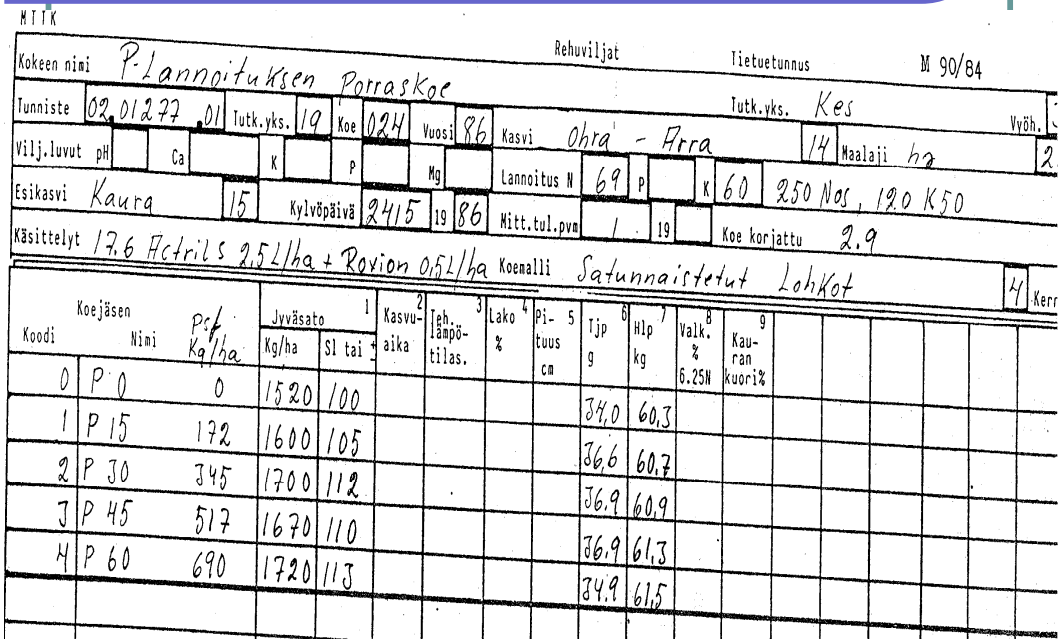


Database

- Published and unpublished reports, MTT Research Stations and farmers' fields
- 43 short- and long-term experiments, 20 sites
- Years 1950 - 2007
- Variable soil groups
- Variable soil test P (STP) status
- spring barley, oats, spring and winter wheat, and winter rye.
- P rates 6–100 kg ha^{-1}



Data extraction



MTTK

Kokeen nimi P-Lannoituksen Porraskoe — Rehuviljat — Tietuetunnus M 90/84

Tunniste 02.01277.01 — Tutk.yks. 19 — Koe 024 — Vuosi 86 — Kasvi Ohra - Arra — Tutk.yks. Kes — Vyöh. — 14 — Maalaji hs

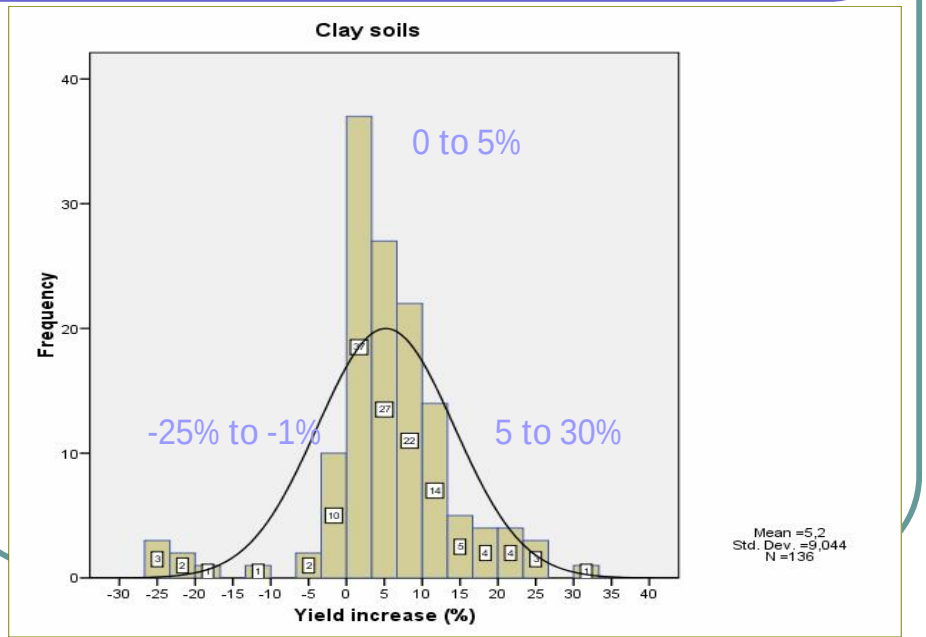
Vilj.luvut pH — Ca — K — P — Mg — Lannoitus N 69 — P — K 60 — 250 Nos, 120 K50

Esikasvi Kaura — 15 — Kylvöpäivä 2415 19 86 — Mitt.tul.pvm 1 19 — Koe korjattu 2.9

Käsittelyt 17.6 Actril S 2.5 l/ha + Roxion 0.5 l/ha — Koemalli Satunnaistetut Lohkot — 4 — Kerr

Koejäsen Koodi	Nimi	P-tf Kg/ha	Jyväsato 1 Kg/ha	Sl tai	2 Kasvu-aika	3 Leh. lämpö-tilas.	4 Lako %	5 Pi-tuus cm	6 Tjp g	7 Hlp kg	8 Valk. % 6.25N	9 Kaur-an kuori%
0	P 0	0	1520	100					34,0	60,3		
1	P 15	172	1600	105					36,6	60,7		
2	P 30	345	1700	112					36,9	60,9		
3	P 45	517	1670	110					36,9	61,3		
4	P 60	690	1720	113					34,9	61,5		

All studies on clay soils



Meta-analysis

Valkama, et al. (2009) Agriculture, Ecosystems and Environment, 130: 75-85

Effects:

- Soil group:
  organic > coarse-textured mineral > clay
- Soil Test Phosphorus (STP) classes:
  low > medium > high

↓

Separately

No effects:

- Cultivation zones
- Soil pH
- Cereal species

↓

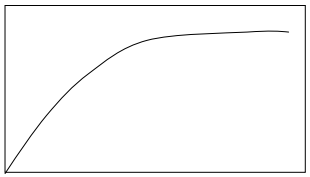
Pooled data

Yield response models

- Mitscherlich model

$$y = A\times(1-e^{-bx})$$

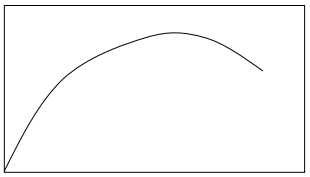
y, yield response
A, the maximum yield
b, constant that governs the rate of yield response
x, P fertilizer rate



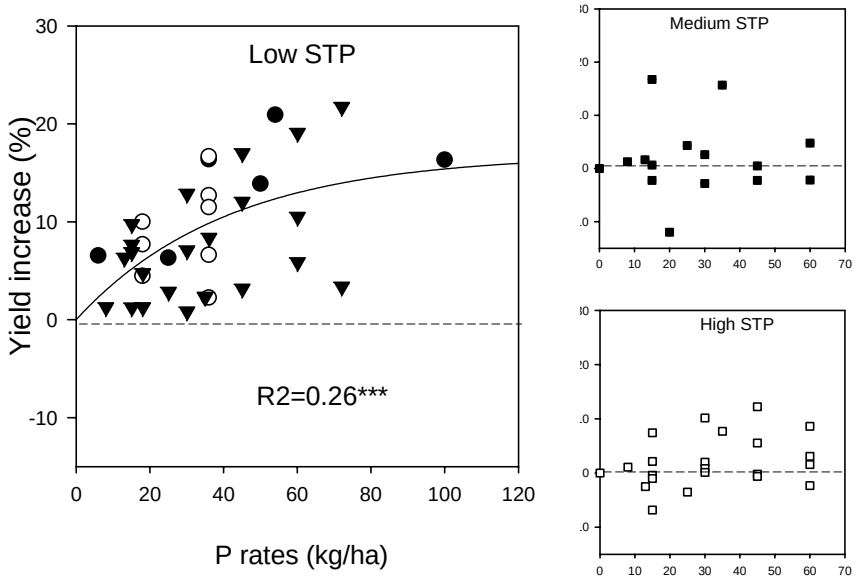
- Quadratic model

$$y = y_0 + ax + bx^2$$

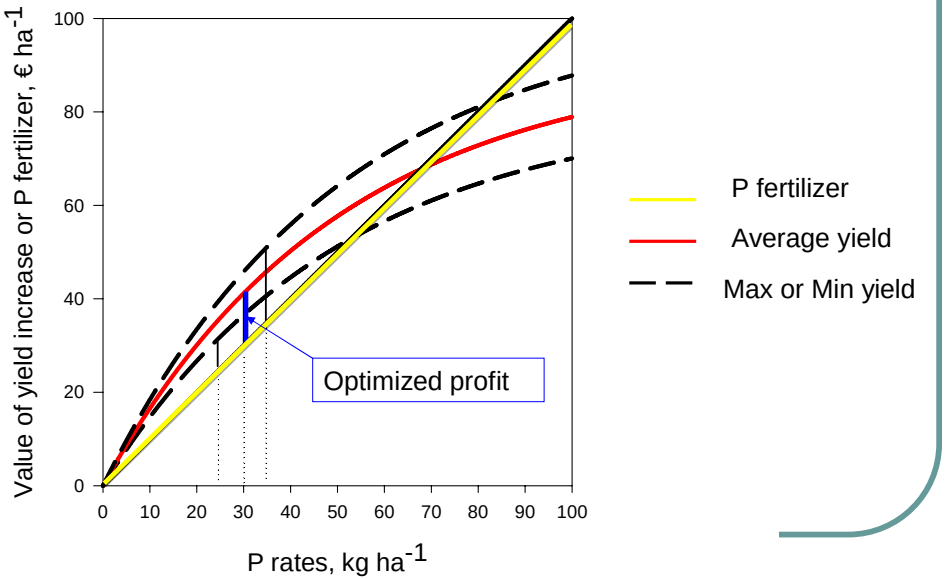
y, yield response;
y_0, yield at P = 0;
a and *b*, fitted constants,
x, the P fertilizer rate.



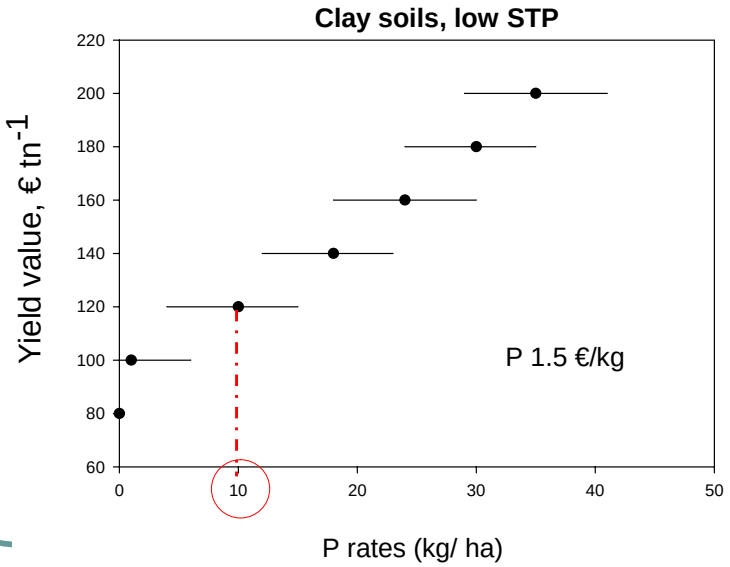
Clay soils



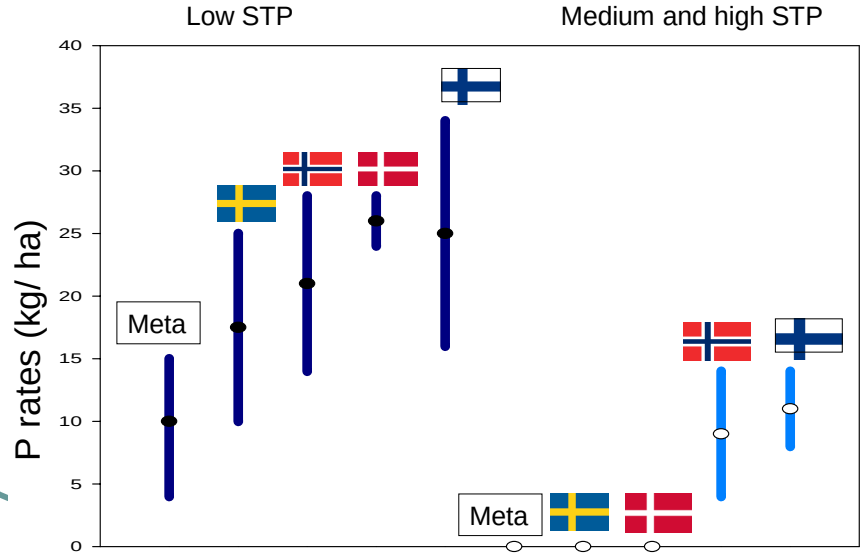
Calculation of optimal P rates



Optimal P rates



P fertilizer recommendations



Conclusions:

- Meta-regression is useful and reliable method to analyze **a large collection of results**.
- Meta-regression allows to built a model for data **regardless methodological diversity** across studies.
- Preliminary meta-analysis gives an idea which **factors may impact outcomes**.
- P fertilization can be substantially reduced in most agricultural fields, or even omitted without economic loss under current or higher P fertilizer prices.