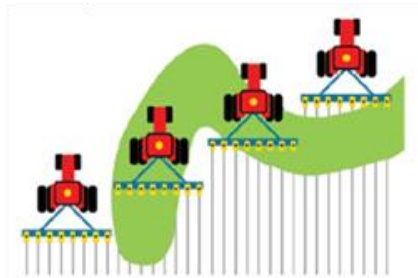
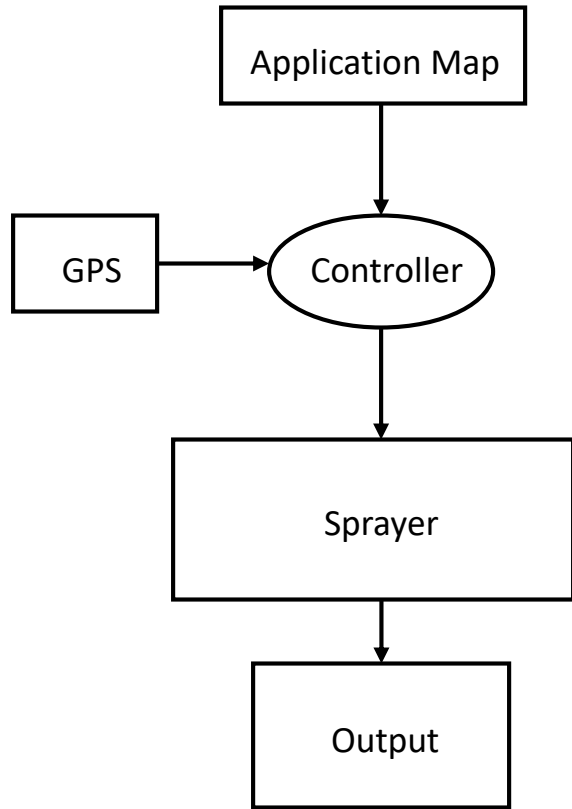


La modellistica nella fertilizzazione variabile di mais e frumento

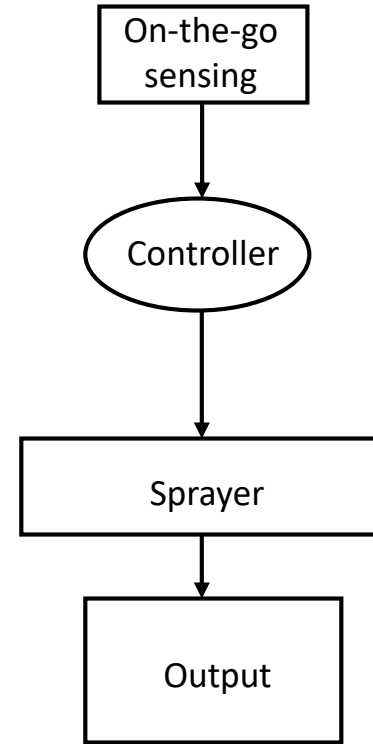
Francesco Morari

Dipartimento di Agronomia Animali Alimenti Risorse Naturali e Ambiente (DAFNAE), Università di Padova

mappe di prescrizione

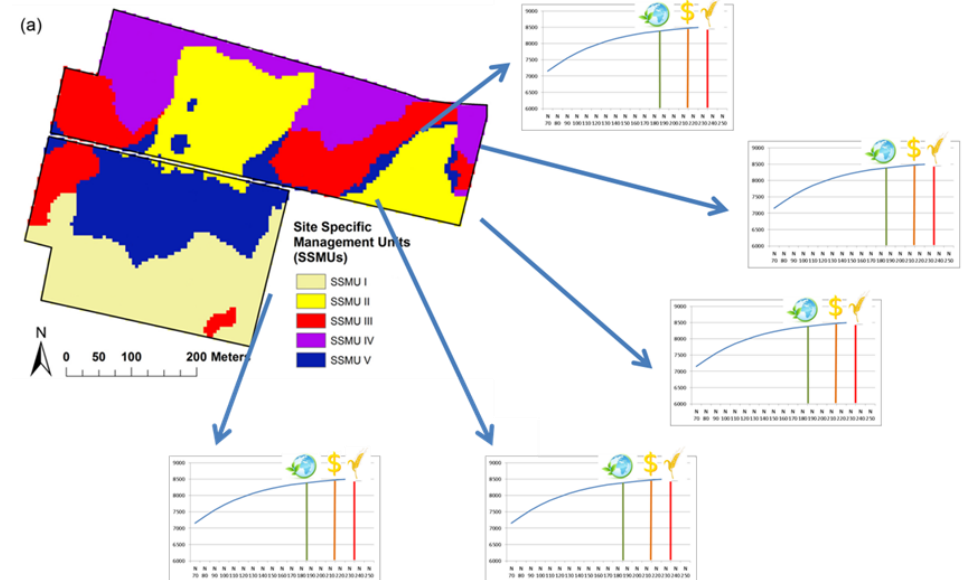
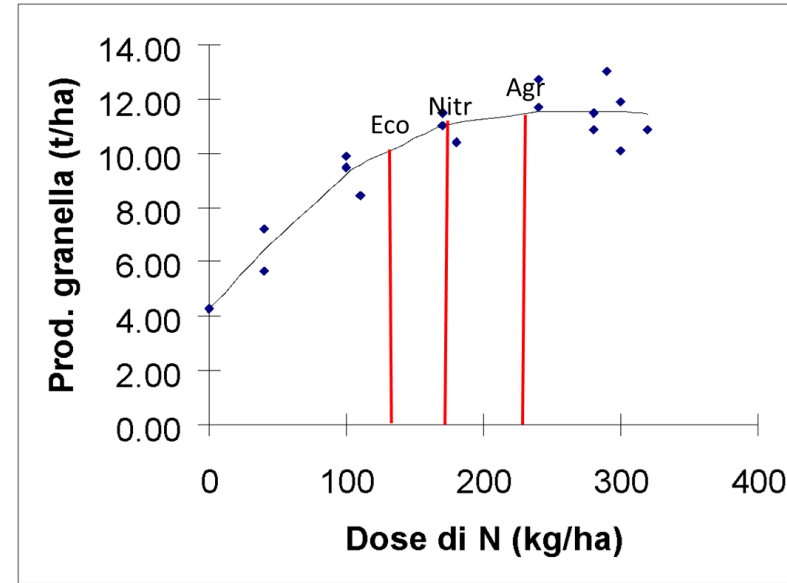
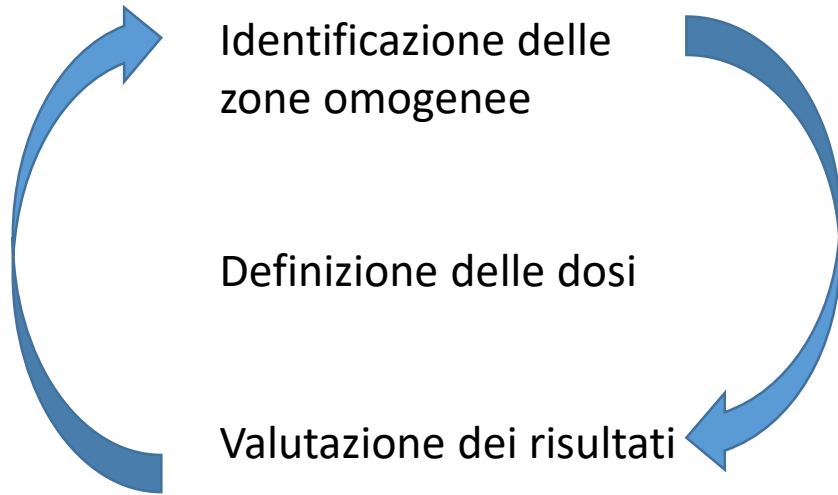


Sistemi on-the-go

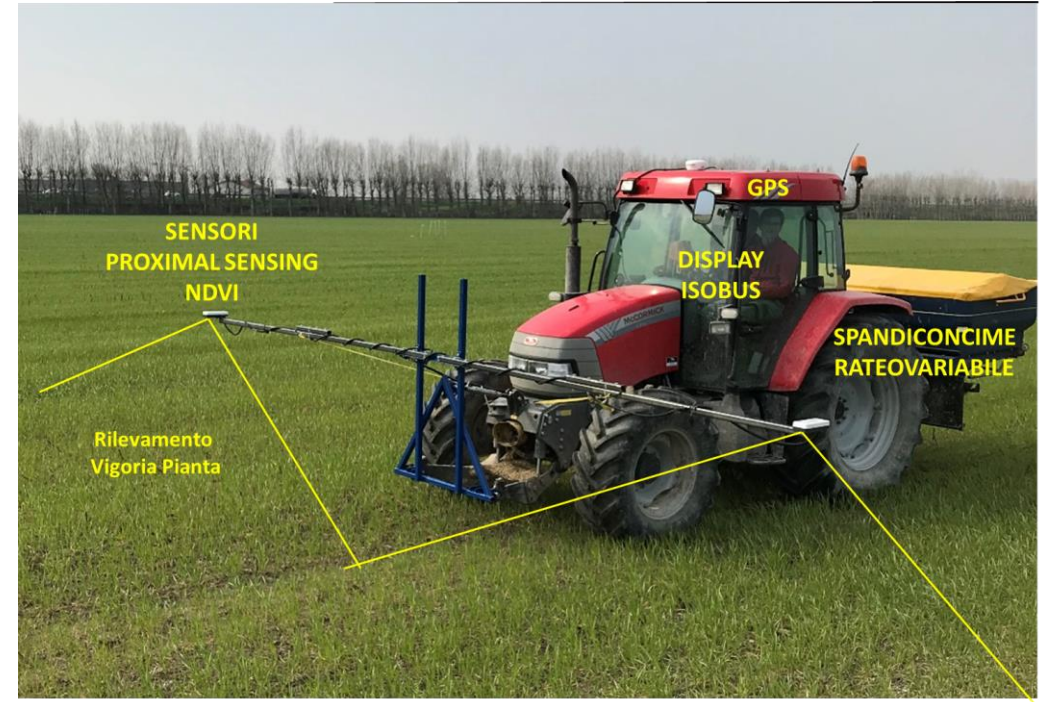
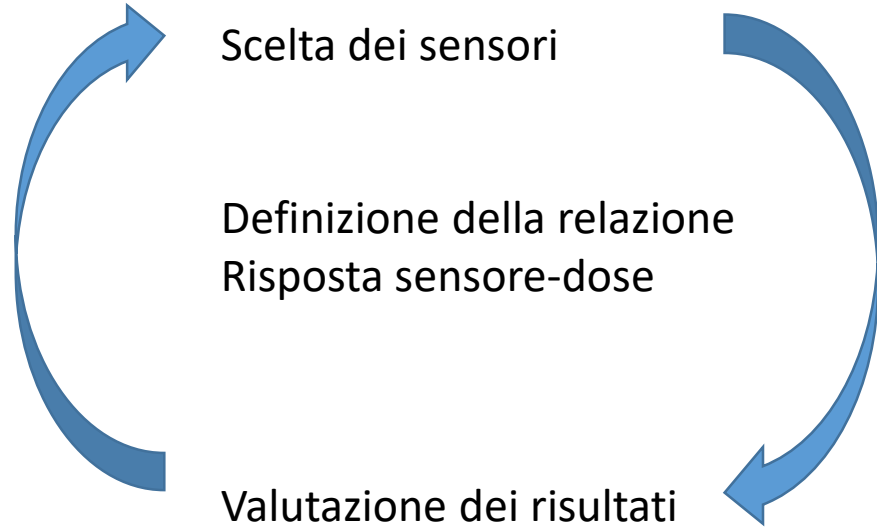


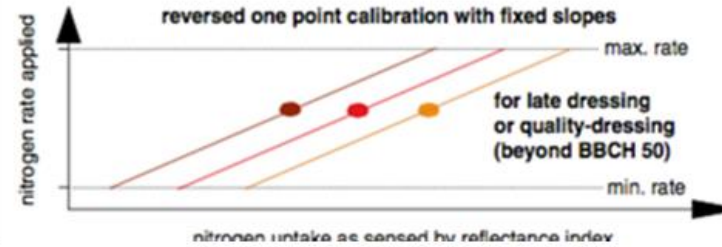
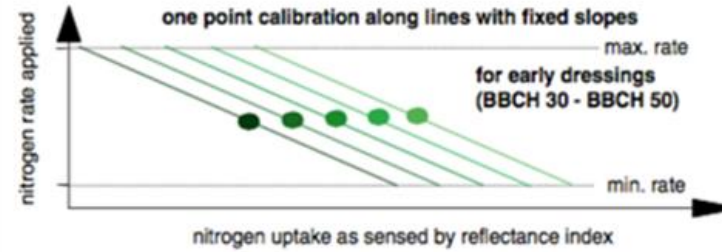
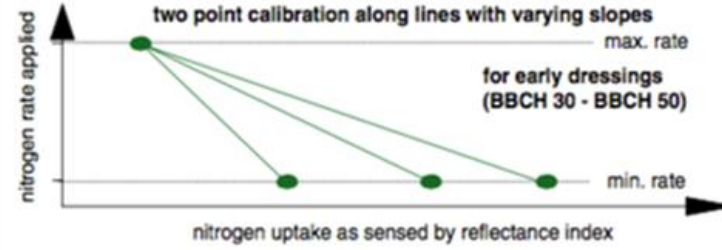
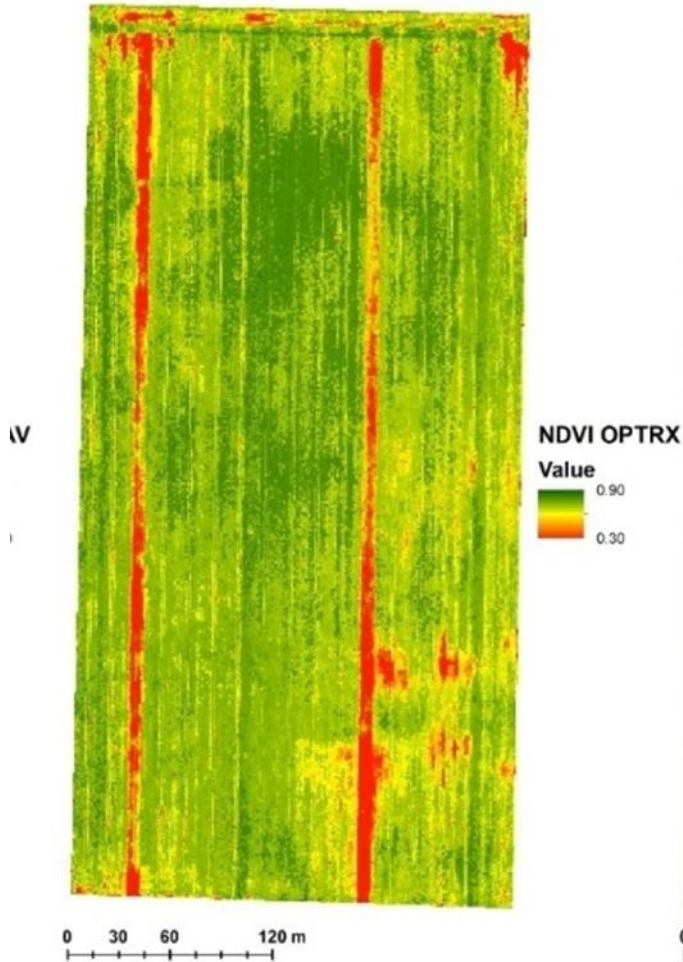
(Vellidis, mod.)

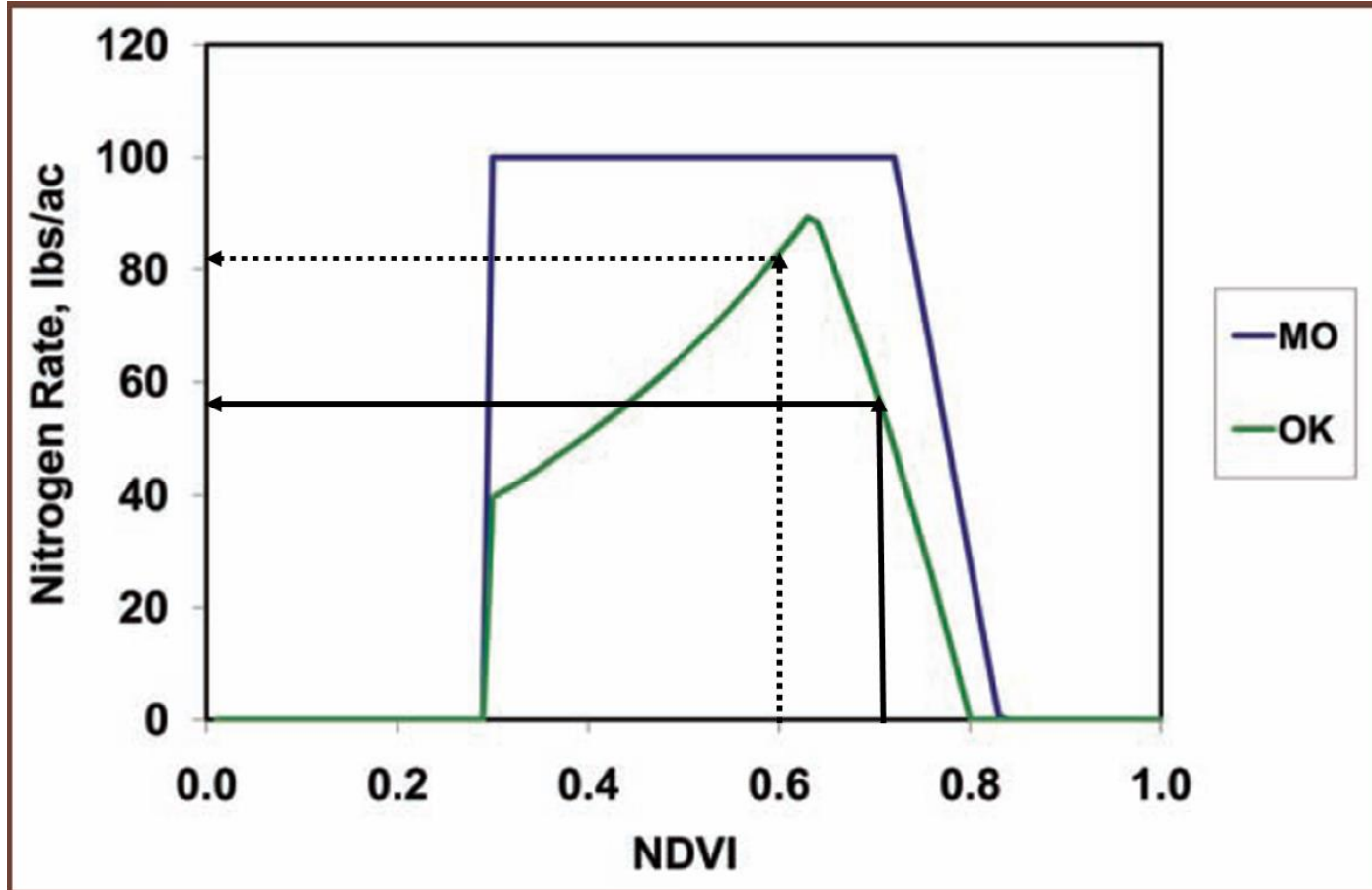
mappe di prescrizione



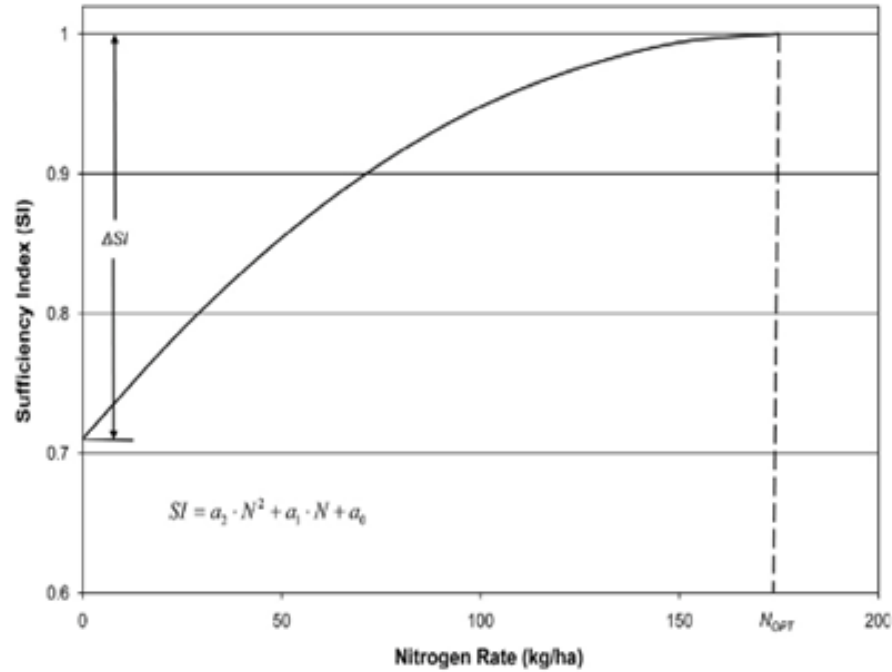
Tecnologia on-the-go







(Borghetti, 2012)

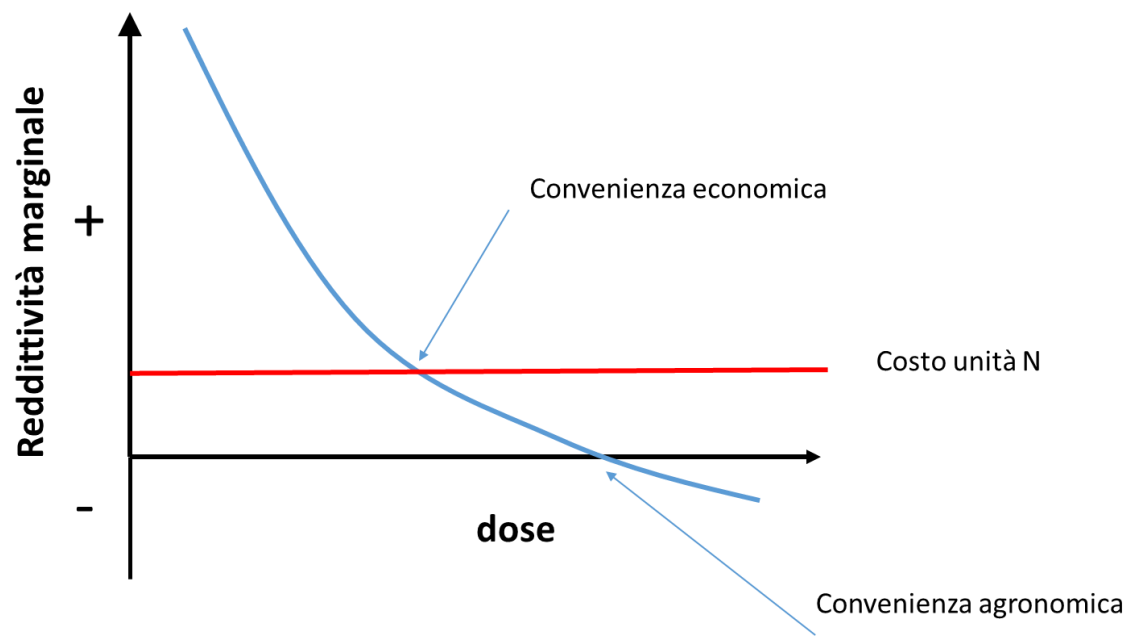
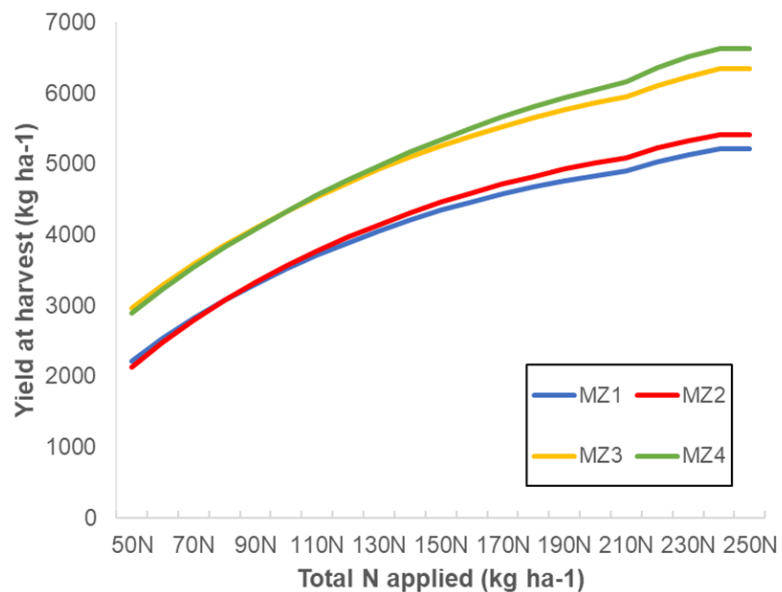


sufficiency index

$$SI = \frac{VI_{\text{Sensed Crop}}}{VI_{\text{Reference}}}$$

$$N_{\text{APP}} = \sqrt{\frac{N_{\text{OPT}}^2}{1 - SI(0)} \cdot (1 - SI)} = N_{\text{OPT}} \cdot \sqrt{\frac{(1 - SI)}{\Delta SI}}$$

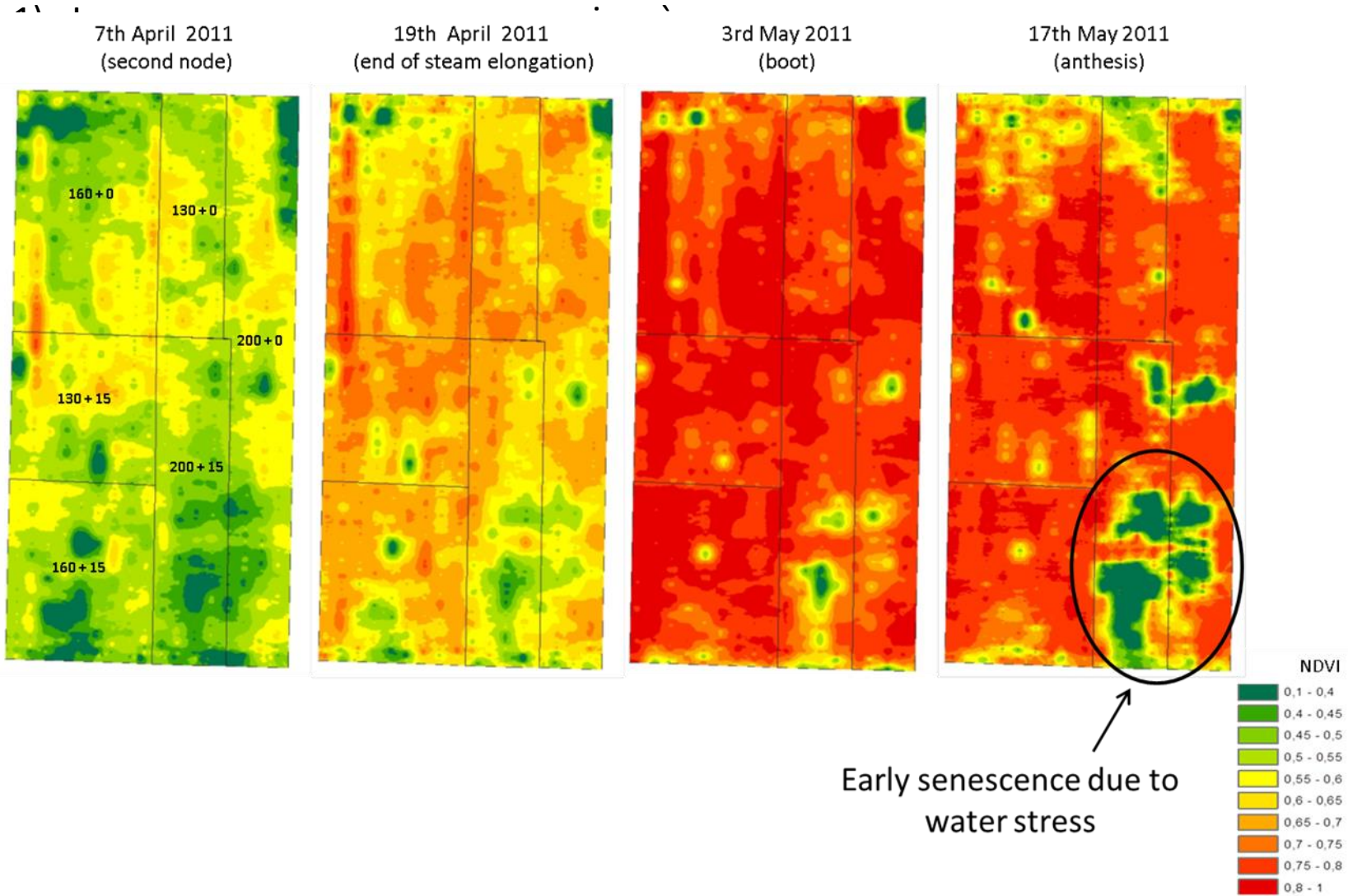
Figure 3. Relationship between nitrogen rate and sufficiency index (Holland and Schepers (2010)).



Quali problemi nell'applicare questi metodi?

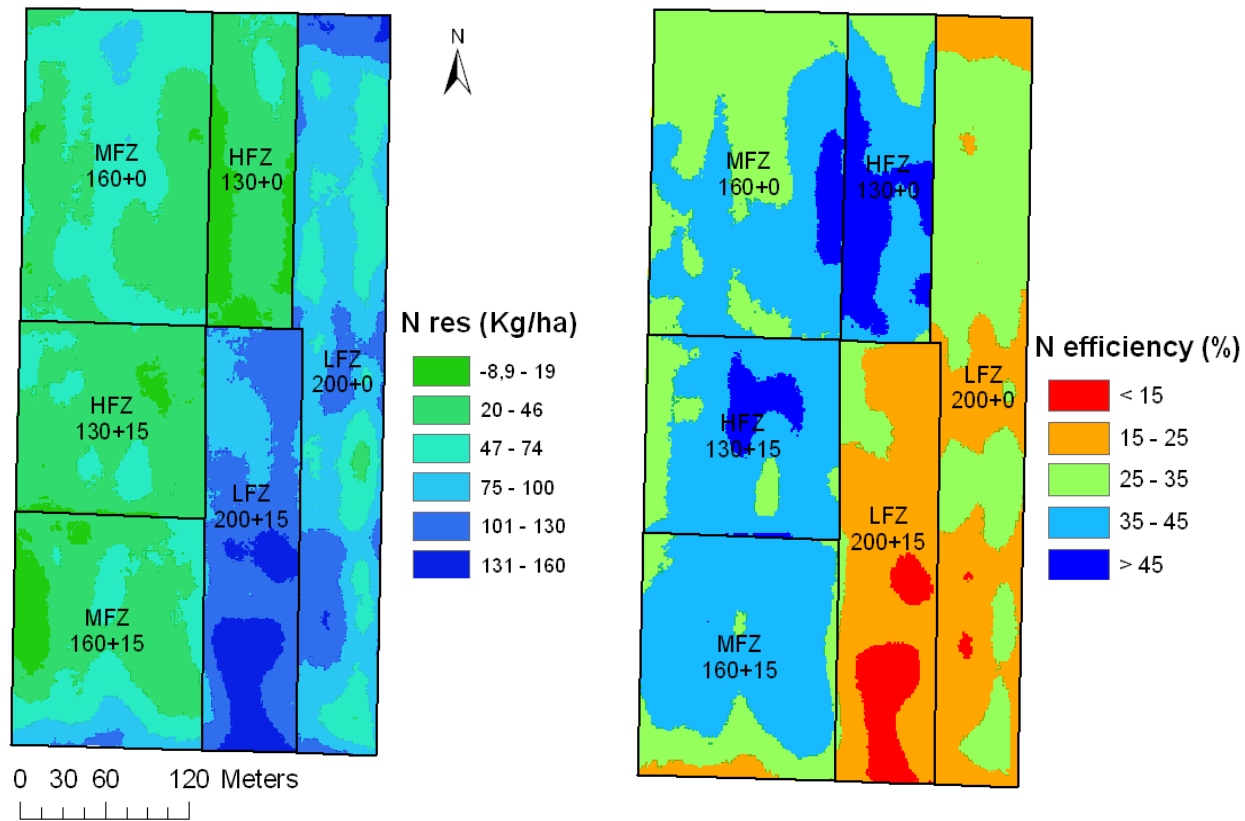
- 1) Le zone omogenee non sono mai così omogenee
- 2) Le dosi che stimiamo si riferiscono a medie stagionali

Quali problemi nell'applicare questi metodi?



Quali problemi nell'applicare questi metodi?

- 1) Le zone omogenee non sono mai così omogenee
- 2) Le dosi che stimiamo si riferiscono a medie stagionali



La nostra visione

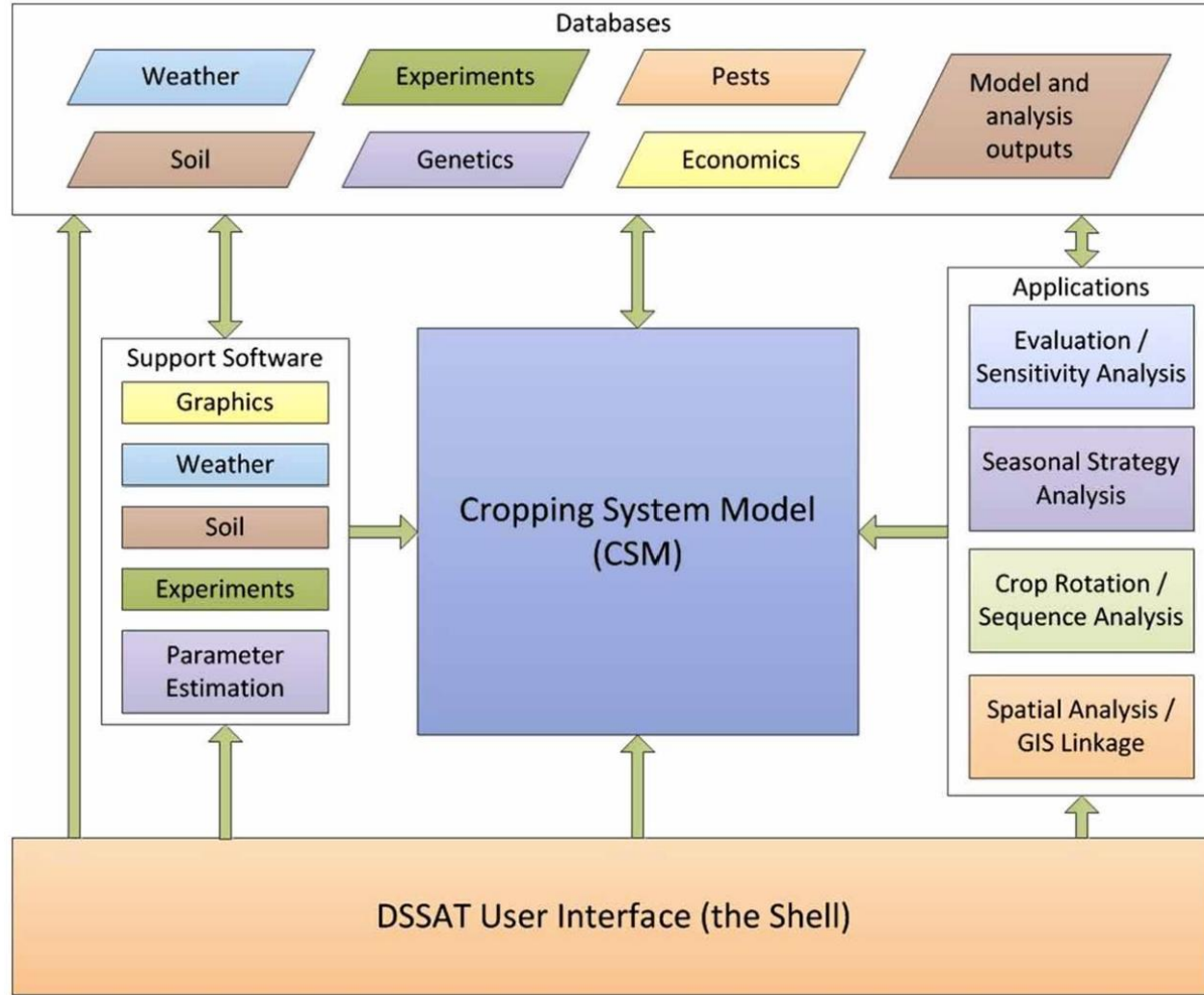


1. Meteorological services sending information (dry, wet,...) to tractor's monitor
2. Simple models predicting relative yield/protein at 2-3 months
3. Coupling metamodel information with "on the go" NDVI sensing
4. Nitrogen VRA





Il progetto AgriGNSS



Hoogenboom et al., 2017

1) Fertilizzazione uniforme

- Gestione ordinaria e uniforme della fertilizzazione

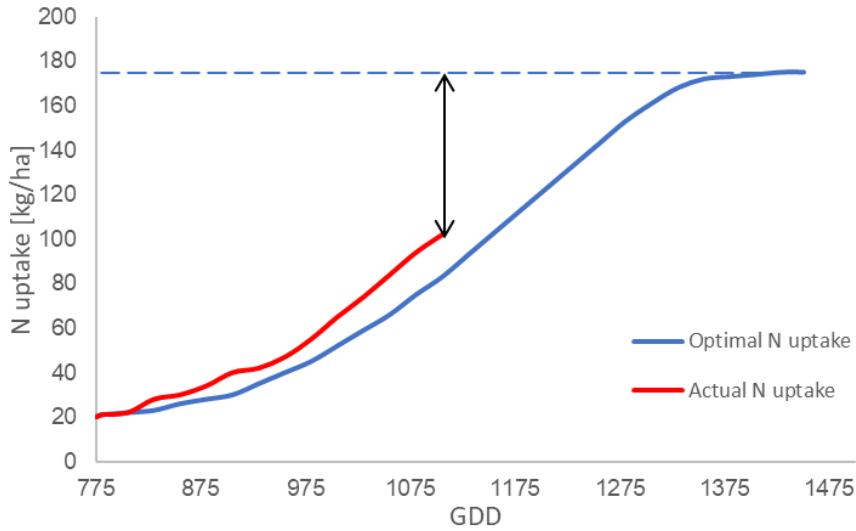
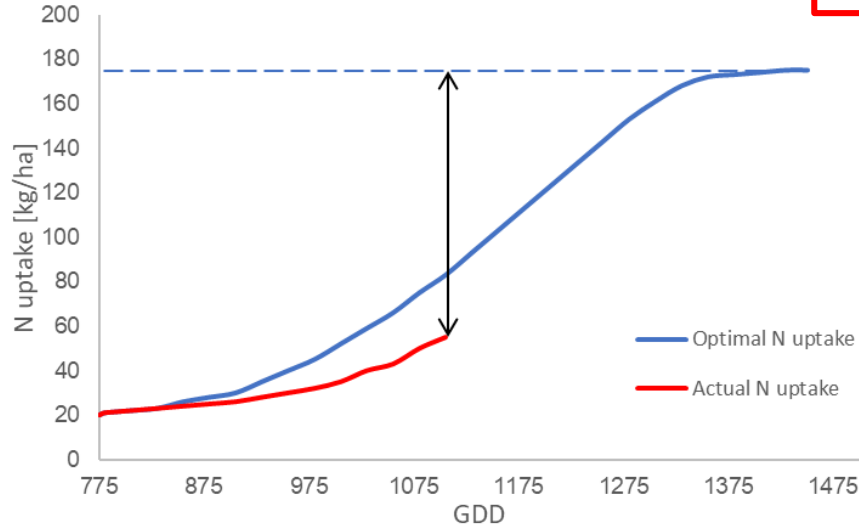
2) VRA₁ :

- DSSAT alimentato con dati meteo storici (1992-2018)

3) VRA₂ :

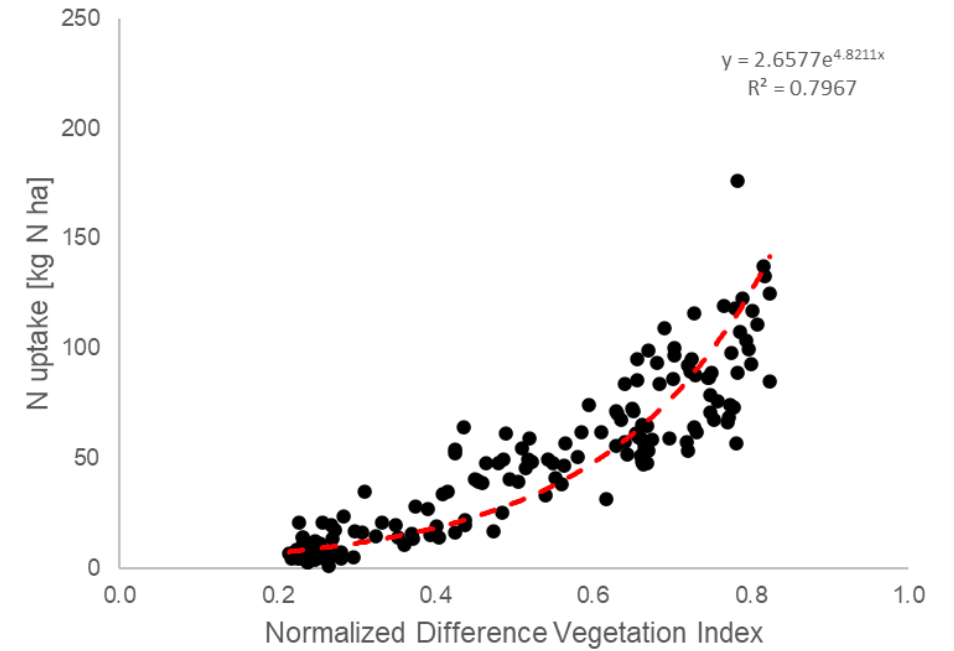
- DSSAT alimentato con dati meteo previsionali e integrati con sistemi di proximal sensing

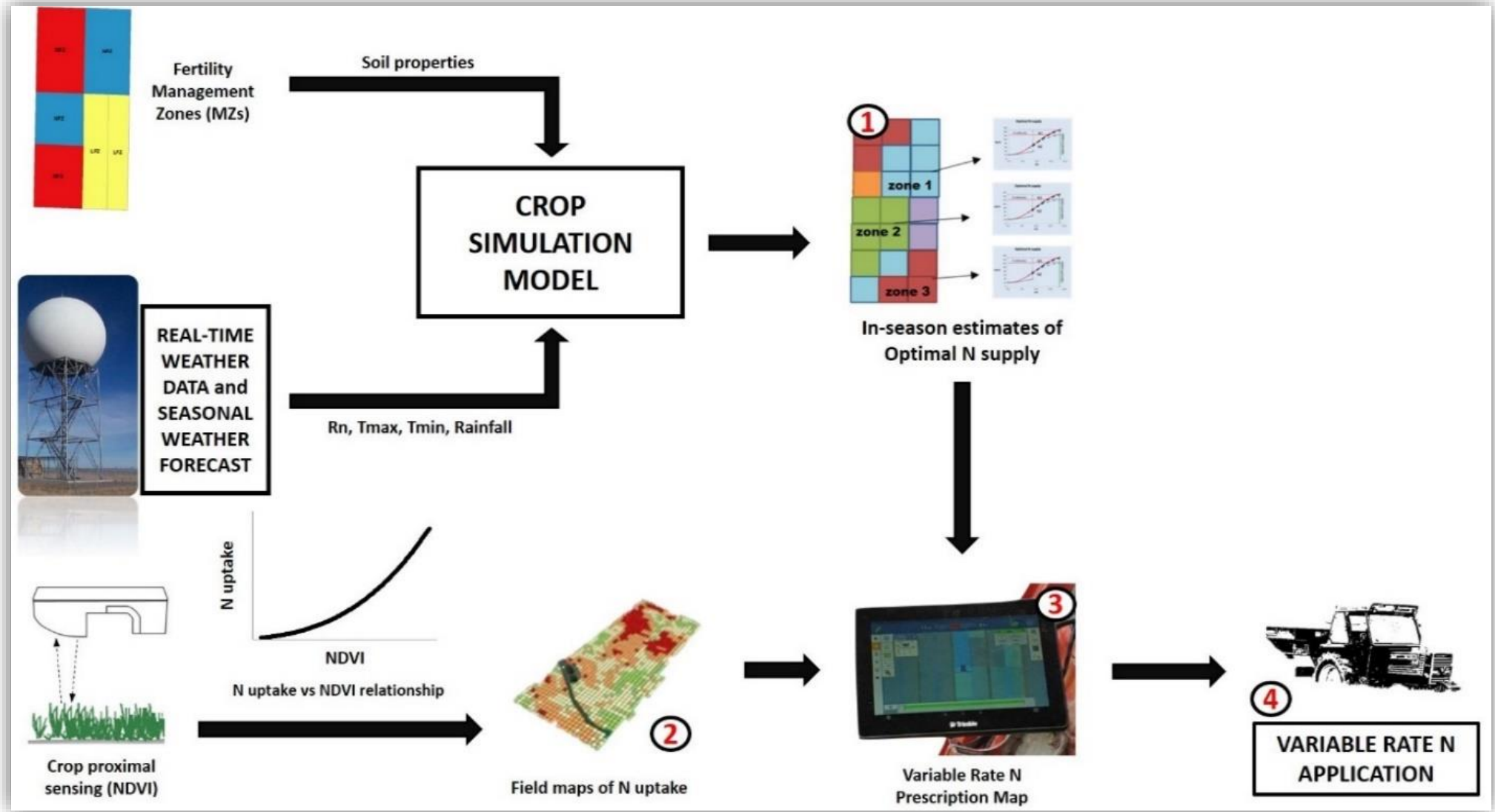
Actual N upt < Optimal N upt



Actual N upt > Optimal N upt

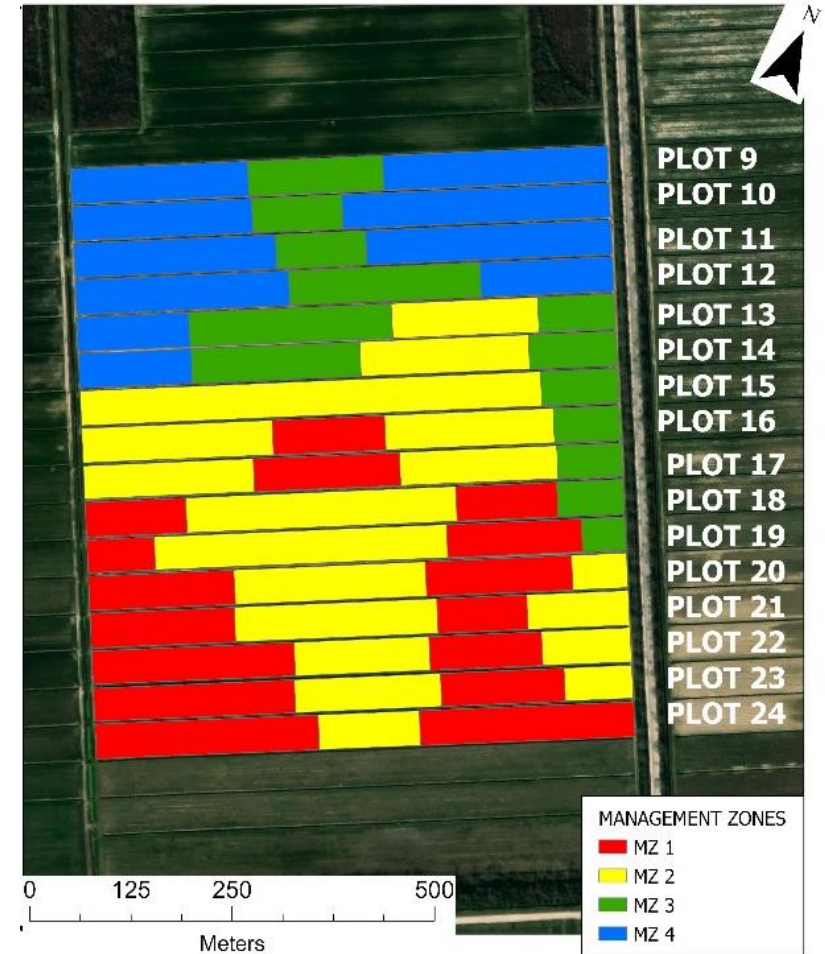
$$N_{rate} = \frac{OPTIMAL N_{up} - ACTUAL N_{up} - N_o(t_{end} - t_i)}{EFF_C (t_{end} - t_i)}$$





Experimental Design

- Two crops:
 - ✓ Winter wheat (cv. Rebelde)
 - ✓ Corn (cv. PIO 1028)
- 4 different management zones (Cillis et al., 2017) over 24 ha field
- 3 different fertilization treatments
 - ✓ UNIFORM fertilization
 - ✓ Crop model informed with historical weather data (VRA₁)
 - ✓ Crop model informed with real + seasonal forecasts (VRA₂) and NDVI
- Two different growing seasons
 - ✓ 2018-2019
 - ✓ 2019-2020



Crop model-based approaches for N-VRA

Investigated Parameters

5 sampling dates:

Winter wheat

- Tillering (1st side dressing)
- 2nd node
- Flag leaf (2nd side dressing)
- Flowering
- Harvest

Corn

- V₄ (1st side dressing)
- V₆ (2nd side dressing)
- V₁₀
- R₁
- Harvest

Crop samples



- Total DM biomass
- N uptake
- Height
- Leaf area index

NDVI samplings



- 2 tractor-mounted GreenSeeker NDVI sensors (6 m apart)

Samples at harvest

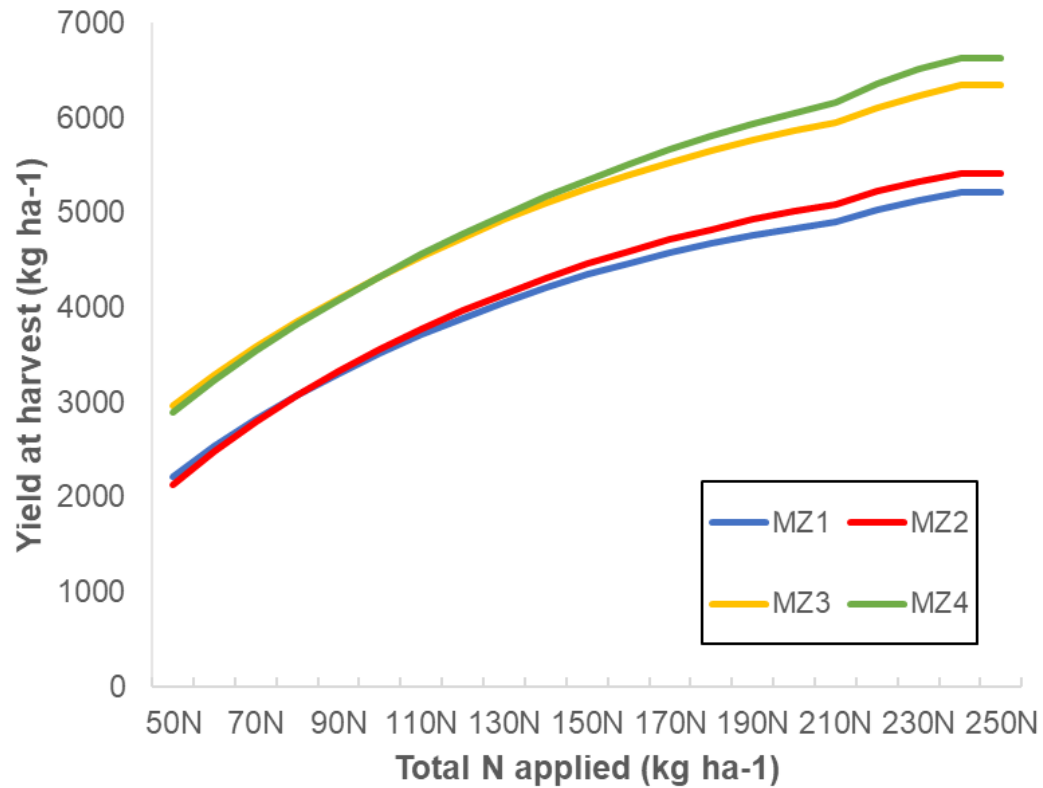


- Harvested yield
- Protein content (only WW)
- Harvest Index

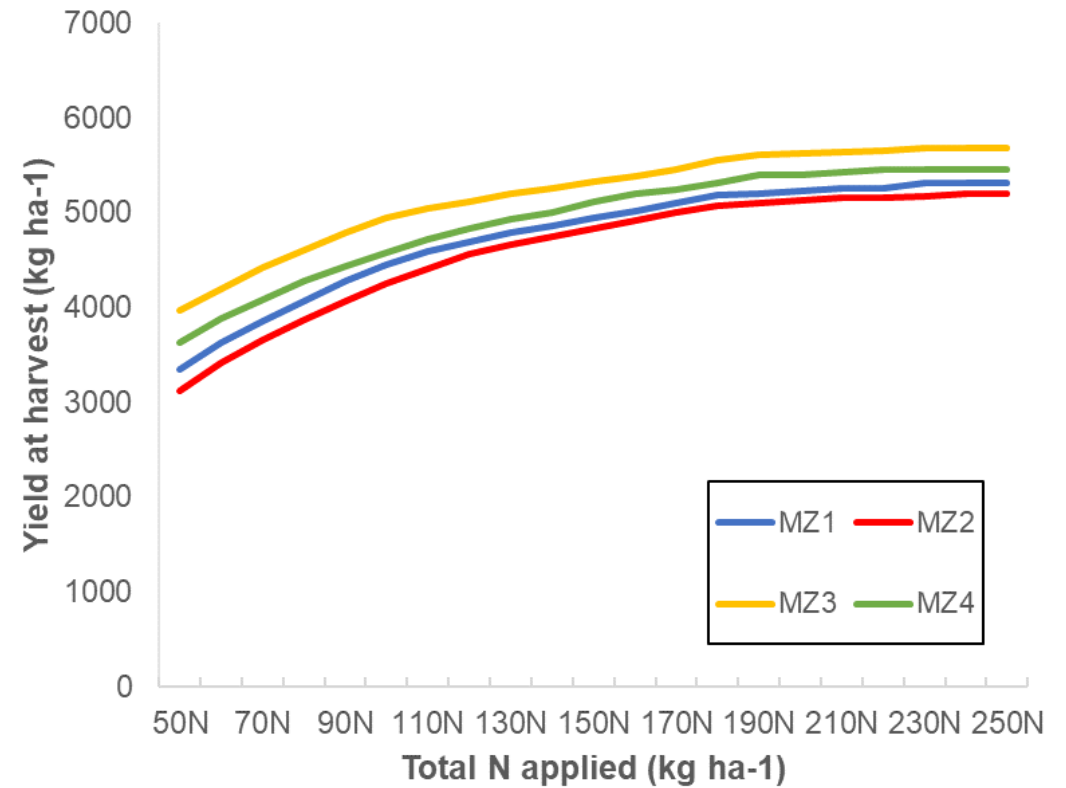
Crop model-based approaches for N-VRA: winter wheat

Results: Response curves, historical vs seasonal forecast

HISTORICAL WEATHER

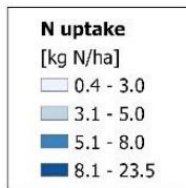


SEASONAL FORECASTS



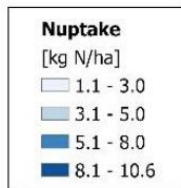
2018-19

(a)



2019-20

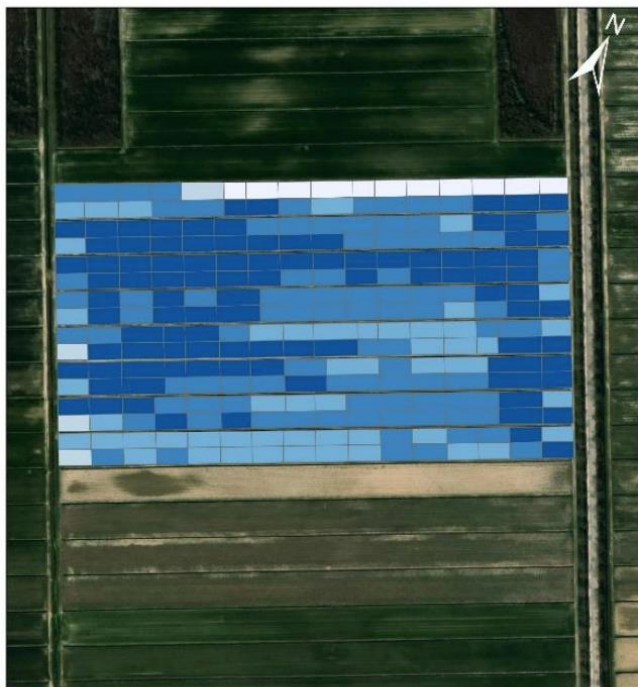
(b)



Frumento: Accestimento

2018-19

(c)



0 120 240
Meters

N uptake
[kg/ha]

16 - 30
31 - 50
51 - 80
81 - 100
101 - 137

2019-20

(d)



0 120 240
Meters

N uptake
[kg/ha]

10 - 30
31 - 50
51 - 80
81 - 100
101 - 112

Frumento: Foglia a bandiera

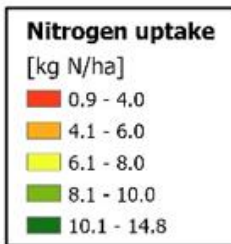
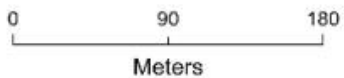
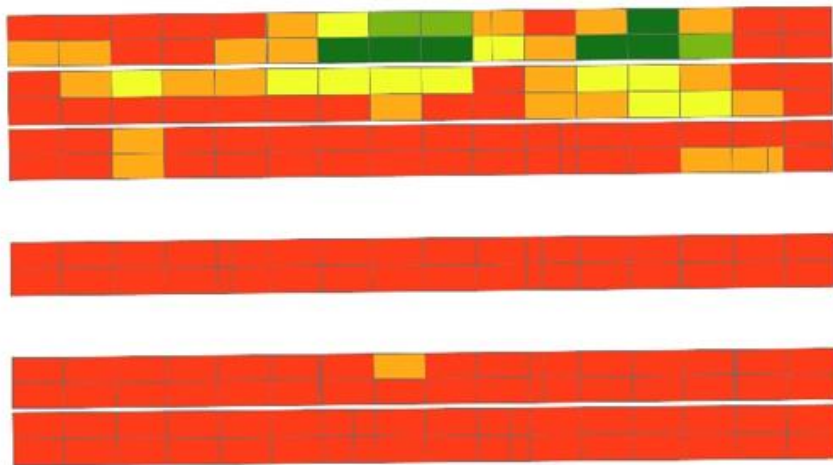
Crop model-based approaches for N-VRA: winter wheat

Treatment	Year	Zone	Base dressing (kg N ha ⁻¹)	Top dressing 1 (kg N ha ⁻¹)	Top dressing 2 (kg N ha ⁻¹)	Total N (kg N ha ⁻¹)
UNIFORM	18-19	-	32	70	70	171
VRA1	18-19	3	32	70	60	162
VRA1	18-19	4	32	70	80	182
VRA2	18-19	3	32	80	20	132
VRA2	18-19	4	32	80	25	137
UNIFORM	19-20	-	32	40	70	142
VRA1	19-20	1	32	60	40	132
VRA1	19-20	2	32	70	30	132
VRA2	19-20	1	32	70	30	132
VRA2	19-20	2	32	80	15	127

Crop model-based approaches for N-VRA: winter wheat

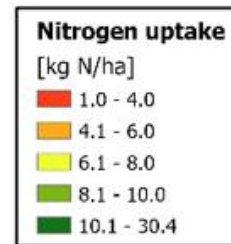
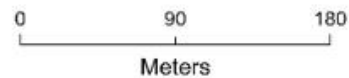
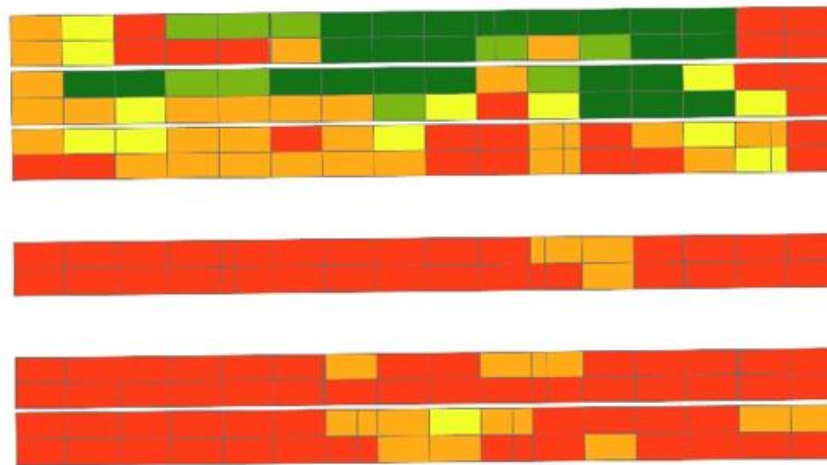
Year	Fertilization approach	Yield (t DM ha ⁻¹)	Protein Content (%)	AE (kg yield kg N ⁻¹)	Gross Margin (€ ha ⁻¹)
2018-2019	Uniform	4.90 ^a	14.5 ^a	28.7 ^a	506.8
	VRA1	5.53 ^b	14.9 ^a	31.7 ^b	659.2
	VRA2	4.84 ^a	15.0 ^a	36.2 ^c	538.0
2019-2020	Uniform	2.72 ^a	14.1 ^a	19.2 ^a	62.3
	VRA1	2.94 ^a	16.4 ^b	22.3 ^{ab}	125.4
	VRA2	3.11 ^a	16.3 ^b	25.4 ^b	167.9

2019

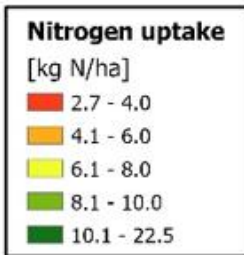
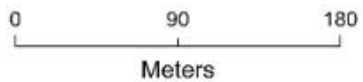
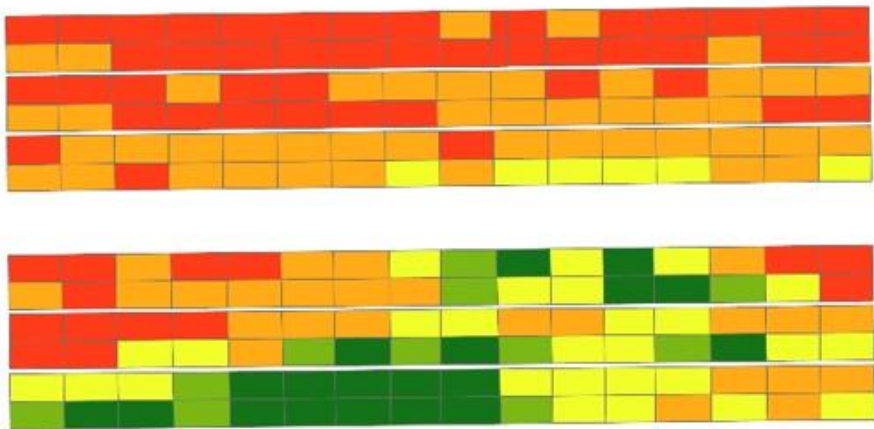


2020

Mais: V4

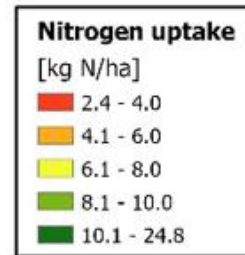
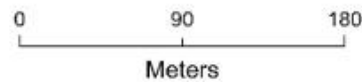
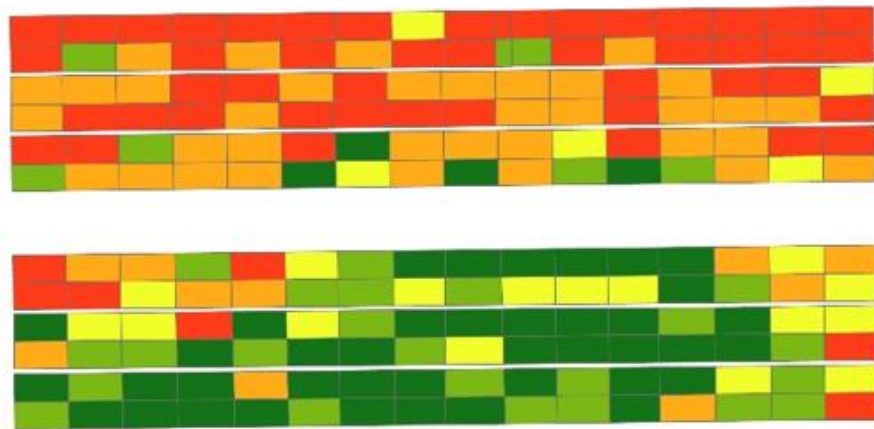


2019



2020

Mais: V6



Year	Fertilization treatment	Zone	Yield (t DM ha ⁻¹)	AE (kg yield kg N ⁻¹)	Gross Margin (€ ha ⁻¹)
2020	Uniform	avg	8.44 A	48.8 A	1488.8
		MZ19H	9.85±0.35	55.0±1.20 ^a	1795.0
		MZ20L	9.02±0.25	50.6±1.17 ^a	1616.4
		MZ20H	7.86±0.21 ^a	40.8±1.16 ^a	1361.2
	VRA1	avg	8.59 A	39.8	1476.3
		MZ19H	9.48±0.23	45.1±1.18 ^a	1689.6
		MZ20L	9.44±0.30 ⁻	43.0±1.18 ^a	1682.8
		MZ20H	7.74±0.47 ^{ab}	31.2±1.21 ^a	1269.8
	VRA2	avg	8.46 A	55.7 A	1467.2
		MZ19H	-	-	-
		MZ20L	8.24±0.30 ⁻	61.4±1.19 ^a	1431.8
		MZ20H	8.67±0.17 ^b	51.0±1.17 ^a	1500.4

Conclusioni

L'applicazione dei modelli ha sempre garantito un miglioramento delle performances produttive, ambientali ed economiche rispetto all'applicazione uniforme

L'integrazione tra DSSAT e il proximal sensing non sembra essere promettente nel mais a causa degli attuali vincoli operativi

Nel frumento è possibile intervenire anche nelle fase tardive e sfruttare la variabilità nell'assorbimento dell'azoto ai fini della spazializzazione della dose

Visti gli attuali prezzi dei fertilizzanti, esiste una convenienza non solo ambientale ma anche economica nell'applicazione della VRA

Grazie per l'attenzione