Crop yield and yield quality in ten silvoarable agroforestry systems across Germany

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MODEMA

A Germany-wide model and demonstration network for agroforestry: scientific evidence and practical support for farmers

Background

- Crop yield varies in temperate agroforestry systems from tree row to crop alley centre (Koch et al. 2025; Pardon et al. 2025)
- Directions of variability are sometimes unclear; farmers may retreat from establishing agroforestry systems

→ Evidence from practical fields are needed to convince other farmers

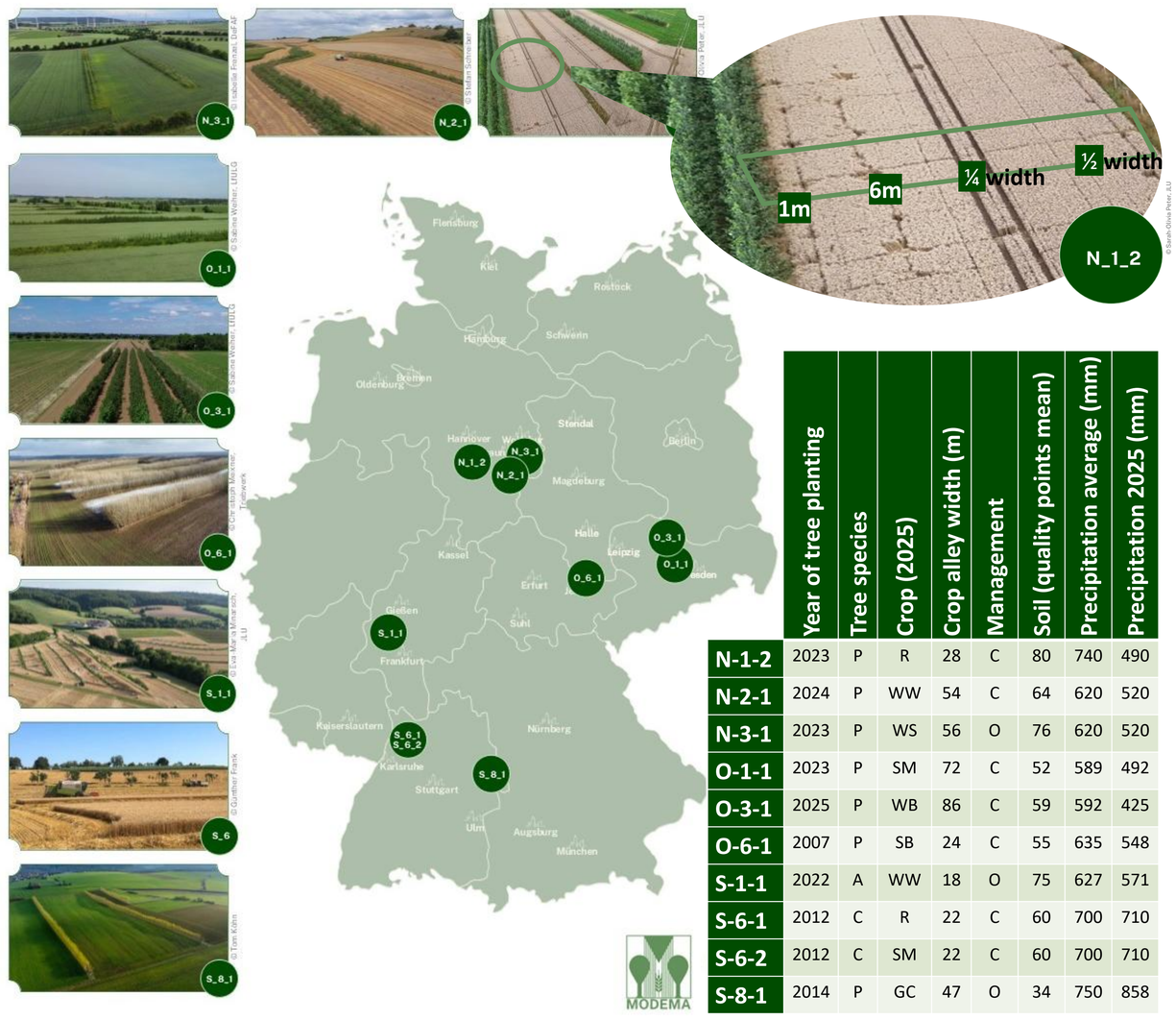
Research Questions

- Is the pattern valid for typical arable crops in Germany?
- How do pedoclimatic conditions contribute to yield variability in alley-cropping systems?
- How is crop quality affected by tree rows?
- Can crop quality variability compensate for yield reduction?

Agroforestry systems & methods

- 10 alley-cropping systems across Germany under different pedoclimatic conditions and management (Fig 1).
- 2025: Assessment of crop development and yield along a common transect design (Minarsch et al. 2024): 6 transects with 4 measurement points (1x1 m) at fix (1m and 6 m) and variable (1/4 crop alley width, ½ crop alley width) distances (Fig. 1).
- Yield normalization along transects:

  relative yield = yield /(mean of transect)
- Crop quality analyses with near-infrared spectroscopy (NIRS), e.g.:
  - Raw protein content (cereals)
  - Oil content (rapeseed)
  - Net energy for lactation (NEL; fodder crops).
- Relative quality on yield per area base against mean of transect.
- Analysis with linear models and pairwise post-hoc comparison.



	Year of tree planting	Tree species	Crop (2025)	Crop alley width (m)	Management	Soil (quality points mean)	Precipitation average (mm)	Precipitation 2025 (mm)
N-1-2	2023	P	R	28	C	80	740	490
N-2-1	2024	P	WW	54	C	64	620	520
N-3-1	2023	P	WS	56	O	76	620	520
O-1-1	2023	P	SM	72	C	52	589	492
O-3-1	2025	P	WB	86	C	59	592	425
O-6-1	2007	P	SB	24	C	55	635	548
S-1-1	2022	A	WW	18	O	75	627	571
S-6-1	2012	C	R	22	C	60	700	710
S-6-2	2012	C	SM	22	C	60	700	710
S-8-1	2014	P	GC	47	O	34	750	858

Fig. 1 Ten alley-cropping systems at nine MODEMA partner farms; transect with yield sampling points (1x1m) at 1m, 6m, ¼ crop alley width and ½ crop alley width; description of systems: trees (P: poplar; C: cherry mix; A: apple mix); crops (WW: winter wheat; WS: w spelt, WB: w barley; SB: summer barley; R: rapeseed; SM: silage maize; GC: grass clover); management (C: conventional; O: organic); soil quality based on German classification with max. 100 points.

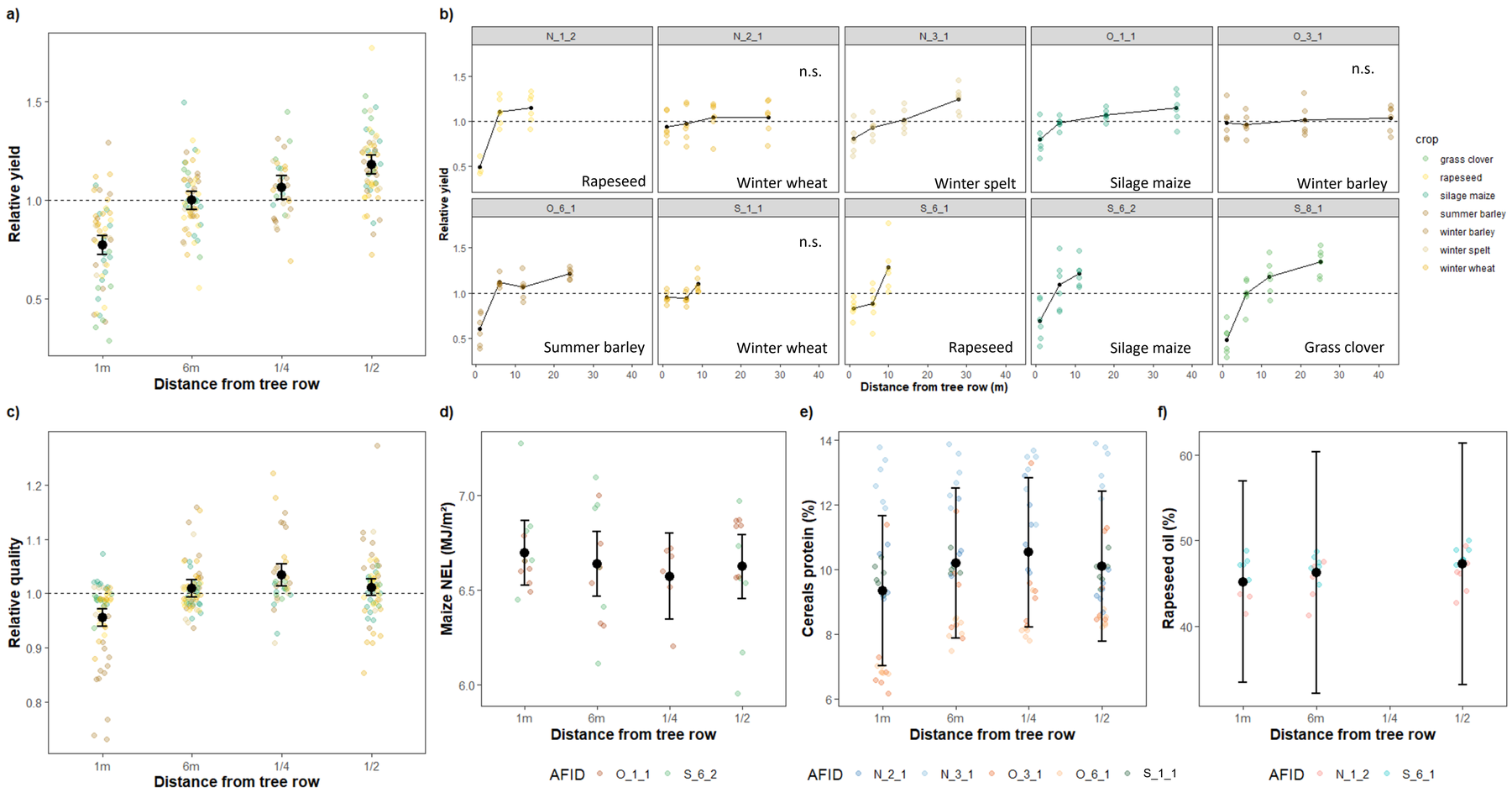


Fig. 2 a) Relative yield and c) relative quality across ten agroforestry systems and eight different crops; b) relative yield of ten agroforestry systems and eight different crops with numeric distance from the tree row along the crop alley; quality parameter of d) silage maize, e) cereals, f) rapeseed for agroforestry systems (AFID).

Highlights

- Crop yields followed a pattern through the crop-alley across various crops (Fig. 2a).
- Winter cereal yields (wheat and barley) were not significantly different between distances (Fig. 2b).
- Crop quality across different crops and quality indicators followed a similar pattern as yield but less pronounced (Fig. 2c).
- Quality response was not uniforam across quality parameters (Fig. 2d-2f).
- Maize energy level was highest close to the tree rows, but energy gains could not compensate for lower crop yield (Fig. 2d).

→ A non-agroforestry reference site provided a relative yield of 1.08 and relative quality of 1.01, but direct comparison is difficult (Thakur et al. 2026).

→ Data collection will be continued!

Acknowledgements

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References

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