A systematic synthesis of agricultural management impacts on crop yield, soil quality, and environment

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Introduction

• Many meta-analysis studies have been done in agriculture, especially in the last decade (Krupnik et al. 2019).

• Our aim was to develop a decision support system and integrate simple algorithms on the effects of recommended agronomic management practices on agricultural sustainability indicators.
  • **Crop**: crop yield, N and P use efficiency (NUE and PUE)
  • **Soil**: C, N and P contents and soil compaction
  • **Environment**: N and P surplus, N (NH$_3$ and N$_2$O) losses to air

• This resulted in a review of 113 meta-studies to:
  • Identify gaps where more studies are needed
  • Synthesize mean effects of management while accounting for site properties
Overview of selected studies

Number of meta-studies assessing management impacts

Impact indicator:
- Crop yield
- Nuptake NUE
- Puptake PUE
- Soil C
- Soil N
- Soil P
- Soil Compaction
- CO2 emissions
- N2O emissions
- NH3 emissions
- NO3- surplus
- PO43- surplus

Management practice:
- Rotation or multi-crop
- Cover crop
- Legume
- Residue management
- Irrigation
- Reduced tillage
- No tillage
- N fertiliser
- P fertiliser
- N/ P fertiliser combined
- Right rate, organic-mineral
- Right rate
- Right rate placement
- Enhanced efficiency
- Biochar

Selected studies focus on:
- Crop
- Soil/Water
- Fertilizer & 4R
- Other amendments
Methods of selected studies

• Weighting
  • 58% – weighted meta-analysis
  • 40% – inverse-variance weighting
  • 23% – inverse-variance weighting and removal of studies with missing variance

  → Indicates guidelines needed for weighting and study variance

• Assessment of covariate effects (site properties)
  • 58% – division of total observations into subgroups
  • 23% – single factor multiple regression (one covariate)
  • 7% – multiple factor multiple regression (several covariates)

  → Indicates data needed from field studies on site properties to allow for integrated analysis of local effects
Synthesis of meta-analysis effect sizes

- Effects are quantified for all mentioned indicators
  - (Here key examples presented for crop yield, soil carbon, N surplus)
- More than 10 types of measures are evaluated
- Each individual mean is an effect size reported by one meta-study
  - All effects transformed to annual percentage change
- The weighted mean is the inverse-variance weighted mean of multiple individual means
Effect of measures are site-specific!

This table illustrates that the overall effect of a measure depends on site properties.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Management measure</th>
<th>Overall impact (% yr⁻¹)</th>
<th>n overall effect sizes</th>
<th>Average effects of covariates on impact of measure (+/-)</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil texture</td>
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<td></td>
<td></td>
<td>Coarse</td>
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<td>yield</td>
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<td>Reduced Tillage</td>
<td>-2</td>
<td>11</td>
<td>-</td>
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<tr>
<td>SOC</td>
<td>Diverse rotation</td>
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<td>15</td>
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<td>20</td>
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<td>Reduced Tillage</td>
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<td>13</td>
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<tr>
<td>N2O emissions</td>
<td>Diverse rotation</td>
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<td>N surplus</td>
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</table>

Positive/increase
Negative/decrease
No data