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Ökonomische und ökologische Wirkung der ortsspezifischen Stickstoffdüngung

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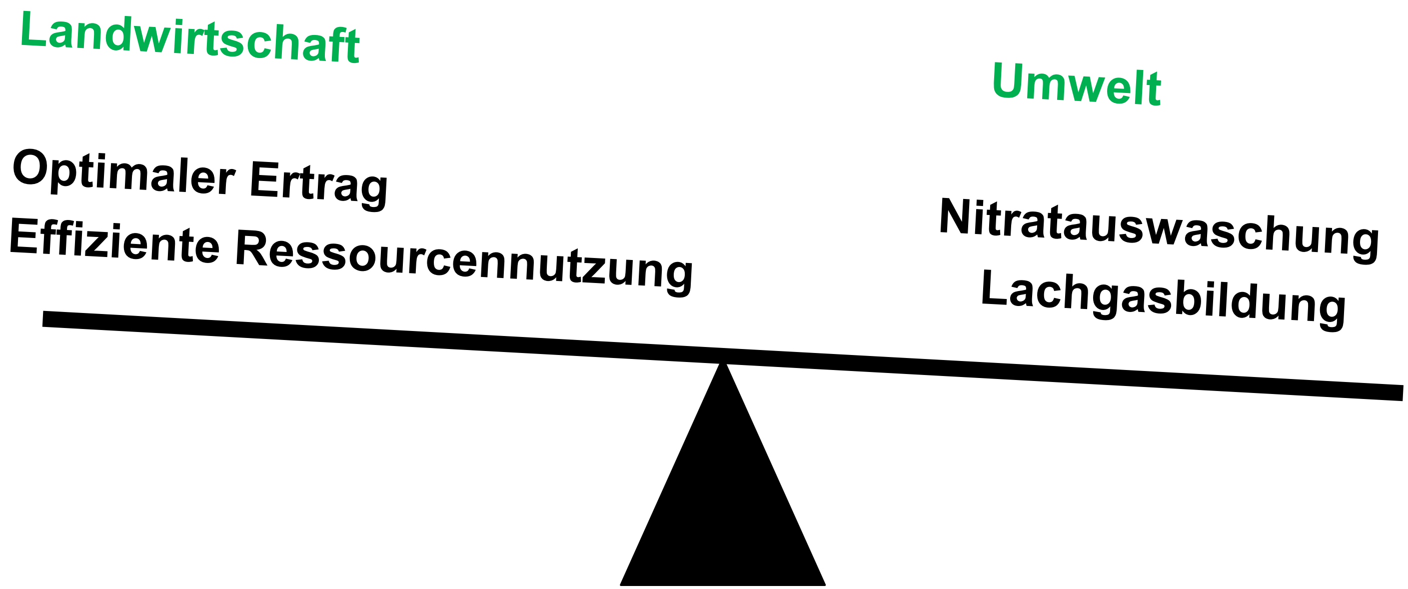
Gut dosierte Stickstoffdüngung – eine Herausforderung



→ Die Schweizer Landwirtschaft weist einen Stickstoffüberschuss aus, den es zu senken gilt.

source: T. Anken

Die Variabilität im Feld bewirtschaften

- Das **ortspezifische N-Management** zielt darauf ab:
  - die N-Nutzungseffizienz zu verbessern und
    den N-Überschuss zu reduzieren
  - N Nachlieferung von Boden präziser einzuschätzen
  - Ertrag, Qualität und Rentabilität zu erhalten

Fragestellungen

How can we evaluate the economic and environmental effects of the method?

Does site-specific N fertilization bring economic and/or environmental benefits to Swiss wheat production?

What are the alternative possible solutions based on the observed data?

Technical solutions

Political solutions

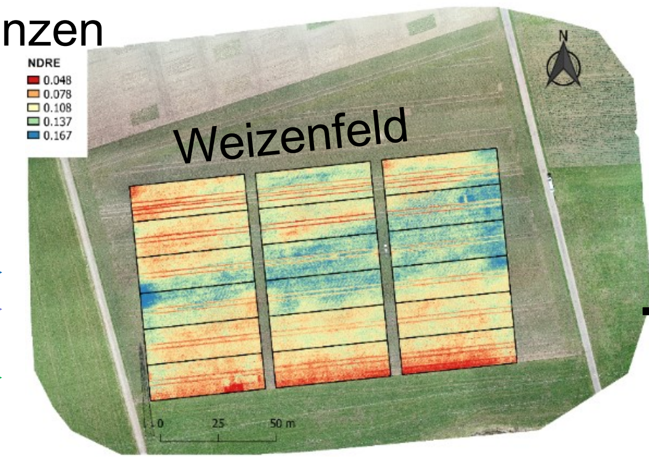
(i) determine two selected indicators: **economic optimum (EO)** of net revenues and the **balanced N supply (BNS)** for seven fields over three years based on the total N inputs from the soil system and N fertilizer

(ii) determine at which level N fertilizer's prices would have to be taxed to align the EO with a BNS.

Methoden und Datengrundlagen

“Gefühl des Landwirten” durch quantitative Methoden ergänzen

Luftbilder von Drohnen und Satelliten
messen Status der Pflanzen

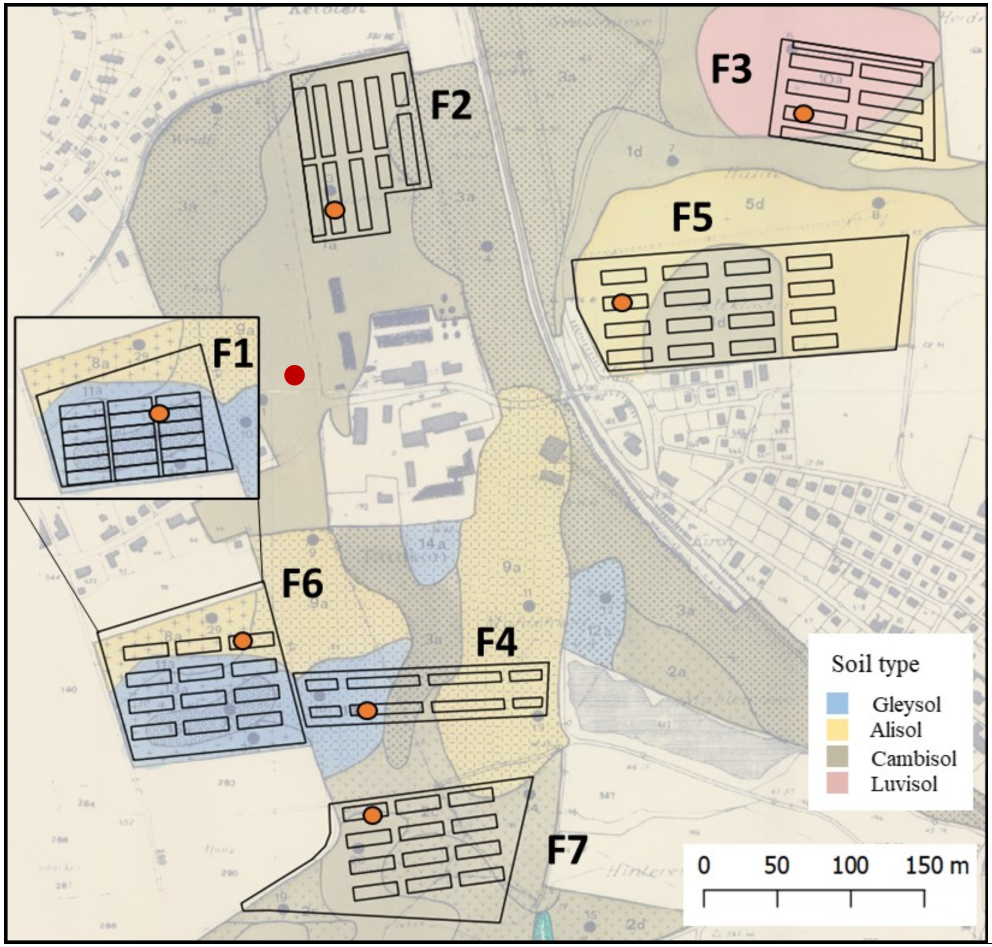


Saugkerzen messen
Nitratgehalt im Boden

Erstellen einer Düngekarte

Angepasste Aus-
bringung im Feld

Feldversuchen in Tänikon (2018-2020)



- **Crop**: **Winter Wheat** (T. *aestivum*)
- *(Varieties: Arnold and Montalbano)*
  - 2018: F1 ca. 2 ha
  - 2019: F2, F3 and F4 ca. 6 ha
  - 2020: F5, F6 and F7 ca. 9 ha
- **Treatments and controls**
  - Standard (**ST**)
  - Variable rate (**VR**)
  - No fertilizer control (NF)

  = N supply from soil and atmosphere (SNS)
  - Spectral control - N rich (NR)

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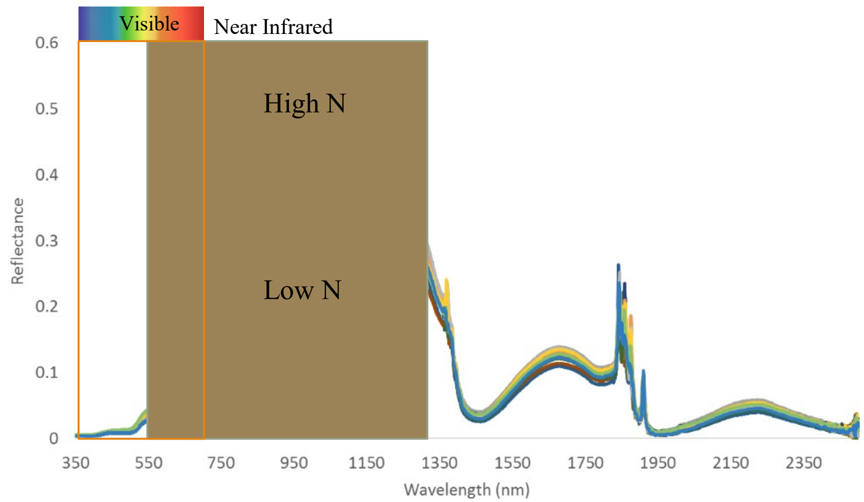
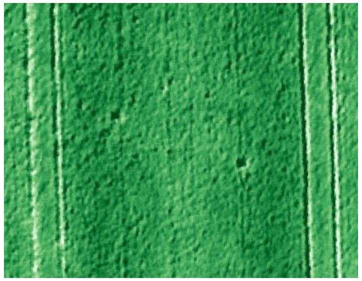
The crop monitoring

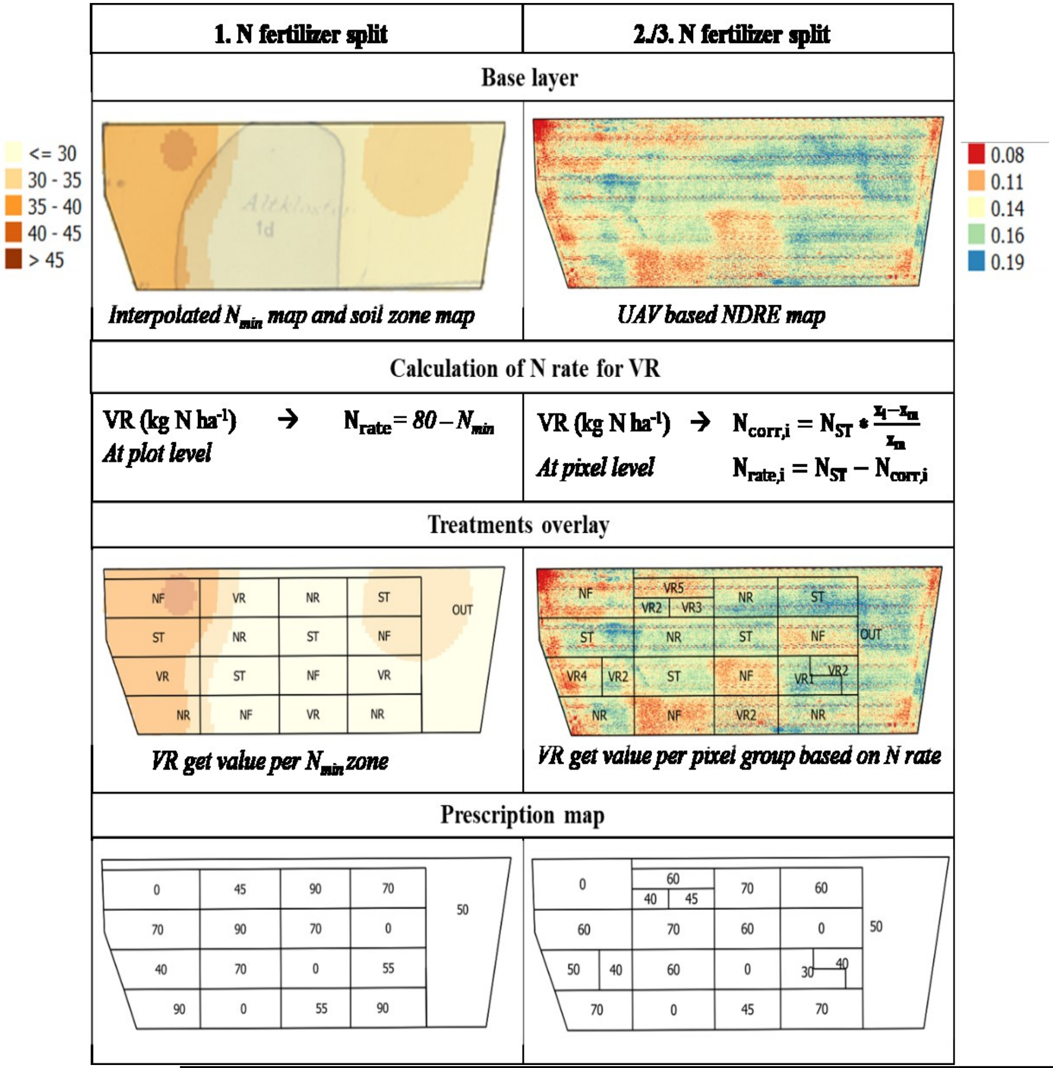
- **UAV-based**
  - DJI P4P + Parrot Sequoia
  - Temporal Resolution: custom
  - GSD: ~ 4.5 cm/px at 80m
  - Spectral resolution: 4 bands (R,G,RE,NIR)
  - Radiometric calibration and georeferencing

- **Standard samples**
  - Crop biomass and CN-content
    [N uptake = Biomass * N concentration]
  - In-season and harvest samples for analysis and calibration
  - 2–3 sampling areas per plot
  - 2-6 replicates per treatment
  - 330 samples over 7 site-years





Applikationskarten



- **ST**: **Local standard** rate
  → 155 kg N ha^{-1}
- **VR**: based on N_{min} method from **PRIF** [14]
  → adjusted amount 80 -160 kg N ha^{-1}
- **Soil** information (N_{min})
  → 1st fraction
- **Spectral** data
  → 2nd / 3rd fractions
- Ammonium Nitrate
  24–27% N content

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The Analysis

Parameters from field trials:
Grain yield and price, N application and cost, Soil N supply

Apparent fertilizer recovery

Net revenues $= Y * P_y - N_{app} * C_N$

$AFR\ (\%) = \frac{Nup - SNS}{N\ app} * 100$

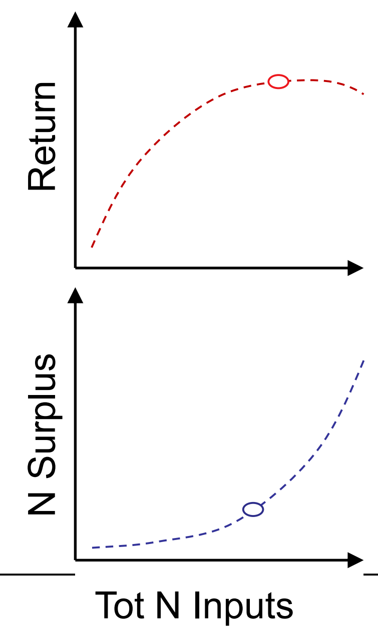
$N\ balance\ = (SNS + N_{app}) - N_{up}$

- **EO of N fertilizer →**

net revenue maximization approach based on a production function using field trial data to determine

- **Balanced N supply →**

threshold of 30 kg N ha^{-1} in N surplus on the quadratic function relating N surplus to total N input (Applied N fertilizer + SNS)



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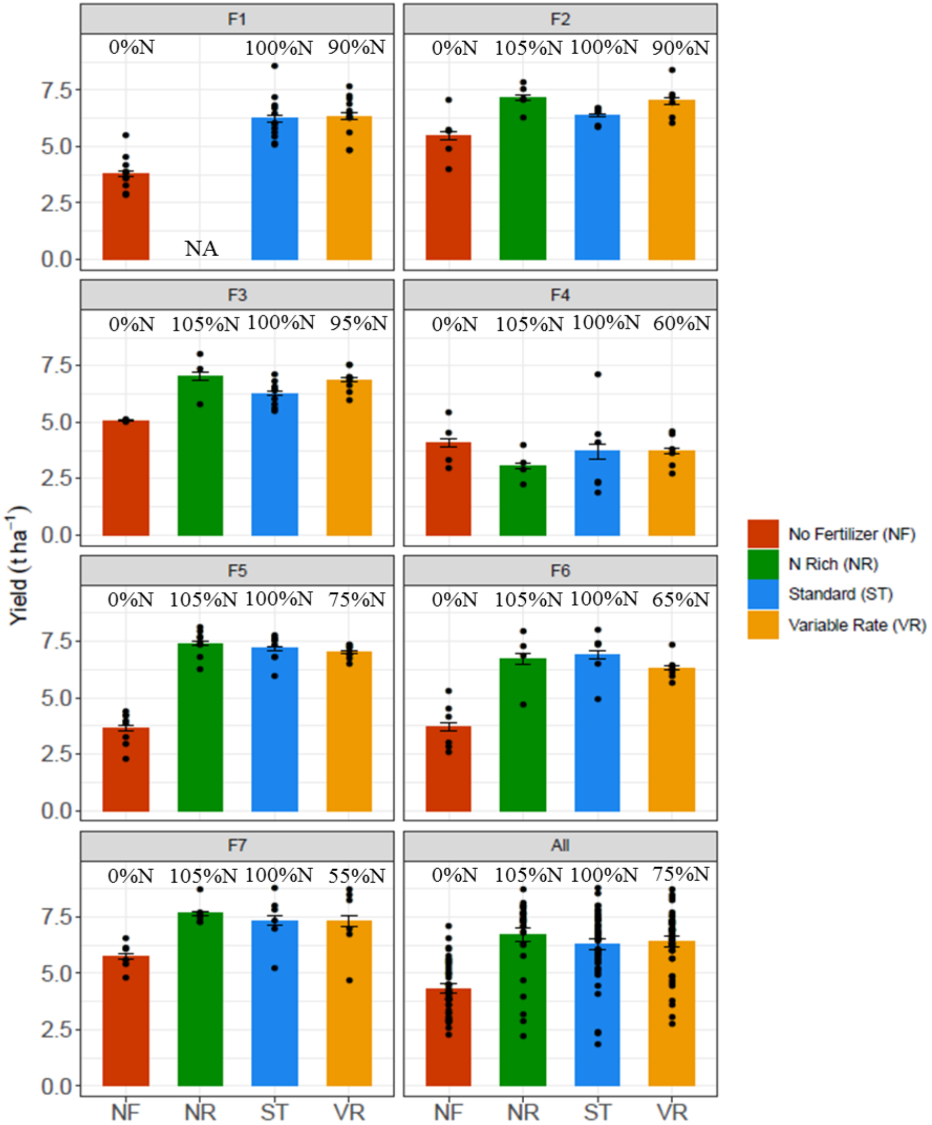
Ergebnisse: Ertrag



- No difference between the fertilized treatments over the seven site-years: 5-7 t ha^{-1}
- 5–40% reduction in applied N
- No significant differences in protein content (>12%)
- N input from the soil system in the NF treatments
  - 66–143 kg N ha^{-1}

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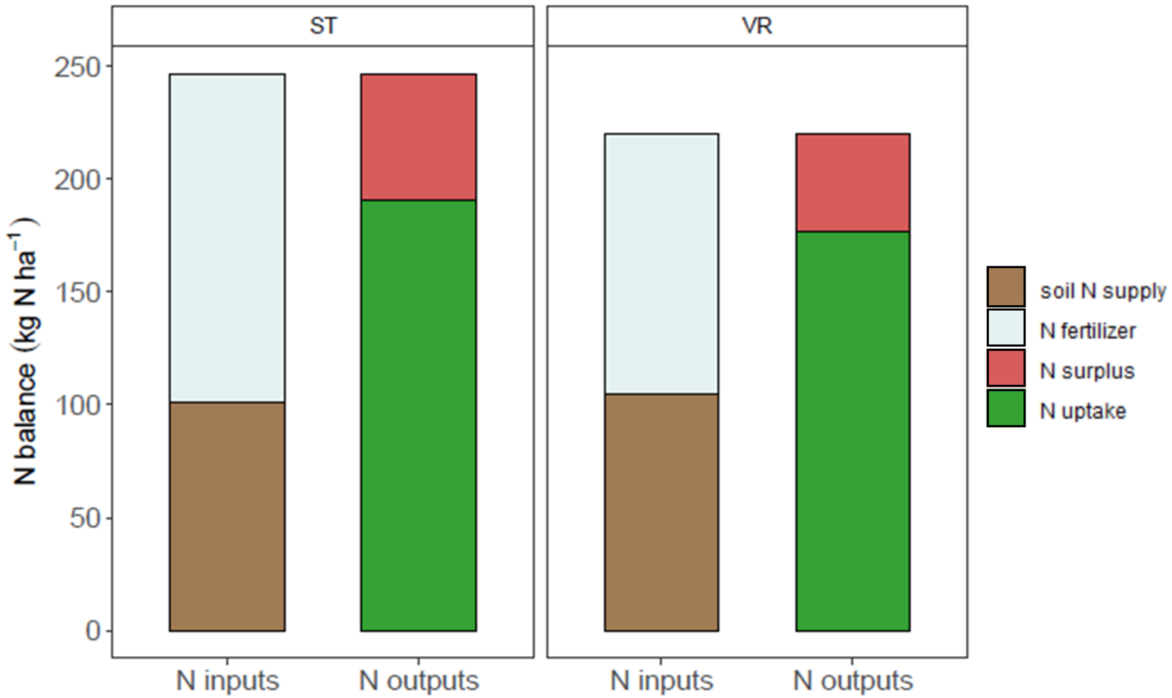
The economic assessment

Field	Treatment	N cost	Grain yield	Net revenues	Difference (VR - ST)	
		CHF ha^{-1}	(t ha^{-1})	CHF ha^{-1}	CHF ha^{-1}	%
F1	ST	193	6.23	3050	77	3
	VR	173	6.34	3126		
F2	ST	266	6.38	3053	352	12
	VR	243	7.02	3405		
F3	ST	264	6.25	2988	327	11
	VR	256	6.87	3315		
F4	ST	268	3.69	1652	109	7
	VR	164	3.70	1761		
F5	ST	268	7.18	3466	-16	0
	VR	200	7.02	3450		
F6	ST	268	6.98	3364	-260	-8
	VR	175	6.31	3104		
F7	ST	268	7.38	3570	69	2
	VR	157	7.30	3639		

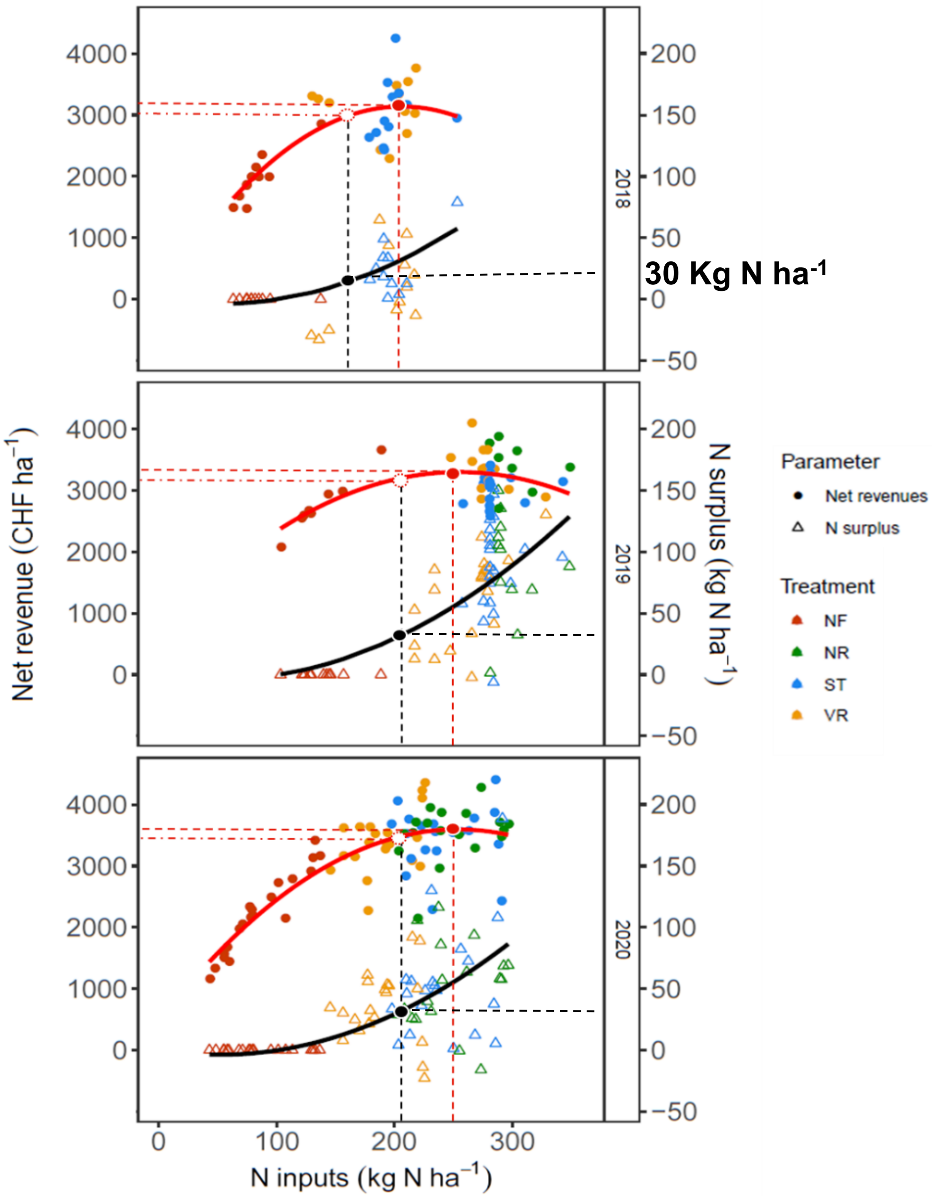
- Reduction in N costs in VR compared to ST
- Higher revenues in VR in 5 out of 7 site-year
- Higher revenues in ST in 2 out of 7 site-year
- Additional costs of labour, VR technology and information to be considered
- Field/farm size is an important determinant

The environmental assessment



- N uptake VR in the same range as ST
- 32% reduction in N surplus
- 13% average increase in N use efficiency

The economic optimum and the balanced N supply



- Economic optimum
  - 200 to 240 kg N ha^{-1}
- Balance N supply (at 30 kg N ha^{-1} surplus)
  - 180 to 205 kg N ha^{-1}
- Solutions to shift the economic optimum:
  - **Technical solution:**

    VR implementation
  - **Political solution:**

    increase of N fertilizer's price by 20–40%

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Diskussionspunkten

- Site-specific N management is not always the optimal solution but appears to provide some advantages.
- Net” revenues do not include cost of technology and information, these are not clear yet.
- Is the economic optimum as we calculated it meaningful?
- The threshold of N surplus really reflect the risk of loss to the environment?
- Can the political solution really provide an advantage?











Danke für Ihre Aufmerksamkeit


Agroscope gutes Essen, gesunde Umwelt

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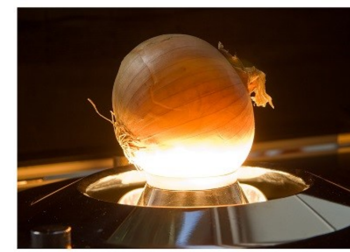







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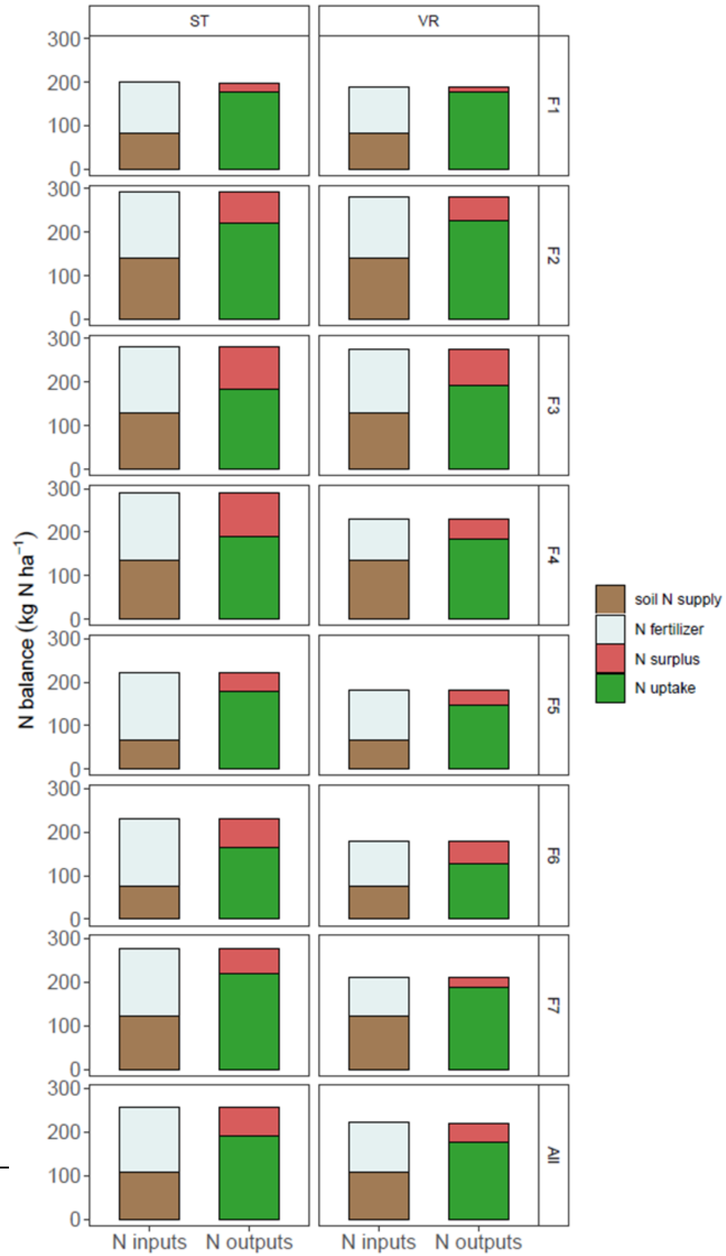

ST
VR
F1
F2
F3
F4
F5
F6
F7
All
N balance (kg N ha^{-1})
0
100
200
300
N inputs
N outputs
soil N supply
N fertilizer
N surplus
N uptake

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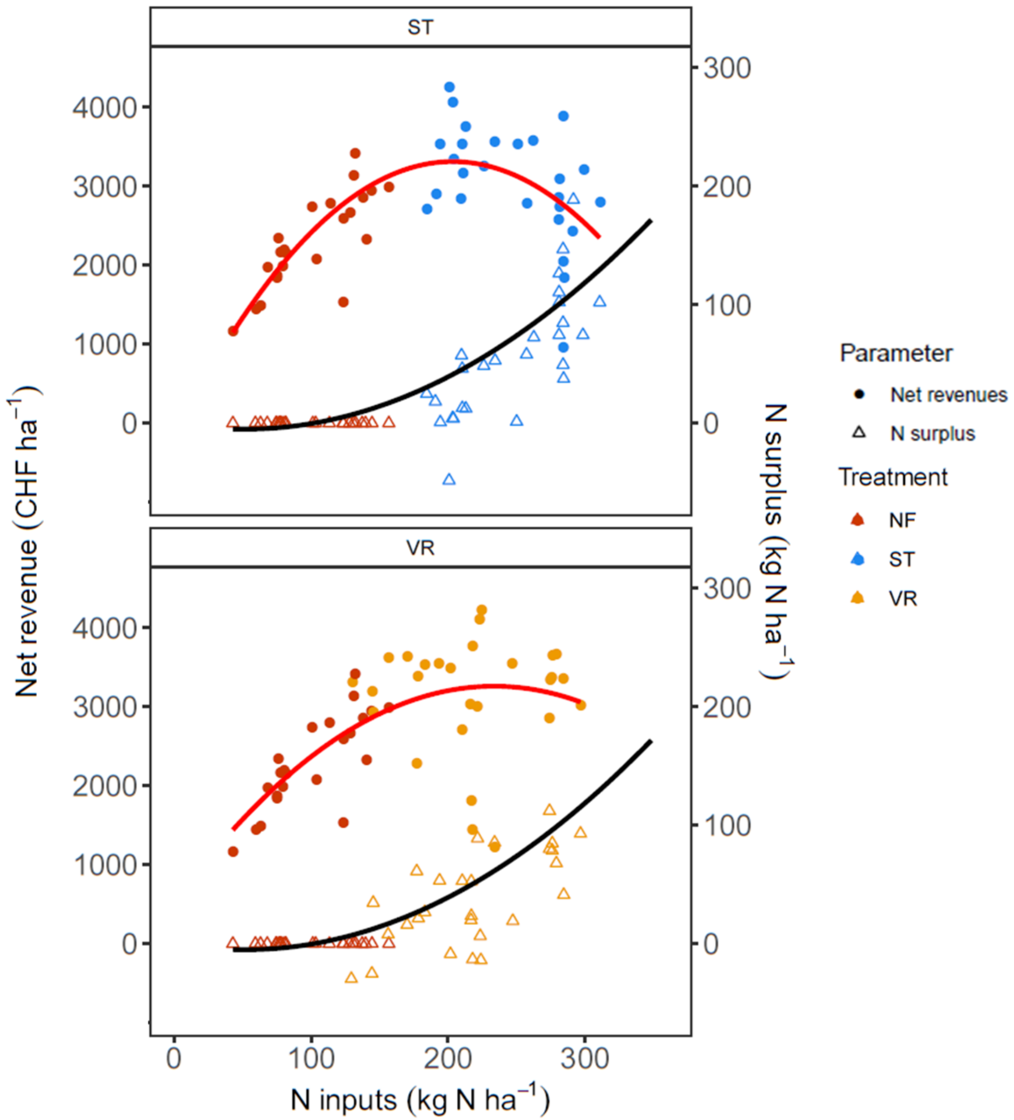
ST
VR
4000
3000
2000
1000
0
300
200
100
0
0
100
200
300
Net revenue (CHF ha⁻¹)
N surplus (kg N ha⁻¹)
N inputs (kg N ha⁻¹)
Parameter
Net revenues
N surplus
Treatment
NF
ST
VR

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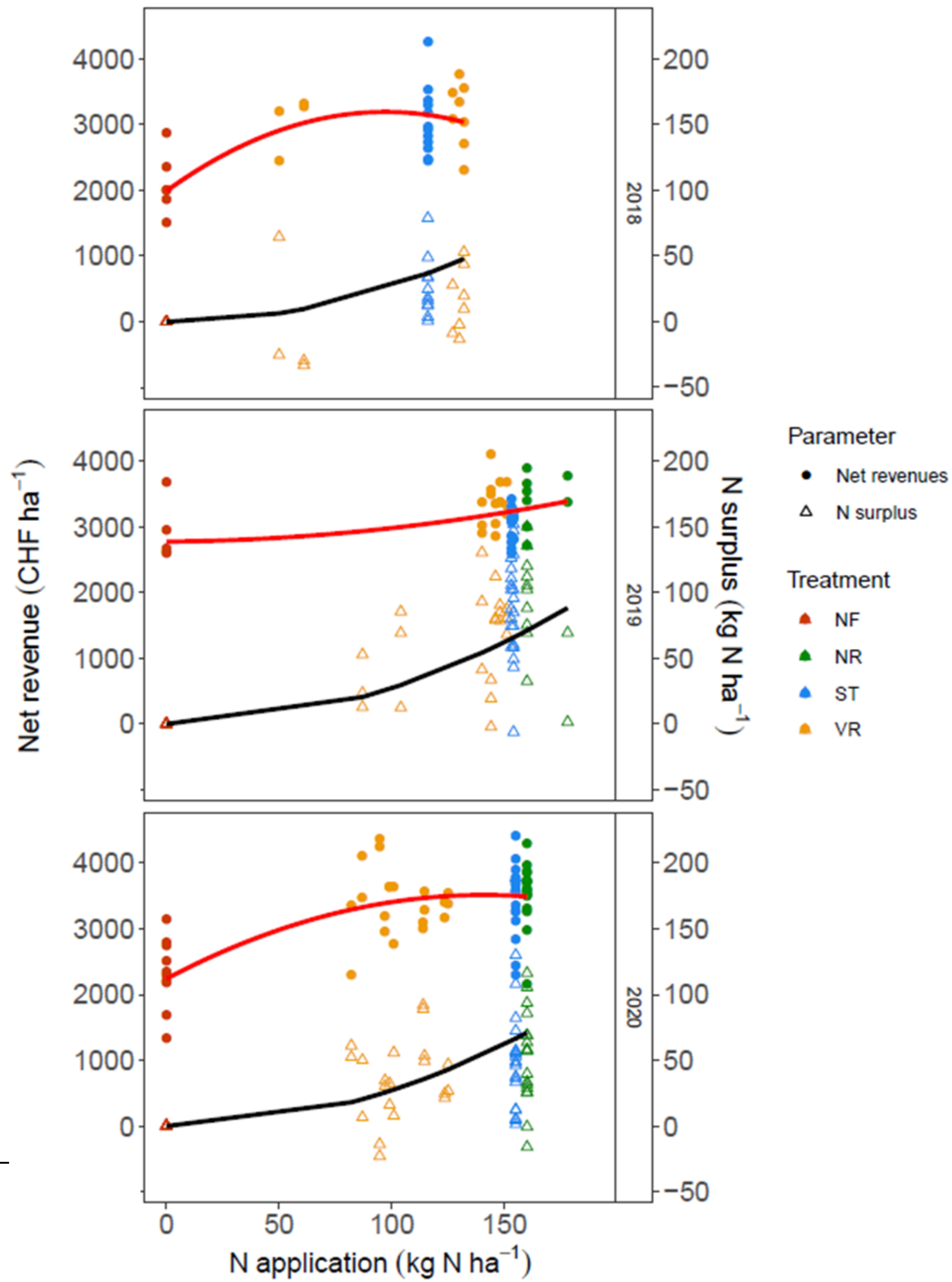

Net revenue (CHF ha⁻¹)
N surplus (kg N ha⁻¹)
N application (kg N ha⁻¹)
2018
2019
2020
Parameter
Net revenues
N surplus
Treatment
NF
NR
ST
VR

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