Cut, carry, compromise? Three years of plant-based fertilization in the Netherlands

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Context

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Main challenges

- Intensive farming – 2nd largest exporter
  - 66 % of the land area in the Netherlands is used for agriculture
- Loss of organic matter and soil fertility
- Nutrient management
  - nitrogen and phosphorus
- Changes in weather patterns
  - adapt water management and irrigation
- Sandy loam soils are prone to leaching
  - Small country, cultivation areas are often close to Natura 2000 areas

pressure for sustainability, circular nutrient flows, reduction of external inputs, and nature-based solutions.

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Case study – SPNA (Stichting Proefboerderijen Noordelijke Akkerbouw)

Kollummerwaard site (20ha) - Arable practice research – Conv/Org

NBS innovations being tested:

- Cut-and-carry fertilization (grass clover)
- Green manure

Cut and Carry: Biomass is grown on separate fields, harvested, and applied to potato fields to supply nitrogen and organic matter

Green manure: On-field cover crops incorporated to improve soil structure, water retention, and microbial life.

This allows nutrients and organic matter to be recycled from within the farm/region and reduces reliance on external inputs.

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Field investigated

Largest exporter to over 80 countries

Crop – Seed potato (mixed rotation with seed potatoes, cereals, sugar beet, and legumes.)

Field Type	Treatment	Expected outcome
Conventional	Conventional fertilizer 	High nutrients, low SOM/biology
Conventional Organic	Goat manure 	Adds SOM, boosts biology
Planty Organic (without compost)	Green clover 	Low input, internal nutrient cycling
Planty Organic (with compost)	Green clover + green compost 	Circular, high SOM and biology

- Reduce dependence on synthetic fertilizers
- Close nutrient cycles locally (circularity)
- Enhance soil fertility & structure
- Maintain yield and quality in seed potato systems

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Research questions

How do different soil management practices affect soil physical, chemical, and biological properties over three years?

To what extent do NBS interventions (cut-and-carry fertilization, green manure, compost) improve soil fertility, microbial activity, and seed potato performance, and how do these practices influence short-term soil resilience?

How do soil depth and sampling moment affect the assessment of soil physical, chemical, and biological properties?

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Methods

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Experimental design

4 fields (rotation)

Conventional

Conventional organic

Planty organic

Planty organic with compost

3 years

2023

2024

2025

2 depths

0 – 20 cm

20 – 40 cm

2 moments of sampling

Before seeding

Before harvest

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Analysis indicators

Soil

- **Physical properties:** Bulk density (BD), soil aggregates and water retention and availability
- **Chemical properties:** pH, soil organic carbon, soil total nitrogen and phosphorus, soil available nitrogen and phosphorus
- **Biological properties:** soil microbial biomass carbon, nitrogen and phosphorus

Crop

- Seed potato yield
- Nitrogen and phosphorus content in seed potato samples

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Results

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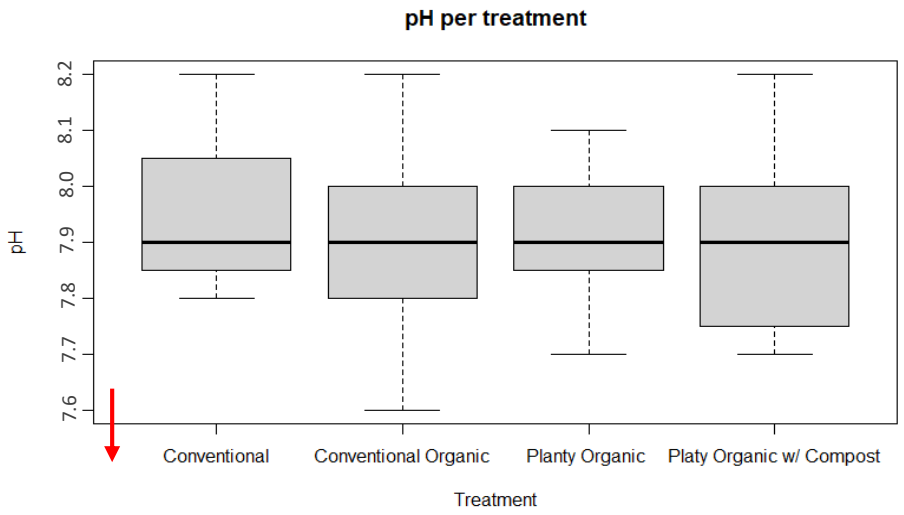
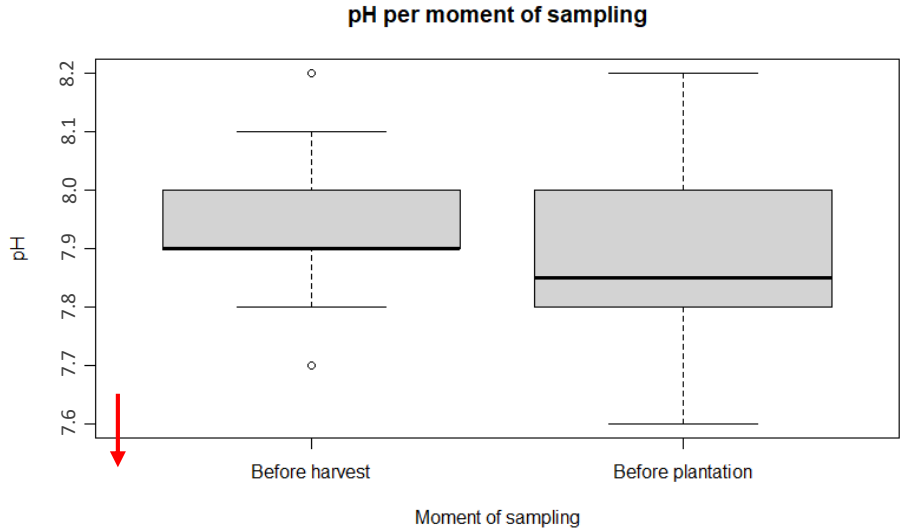
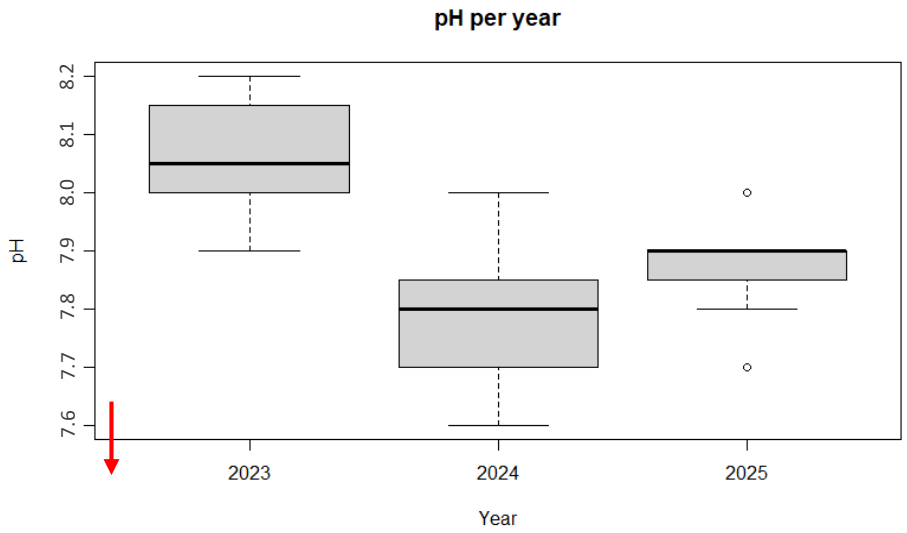
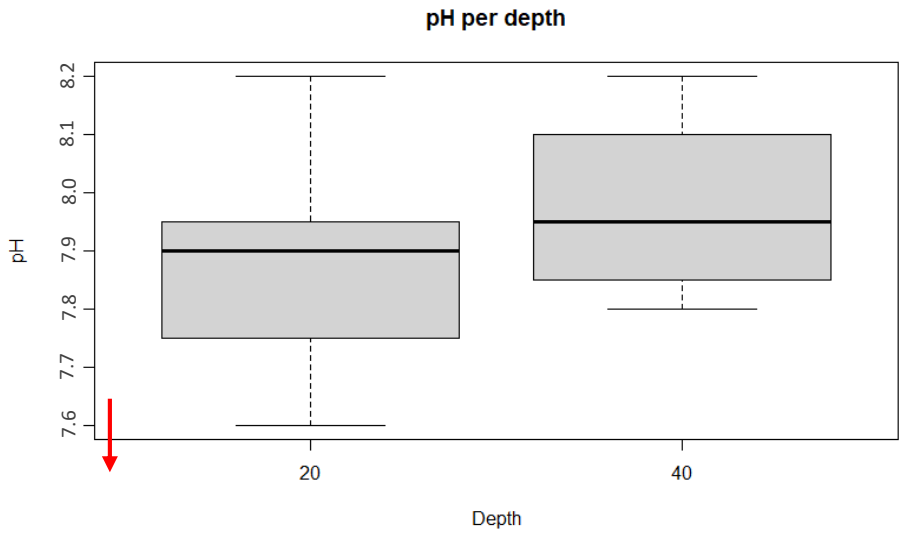
pH









Based on sandy soils:

Suitable for potato production:

5.5 – 6.5 pH

Suitable for soil health:

6.5 – 7.0 pH

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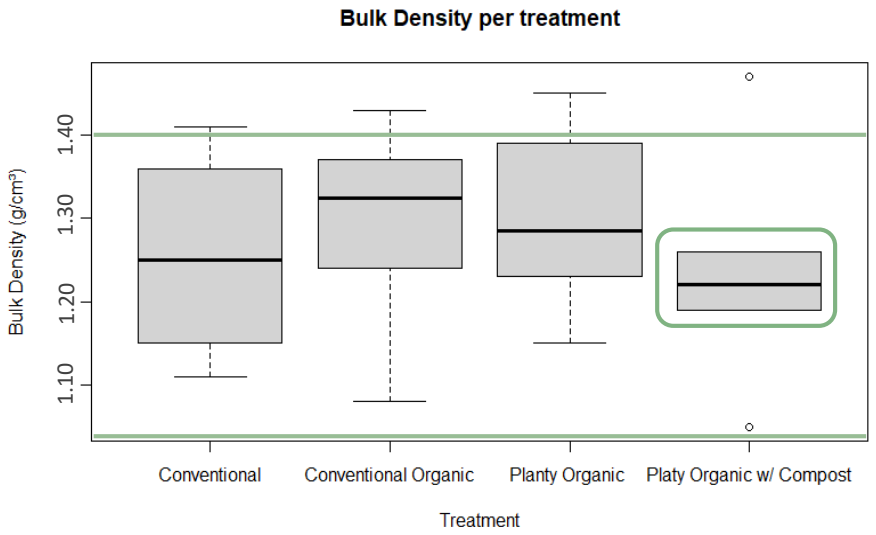
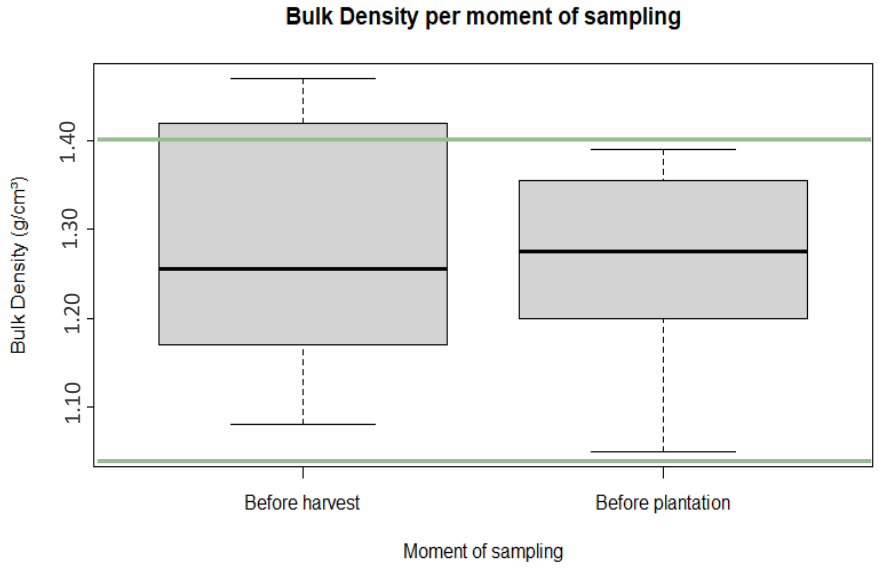
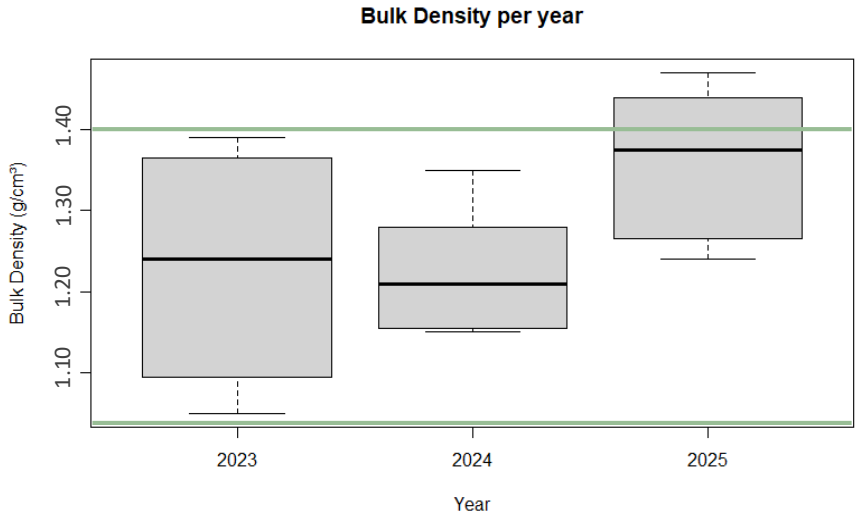
Bulk Density







Based on sandy soils:

Suitable for potato production:

1.2–1.4 g/cm³

Suitable for soil health:

1.0–1.3 g/cm³

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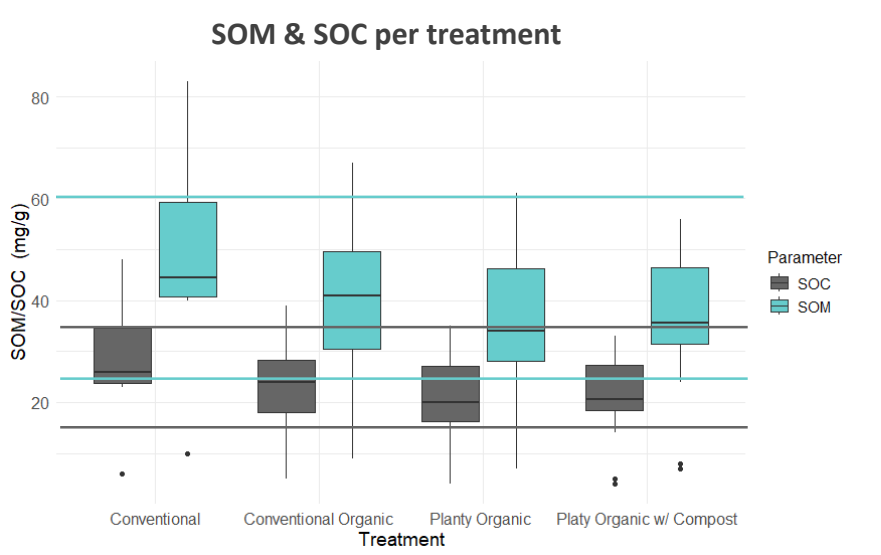
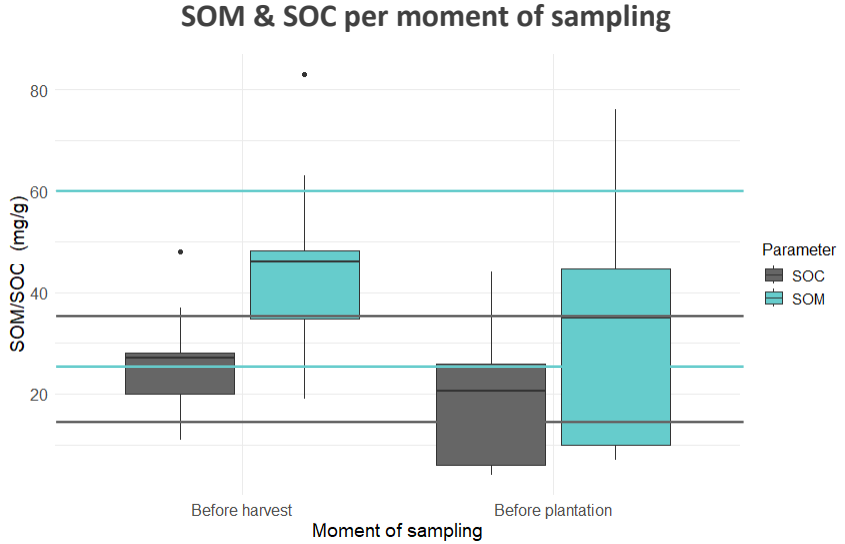
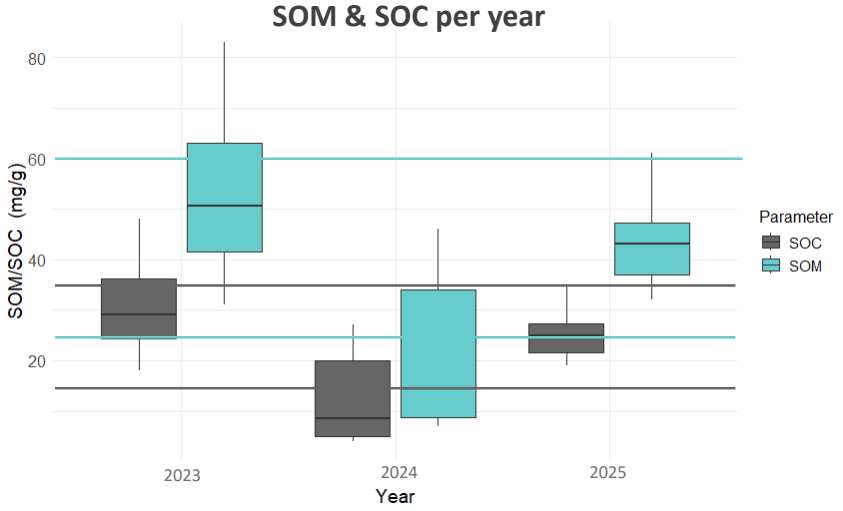
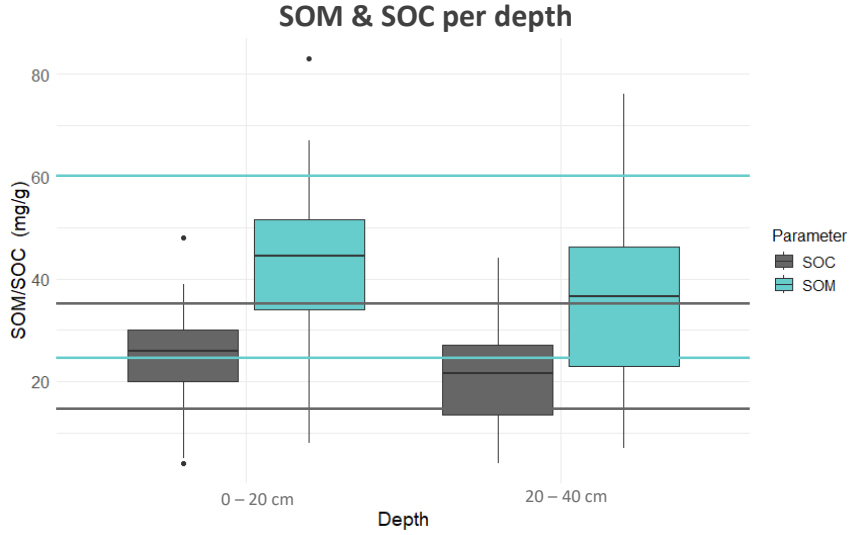
SOM & SOC









Based on sandy soils:

Suitable for potato production:

SOC 15 – 25 mg/g
SOM 26 – 43 mg/g

Suitable for soil health:

SOC 20 – 35 mg/g
SOM 35 – 60 mg/g

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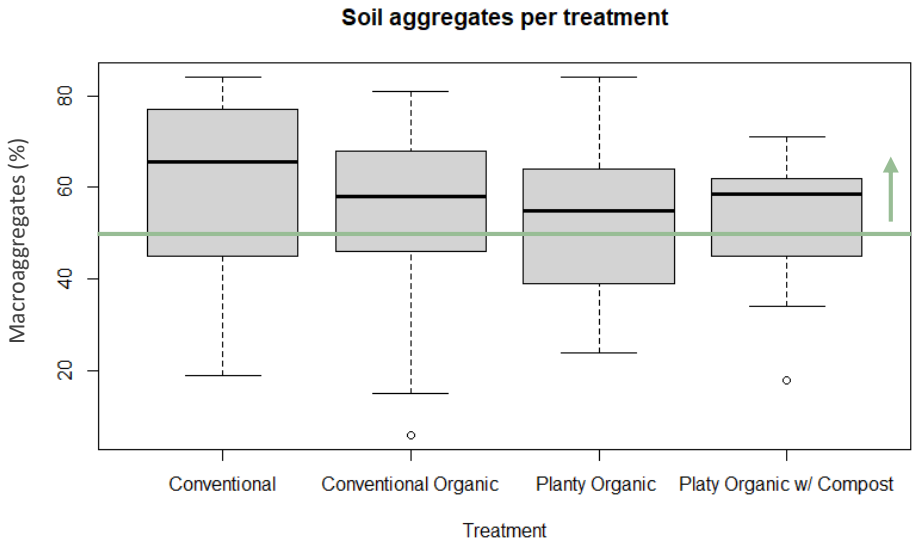
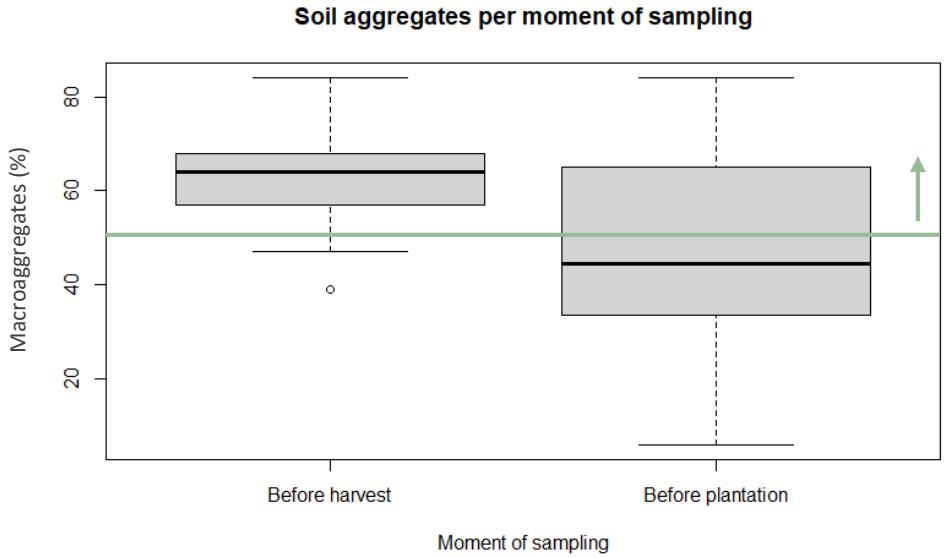
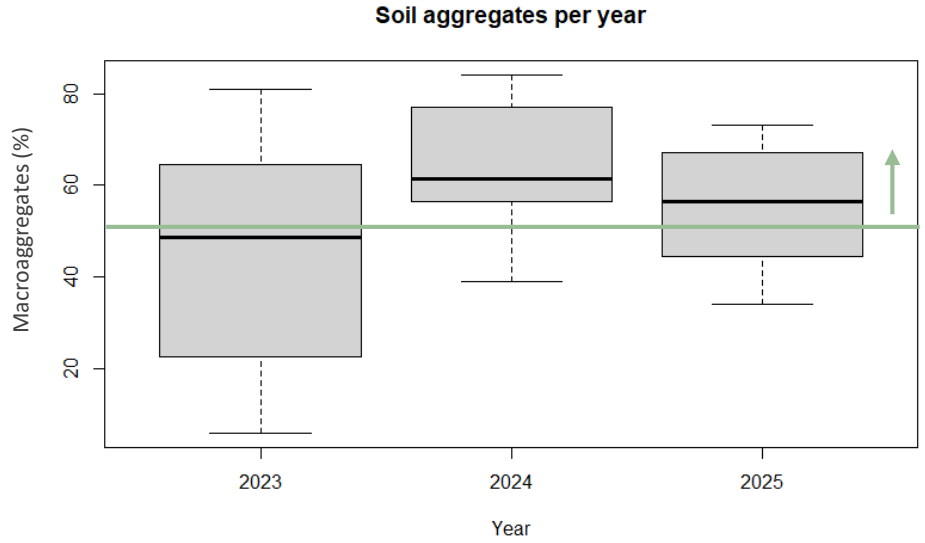
Soil Aggregates







Based on sandy soils:

Suitable for productive agriculture & soil health:

Macroaggregates (>0.25 mm) >50%

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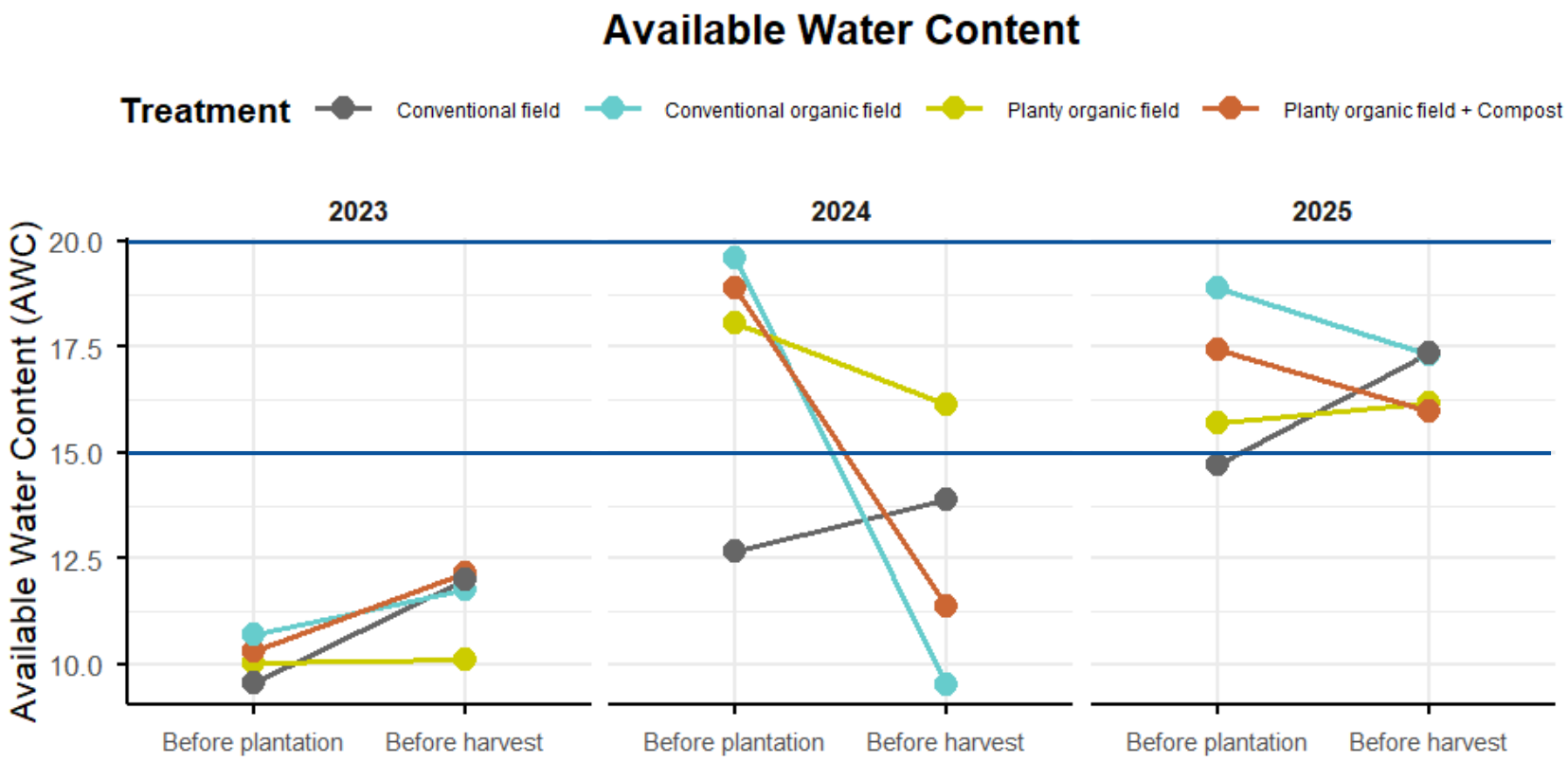
Water Availability



Based on sandy soils:

Suitable for productive agriculture & soil health:

15 – 20 %

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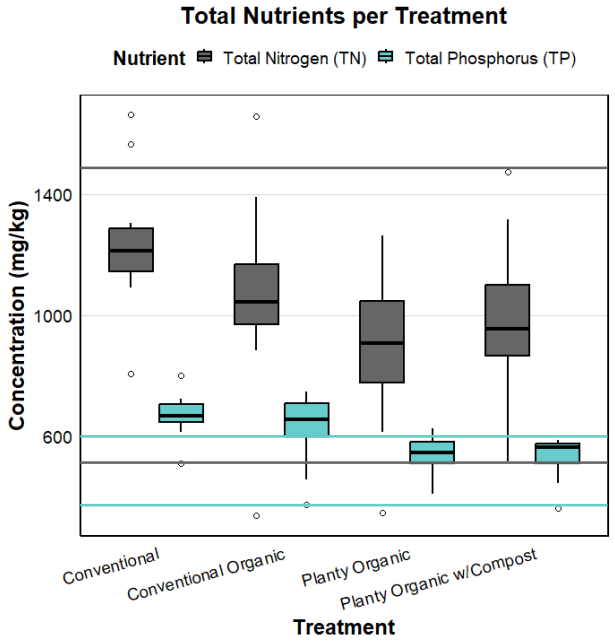
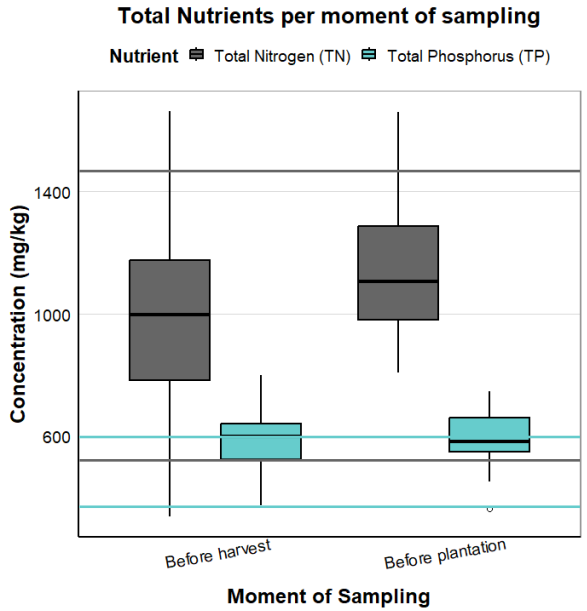
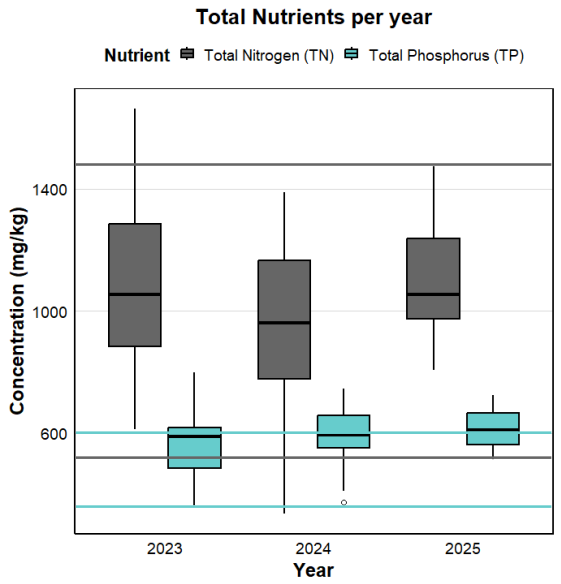
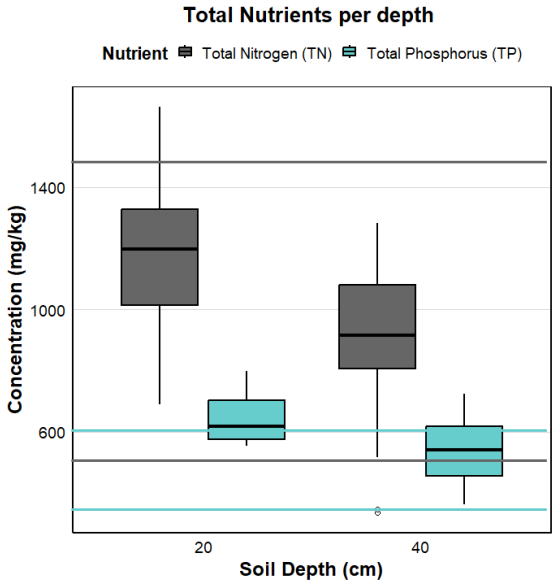
Total N & P









Based on sandy soils:

Suitable for potato production:

TN 700 – 1200 mg/kg
TP 200 – 500 mg/kg

Suitable for soil health:

TN 500 – 1500 mg/kg
TP 200 – 600 mg/kg

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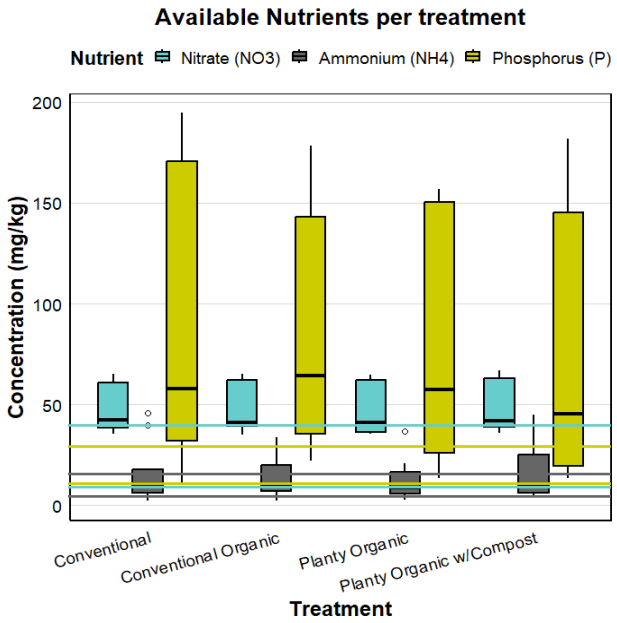
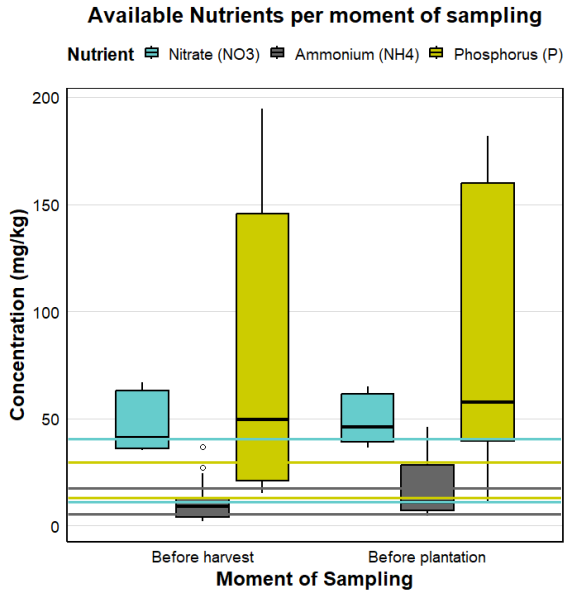
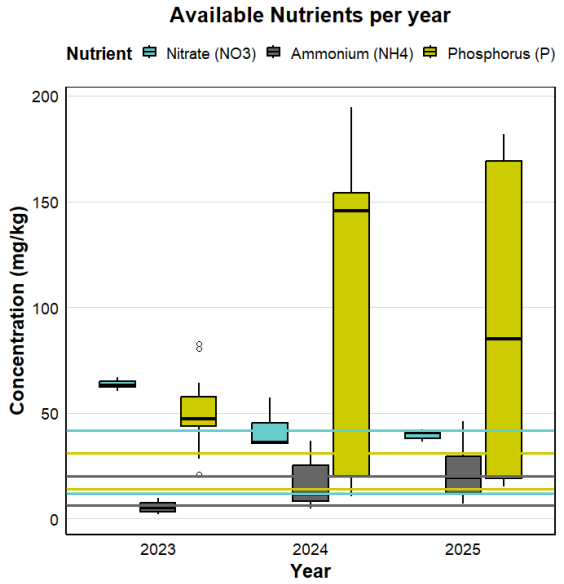
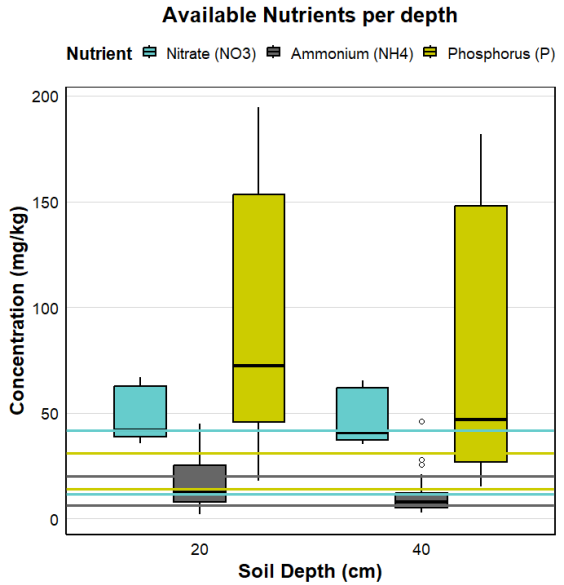
Available N & P









Based on sandy soils:

Suitable for potato production:

NO_3^--N 15 – 40 mg/kg
NH_4^+-N 5 – 15 mg/kg
Olsen P 15 – 30 mg/kg

Suitable for soil health:

NO_3^--N 10 – 30 mg/kg
NH_4^+-N 5 – 15 mg/kg
Olsen P 10 – 25 mg/kg

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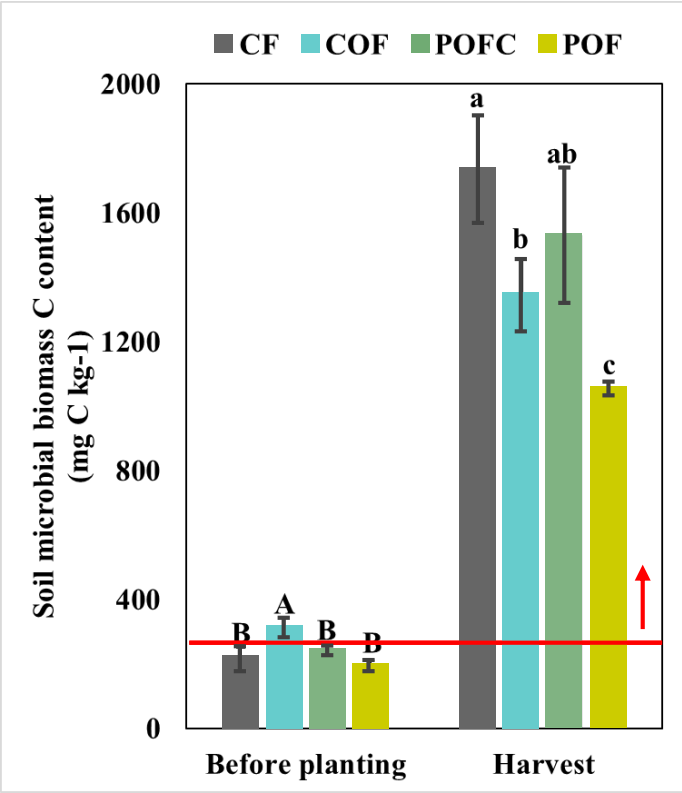
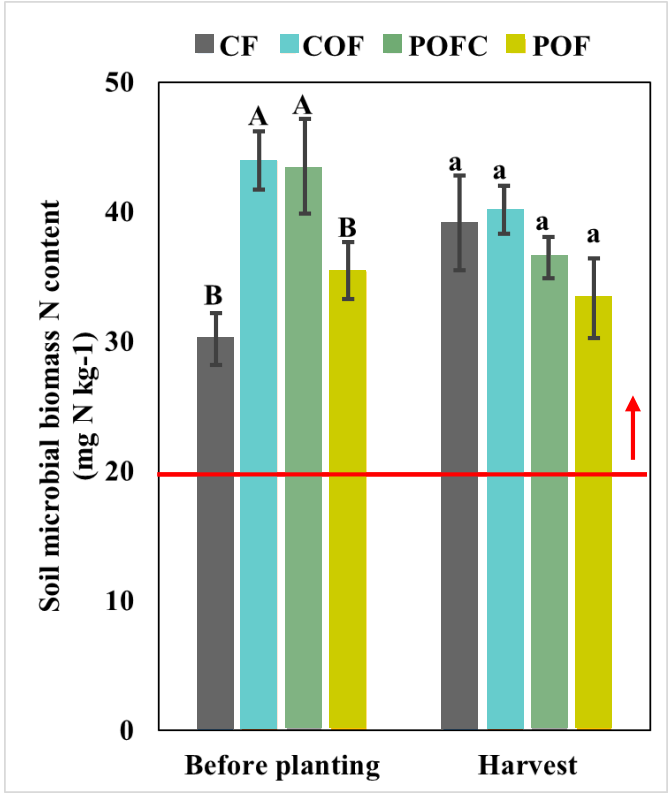
Soil microbial biomass (C, N, P) in 2023

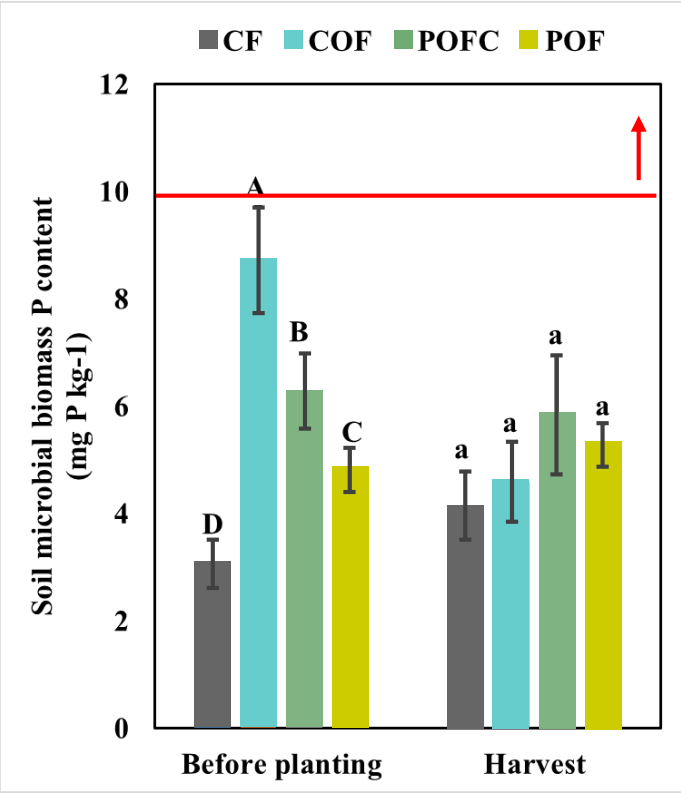
Carbon



Nitrogen



Phosphorus



Suitable for productive potato production:

250 mg C/Kg
20 mg N/kg
10 mg P/kg

Suitable for soil health:

400 mg C/Kg
40 mg N/kg
20 mg P/kg

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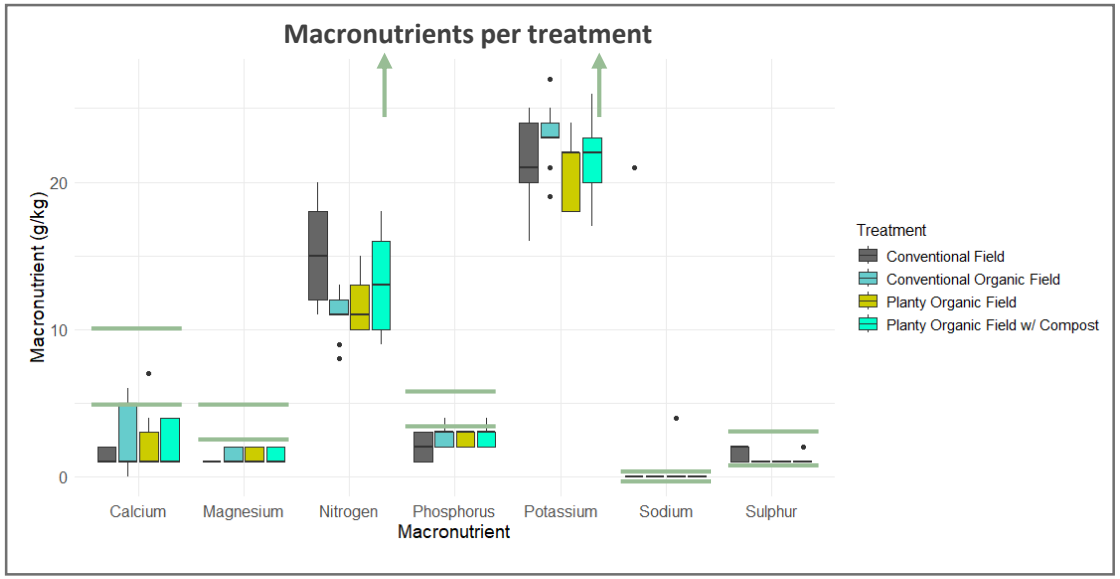
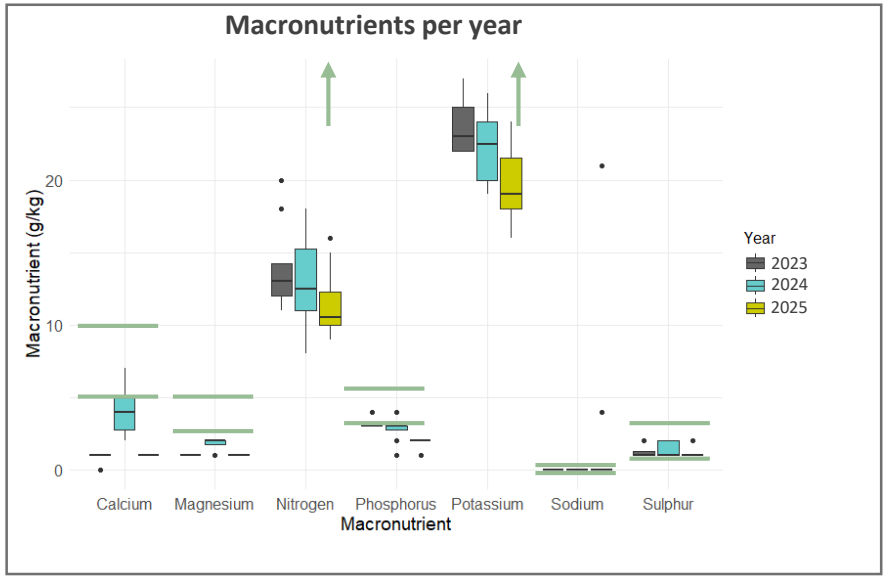
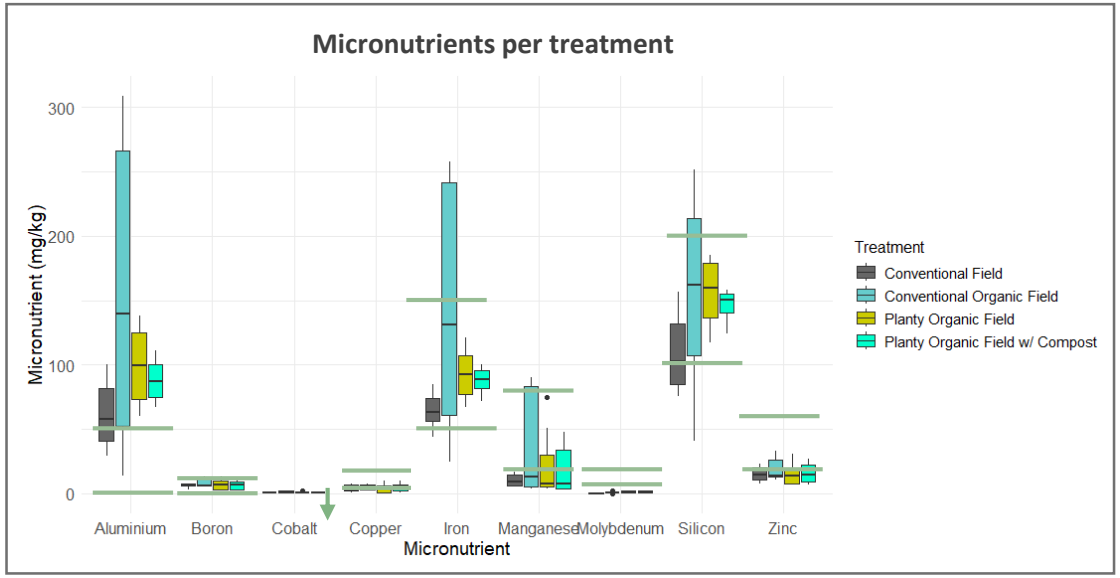
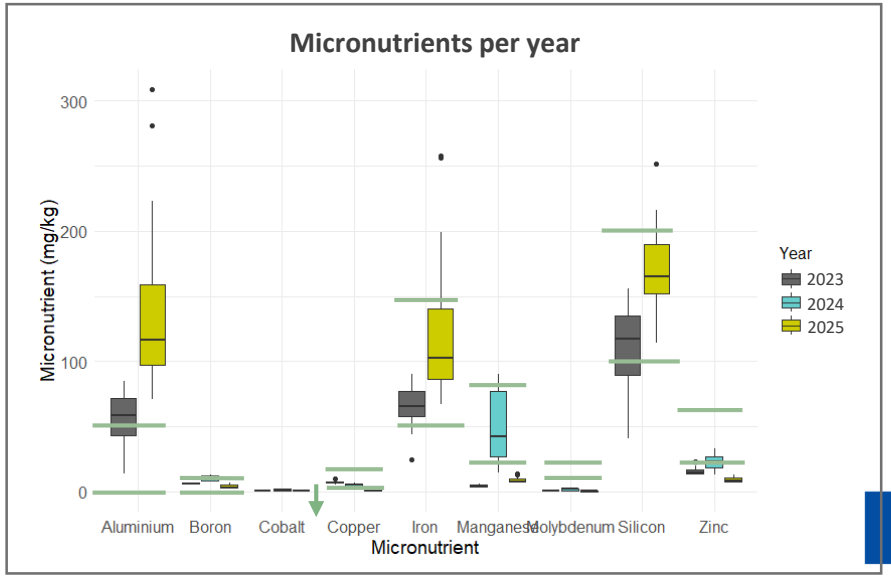
Nutrients in seed potatoes









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Seed potato yield

Field Type	2023	2024	2025
Conventional	36 ton/ha	**41 ton/ha**	**39,2 ton/ha**
Conventional Organic	**38,4 ton/ha**	15,7 ton/ha	33,6 ton/ha
Planty Organic (without compost)	34,15 ton/ha	12,16 ton/ha	31,54 ton/ha
Planty Organic (with compost)	33,71 ton/ha	9,27 ton/ha	7,6 ton/ha

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Conclusions

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General conclusions

- Soil management practices showed limited short-term effects, with environmental conditions dominating soil dynamics.
- In general, NBS and organic systems maintained soil properties similar to the conventional field, but with lower, more sustainable inputs.
- Soil depth and sampling moment influence soil assessment and interpretation.
- NBS benefits may take longer to become measurable.
- The soils investigated may have high buffering capacity, with stable properties across treatments.

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Sustainable soil management could preserve soil conditions at levels similar to conventional treatments while setting the stage for potential long-term benefits.

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Thank you!

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WAGENINGEN UNIVERSITY & RESEARCH

SLM Soil Physics and Land Management

SPNA agroresearch

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