2nd CONFERENCE

PADOVA-SYDNEY

Environment, Sustainable Agriculture and Forest Management

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Precision in conservation agriculture: first results of an experimental study

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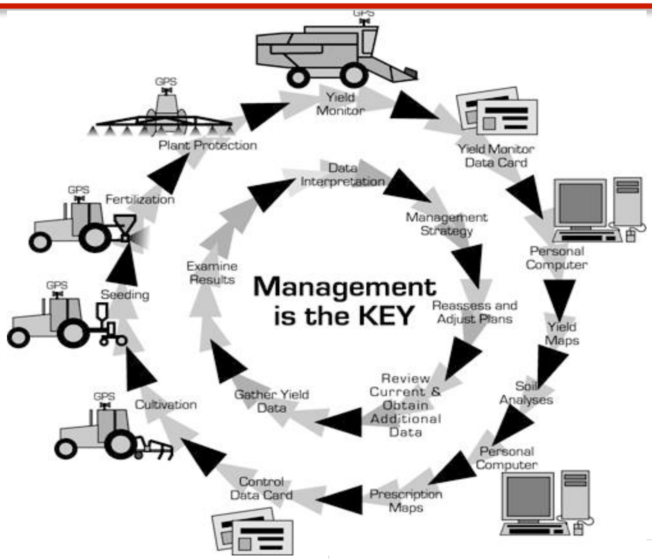
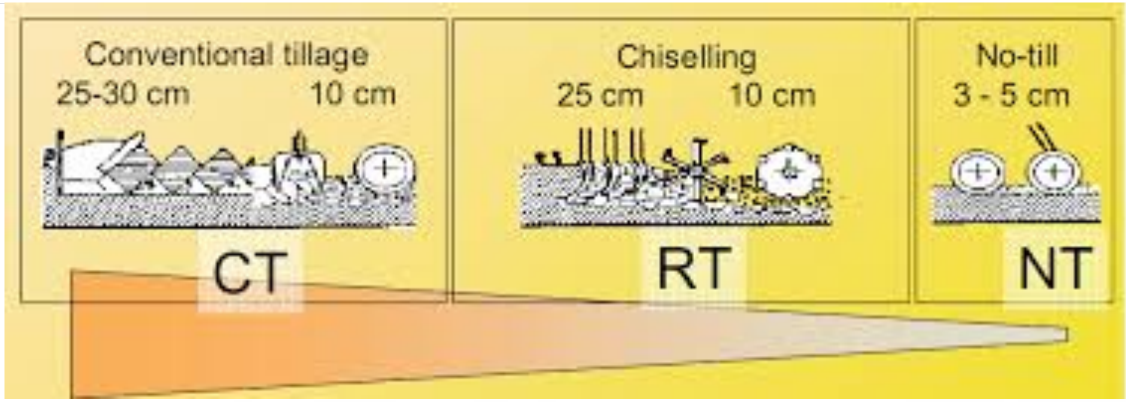
Introduction



- High working capacity
- More efficiency use of soil
- High efficiency of the input
- Economic benefit
- Environmental benefit

- Soil tillage modulation
- Conservation tillage optimization
- Managing and modeling tool support of crop production
- Soil compaction mitigation

- Increase in soil features
- Decrease soil erosion
- Decrease CO_2 emission
- Soil as carbon sink



Introduction

LIFE13 ENV IT 0583 AGRICARE

Introducing innovative precision farming techniques in Agriculture to decrease Carbon Emissions

- Decrease GHG emission
- Enhance soil features and crop yield
- Asses the economic feasibility
- Define the best approach reaching highest net energy value

VENETO AGRICOLTURA TESAF ENEA MASCHIO GASPARDO

Experimental plan

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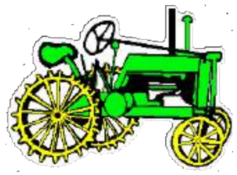
3 years duration

4 crops

2 input managing system



4 soil tillage techniques

Experimental site

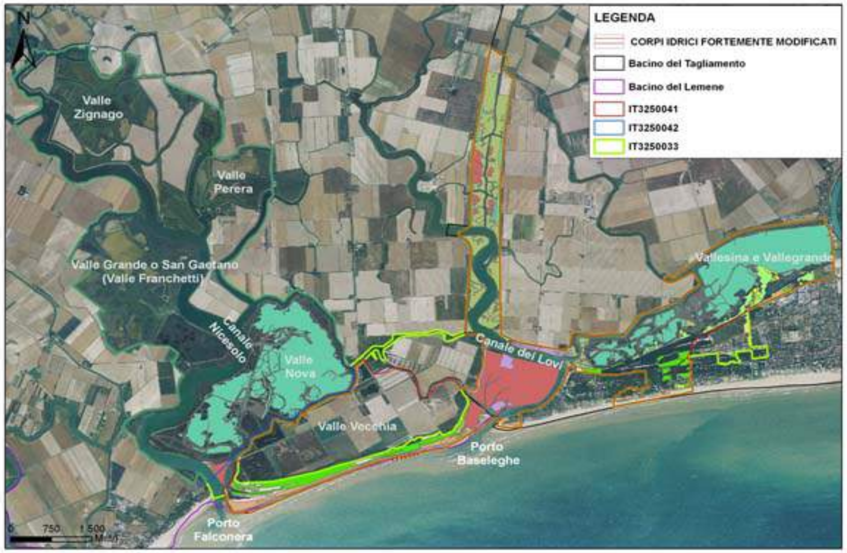
Demonstrative and pilot farm Vallevecchia

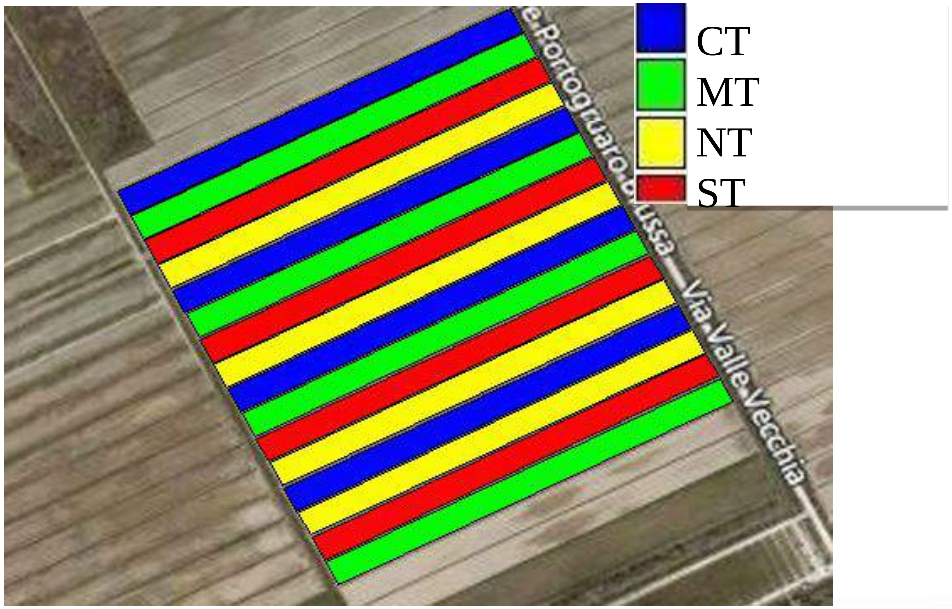
Study area: 23,6 ha divided in 16 plots

Crop rotation: wheat, rapeseed, corn, soybean

Soil tillage:

- Conventional tillage (CT)
- Minimum tillage (MT)
- Strip-tillage with inter-row 55 cm (ST)
- No tillage (NT)





Soil tillage techniques compared

CT

MT

ST

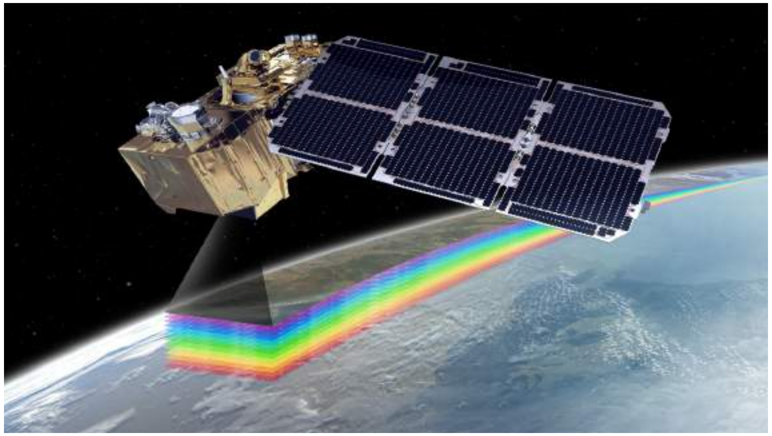
NT

Application of precision farming strategies

Phase	Precision Farming technologies	CT	Conservation Agriculture		
			MT	ST	NT
	Satellite guidance system with RTK differential correction	✗	✓	✓	✓
Phase 1	Analysis of soil variability (historical yield maps, georeferentiated soil analysis)	✓	✓	✓	✓
Phase 2	Study of soil variability and homogeneous zone characterization	✗	✓	✓	✓
Phase 3	Variable rate seed application	✗	✓	✓	✓
Phase 3	Variable rate nitrogen fertilizer application	✗	✓	✓	✓
	Crop yield comparison using yield mapping system	✓	✓	✓	✓

Analysis instruments: Historical data

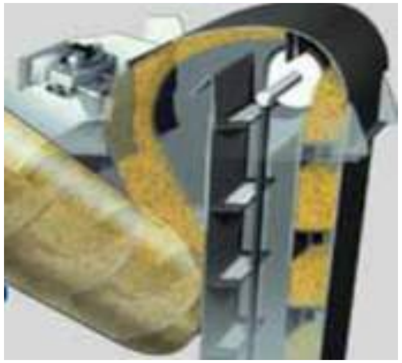
Satellite images



UAV (unmanned aerial vehicle) images

Basic information about the field

Analysis instruments: Historical data



Moisture and yield sensor

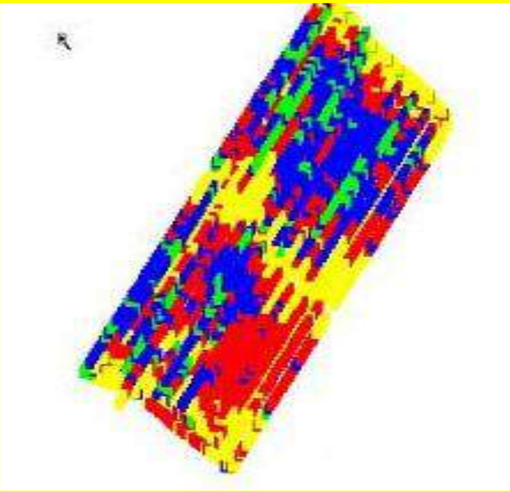
YIELD QUANTIFICATION

On board computer

DATA RECORDING

GPS system

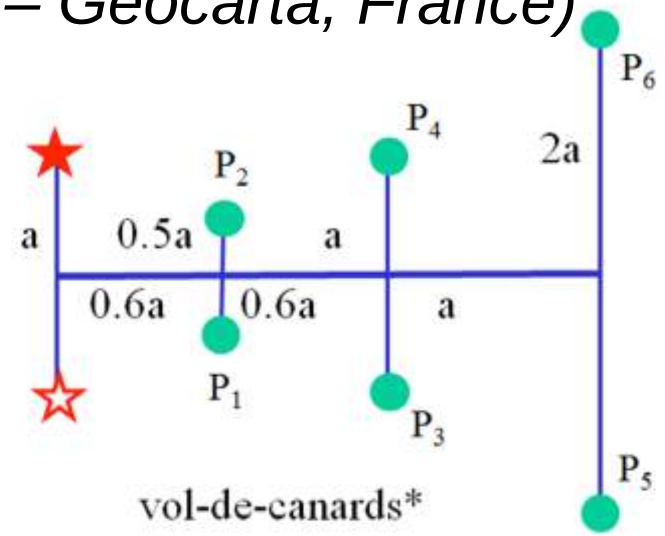
INFIELD POSITIONING



Yield map

Analysis instruments: Soil data

Automatic Resistivity Profiling *(ARP – Geocarta, France)*

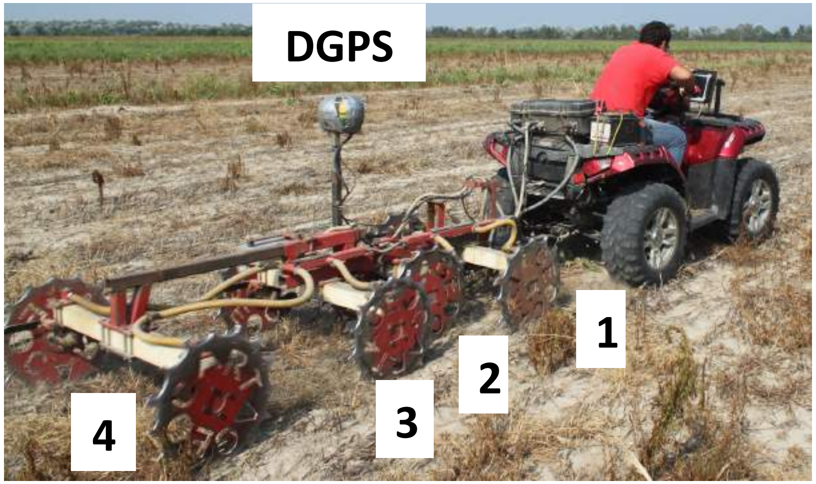


- Electrical data derives from a succession of electrodes represented by 4 toothed metal wheels (electrodes are inserted into the soil through the movement of rotation).

- 1° axle enters a stabilized current to the subsoil

- 2°,3°,4° axle measure the potential that derive from the injected current at 0-0.5, 0-1, 0-2 m.

- Data (expressed in Ohm·m) were real-time referenced by differential global positioning system (DGPS).



Analysis instruments: Soil data

- Sampling points definition

- Soil samples collected at different depth level

● Sampling points

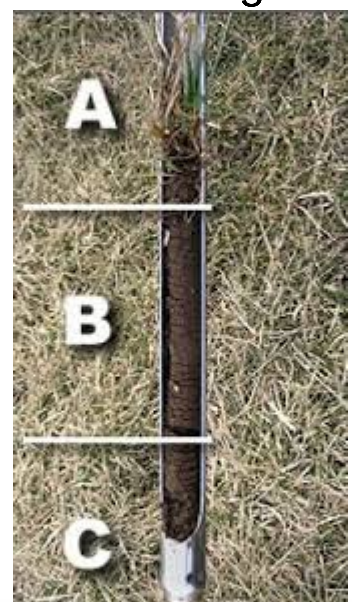
Contributes to define soil spatial variability through:

- Physical features

a) Texture
b) Soil organic matter
c) N,P,K availability

- Chemical features

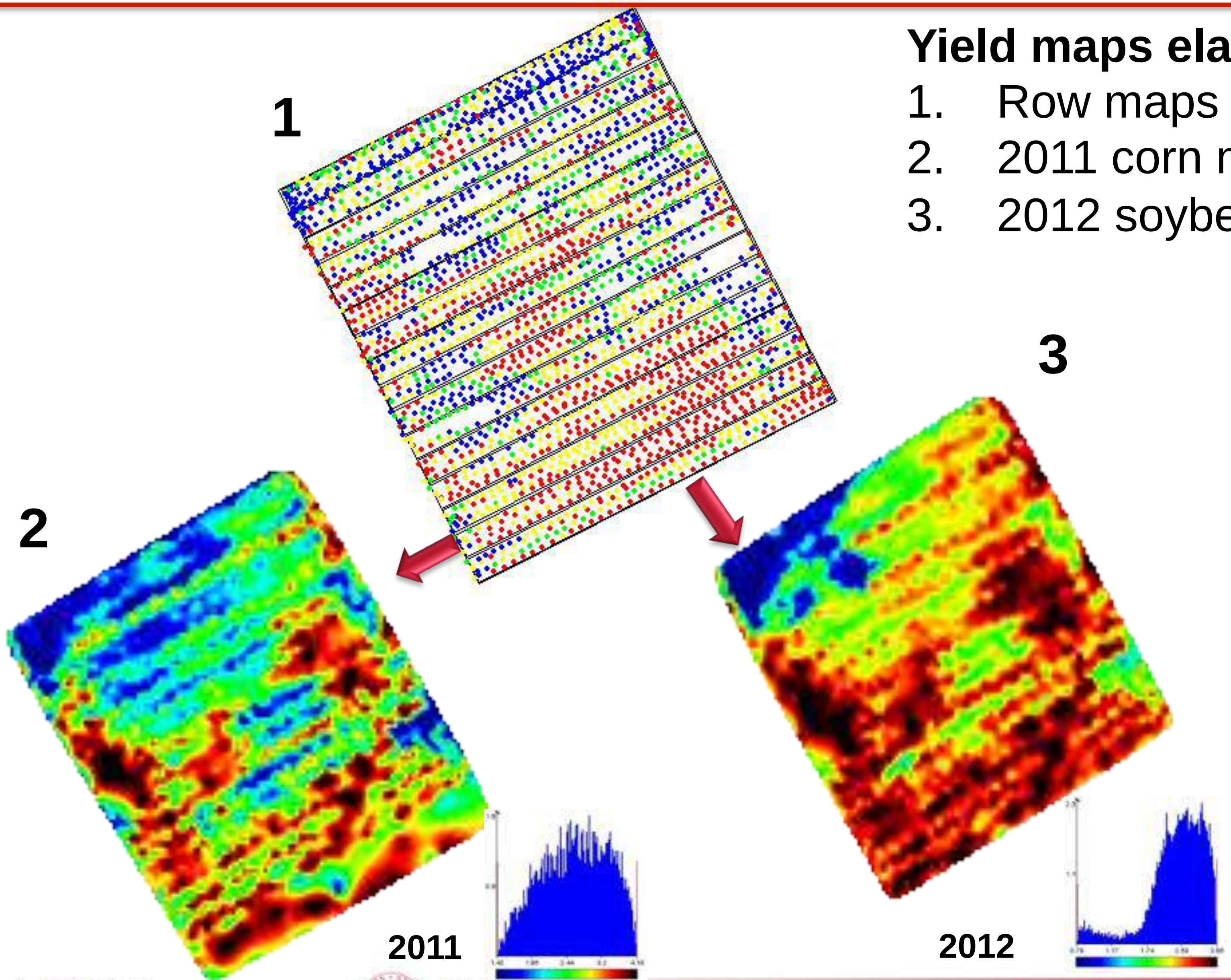
a) Electrical conductivity
b) pH
c) Cation exchange capacity (CEC)



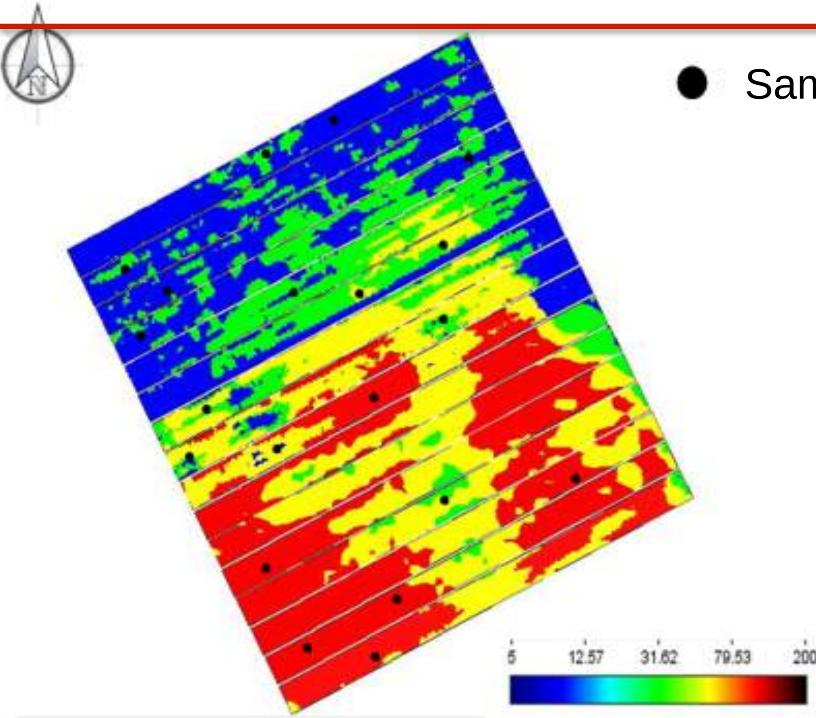
Phase 1: Historical yield maps

Yield maps elaboration

1. Row maps
2. 2011 corn map
3. 2012 soybean map



Phase 1: ARP analysis and soil sampling analysis



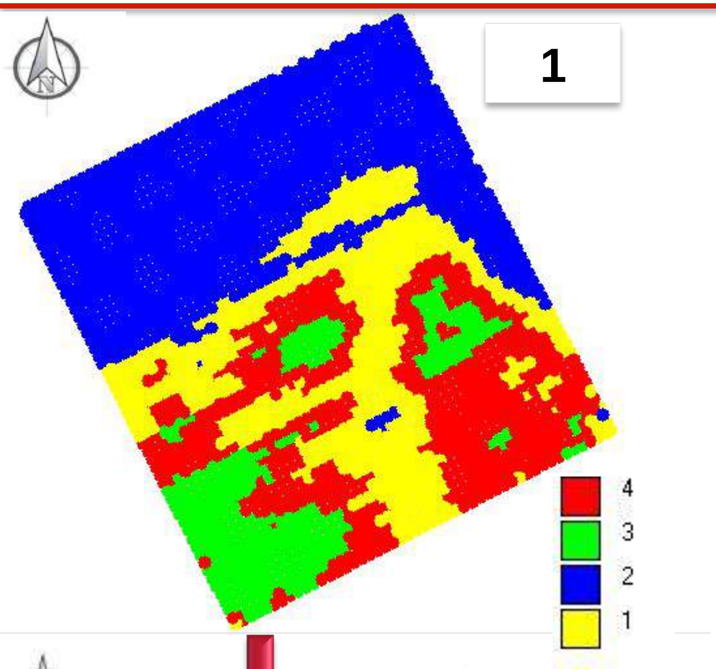
● Sampling point

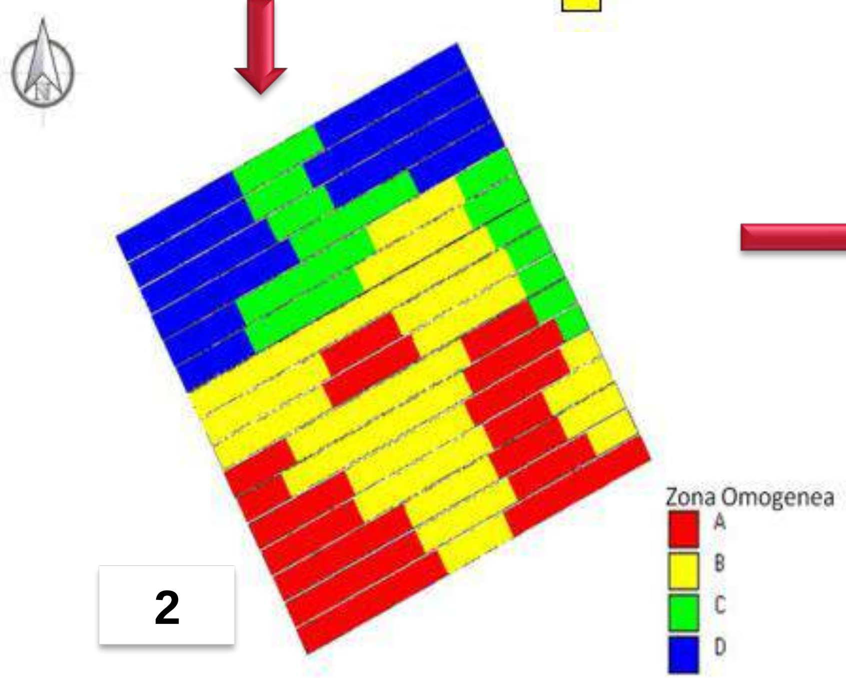
Soil's data collection

- Soil resistivity measurement carried out considering parallel transects at 5 m apart
- 20 sampling points obtained by ARP data (3 depth level: 0-10cm; 10-30cm; 30-60cm)
- Optimization of number of soil samples
- Statistical analysis to define homogeneous classes

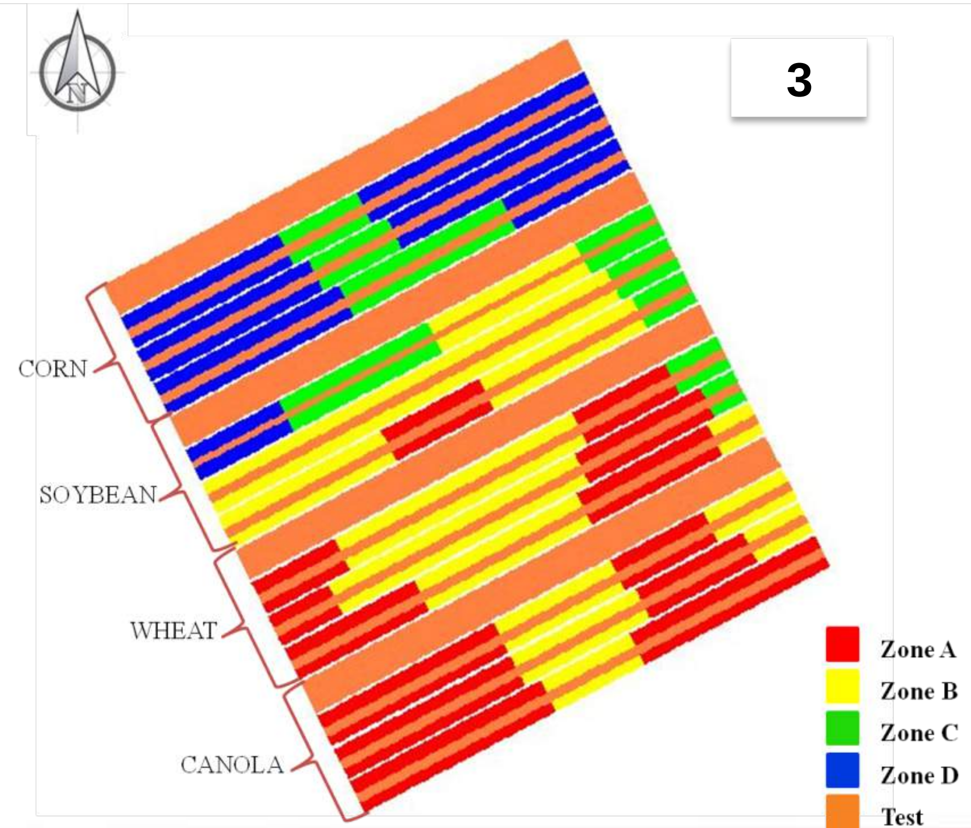
	ZONE A		ZONE B		ZONE C		ZONE D	
Electric conductivity (dS/m)	1,82	aA	2,01	aAB	2,26	abAB	2,39	bB
SAR (Sodium Adsorption Ratio)	0,46	ns	0,5	ns	0,35	ns	0,32	ns
pH	7,25	aA	7,53	bB	7,54	bB	7,48	bB
Active lime (%)	4,07	aA	3,83	aB	3,46	bC	3,48	bC
Total Nitrogen (%)	0,06	aA	0,06	bA	0,08	cB	0,11	dC
Soil Organic Matter (%)	1,22	aA	1,23	aA	1,71	bB	2,38	cC
assimilable phosphorus (mg/kg)	32,83	ns	30	ns	30,86	ns	29,5	ns
exchangeable potassium (mg/kg)	115,83	aA	121,67	aA	151	bB	154,25	bC
Clay (% t.f.)	15,17	aA	16,33	aA	22,14	bB	32	cC
Silt (%t.f.)	25,33	aA	24,67	aA	36,14	bB	47,75	cC
Sand (% t.f)	59,5	aA	59	aA	41,71	bB	20,25	cC

Phase 2: Study of soil variability





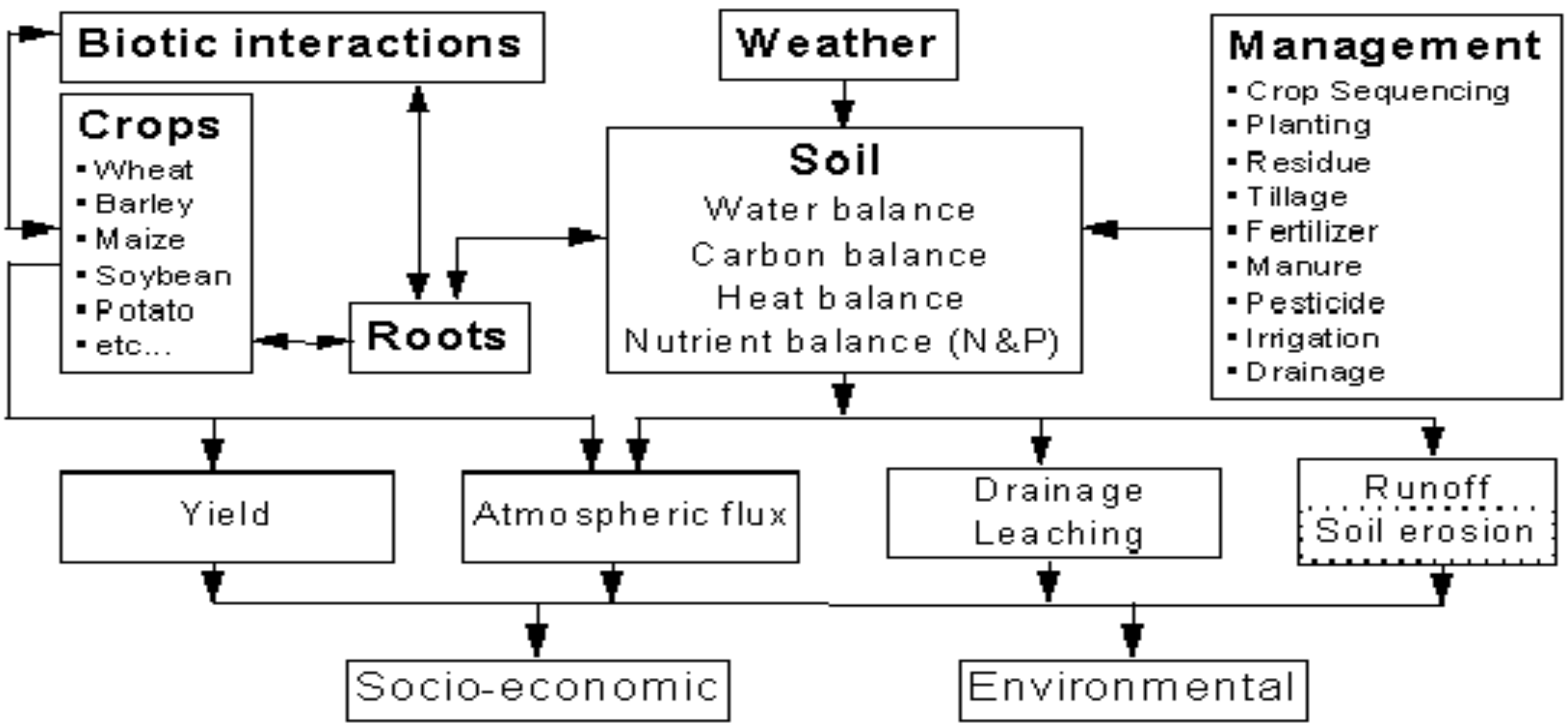
Data interpolation:
1. Management zone analyst (MZA)
2. Homogeneous zones characterization
3. Final experimental plan



Phase 3: Soil managing strategy and VRT

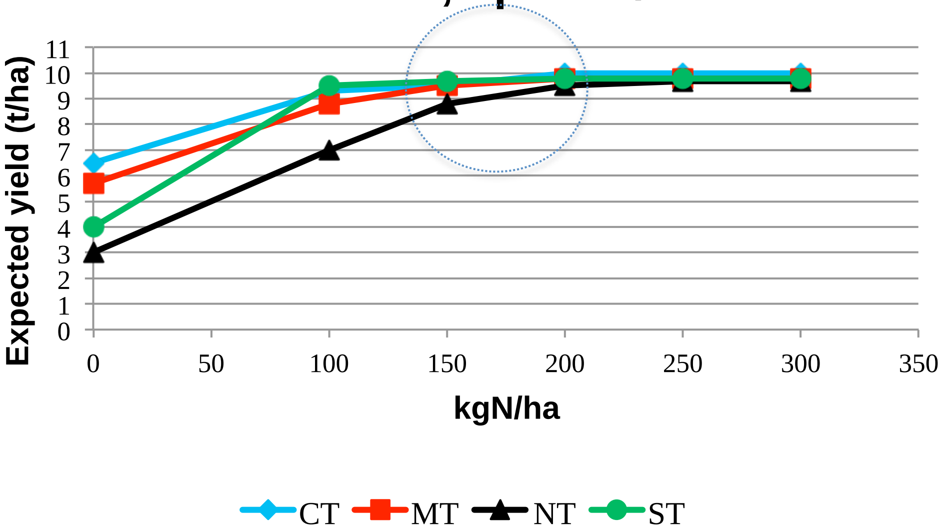
Identify the best way to manage soil variability using a predictive model

SALUS (System Approach to Land Use Sustainability) is a program designed to simulate the production response of herbaceous and woody crops under different agronomic management strategies

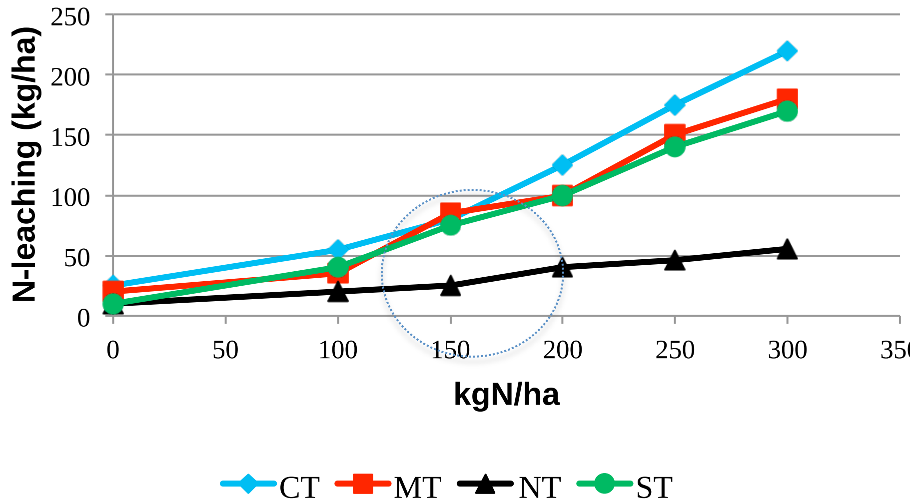


Phase 3: Soil managing strategy and VRT

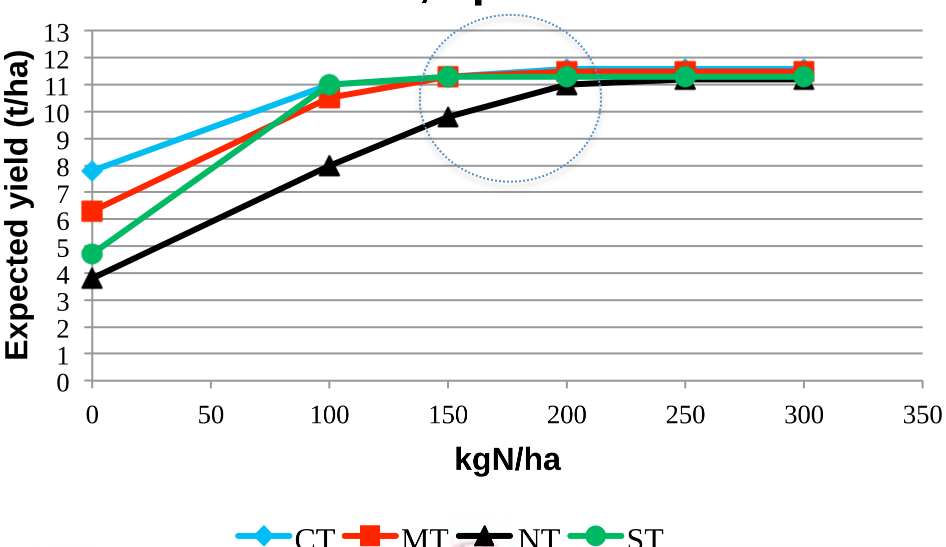
Zone C: 8,5 plants/m²



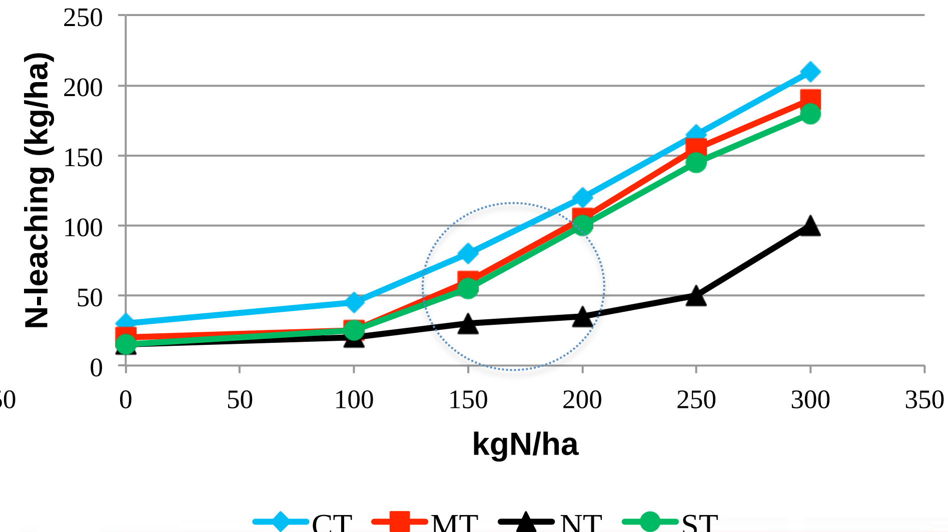
Zone C: 8,5 plants/m²



Zone D: 9,5 plants/m²



Zone D: 9,5 plants/m²



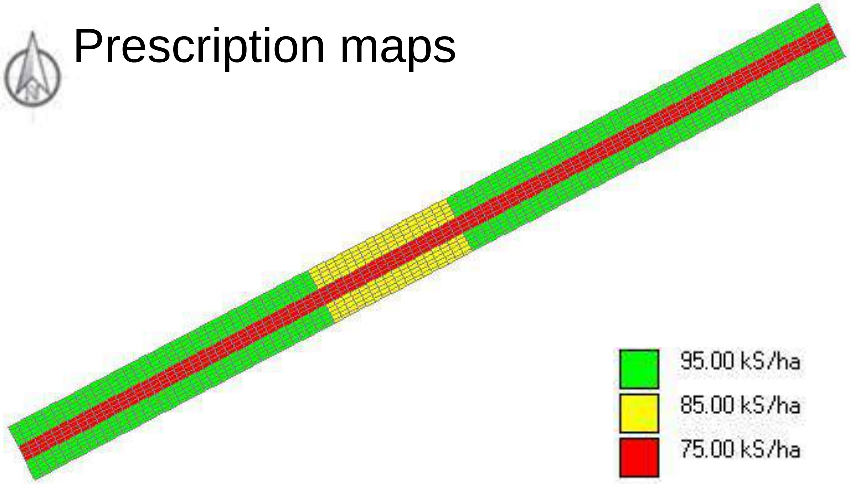
Phase 3: Soil managing strategy and VRT

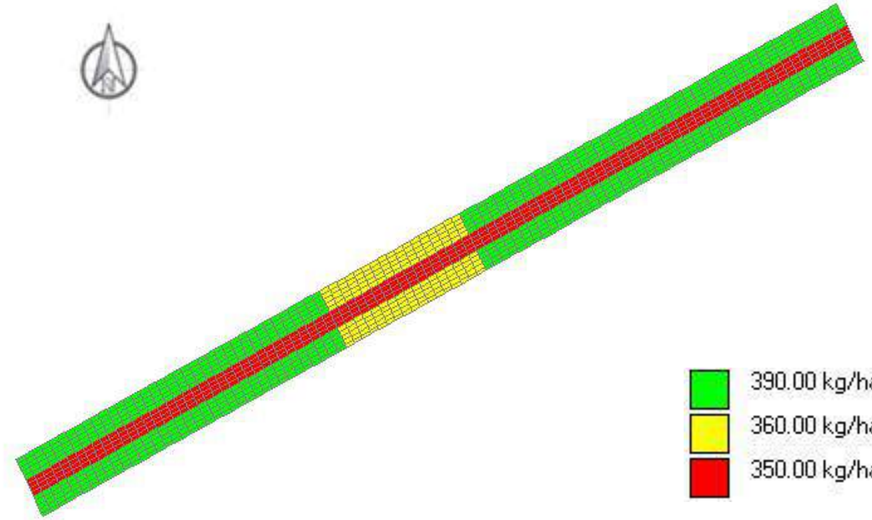
- Rapeseed and wheat: seed rate influenced by soil tillage technique but not by soil variability; N application changes between homogeneous zones.
- Corn: different seed and N rate due to spatial variability and soil tillage techniques requirements.
- Soybean: Variable rate seed application; N fertilization not required by the crop.

Crop	Demotest	Homogeneous zone	Seed rate (seeds/m2)	Nitrogen rate (kgN/ha)
Rapeseed	CT	-	50	128
	MT	A	50	140
		B	50	120
	ST	A	55	140
		B	55	120
	NT	A	55	150
		B	55	130
Wheat	CT	-	500	178
	MT	A	500	150
		B	500	190
		C	500	140
	ST	A	260	150
		B	260	190
		C	260	130
	NT	A	550	150
		B	550	190
Corn	CT	-	7,5	193
	MT	C	8,5	180
		D	9,5	200
	ST	C	8,5	200
		D	9,5	210
	NT	C	8,5	200
		D	9,5	220
Soybean	CT	-	45	-
	MT	B	50	-
		C	40	-
		D	35	-
	ST	B	50	-
		C	40	-
	NT	A	55	-
		B	50	-
		C	40	-

Phase 3: Soil managing strategy and VRT

Prescription maps

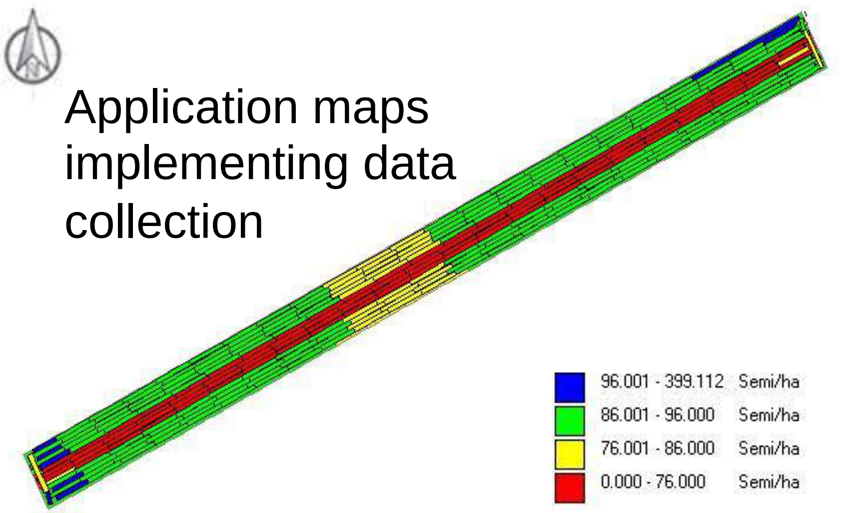


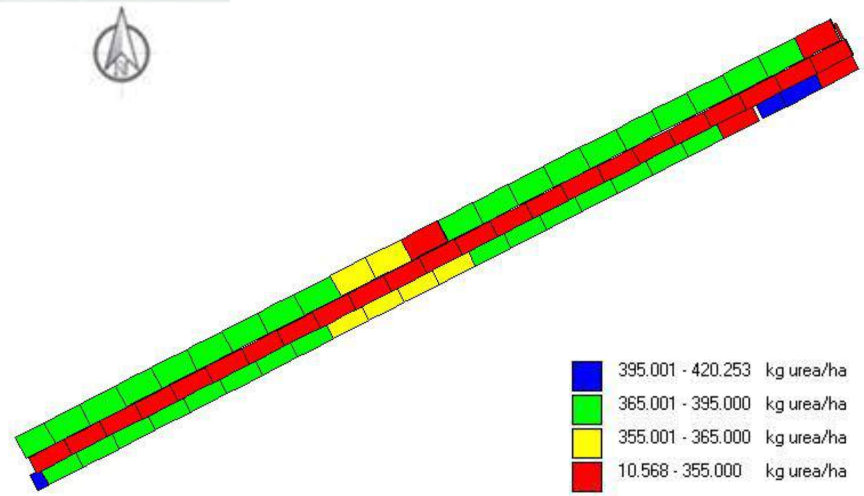


Maps transfer and work performing

Deviations < 10%

Application maps implementing data collection





The economic balance assessment

Machines costs assessed using ASABE standard

- **Machines**
  - Power (kW)
  - Purchase price (€)
  - Economic duration (years)
  - Interest rate (r)
  - Year usage (h/year)
  - Fixed costs (€/year)
  - Quota restoration and maintenance (€/h)
  - Diesel cost (€/l)
  - Workers payment (€/h)
- **Input**
  - Price schedule of 2015 crop season (€/ u.m.)

Parameter	Definition	Value
Nh	Durata fisica in ore	10000 (trattori), 3000 (macchine raccolta e semoventi), 2000-9000 operatrici;
U annuo	Utilizzo annuo in ore	800-1000 trattori, 500 (macchine raccolta e semoventi), 300-700 operatrici;
N	Durata economica in anni	10
i	Tasso di interesse	0,05
Sv	Spese varie	0,01 (trattori e macchine semoventi)
CM	Carico motore	0,65 (trattori e semovente), 0,77 (mietitrebbia)
α	Tasso di riparazione, calcolato come quota dei costi di riparazione accumulati alla fine della vita della macchina del prezzo di acquisto	0,8-1,3
β	Tasso di manutenzione calcolato come quota tra le ore annuali di manutenzione e l'uso annuale della macchina	0,1 (trattori e macchine operatrici), 0,05-0,5 (operatrici)

These items are connected to the economic value of the agricultural product

The energetic balance calculation

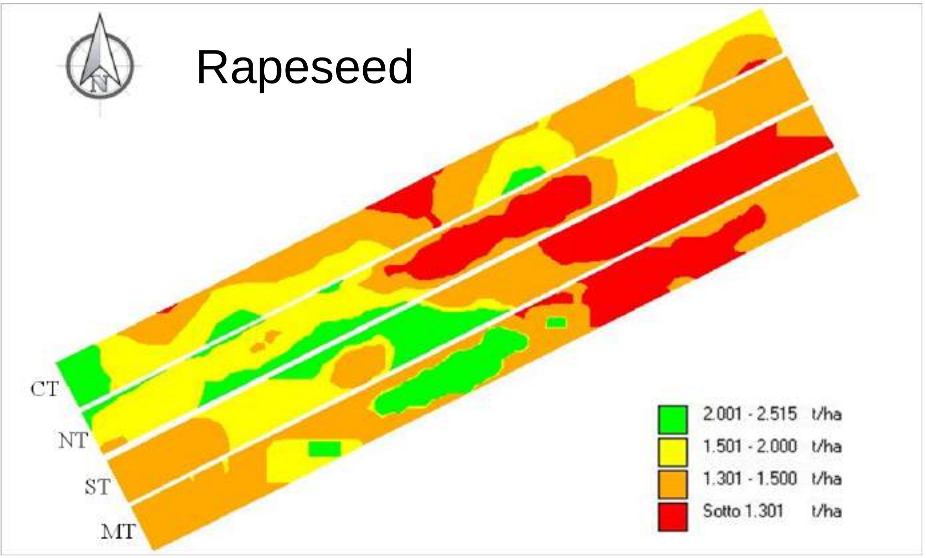
The applied inputs, the agricultural operations carried out during the crop cycle and the crops production (excluded the energy of environmental origin) have been divided into different classes:

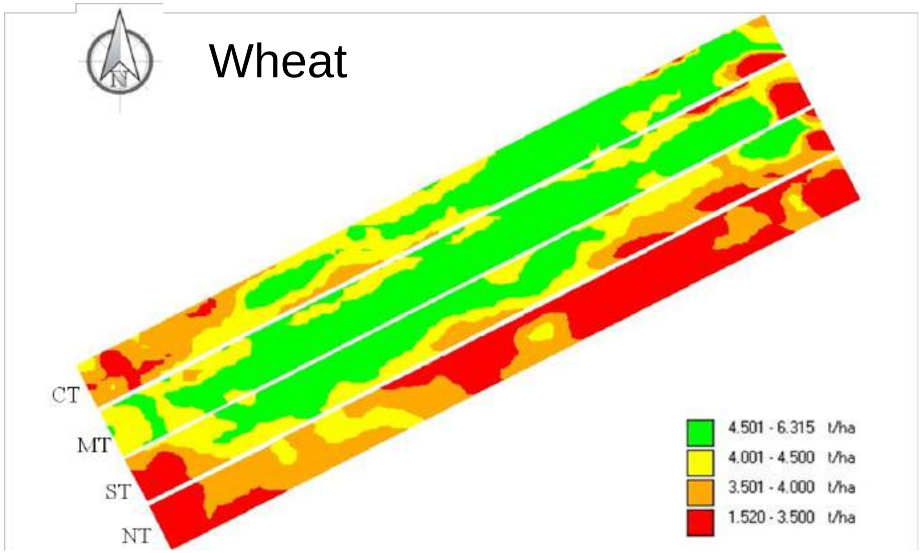
- **Engine/operator machines**
- **Seeds (main cultivation + cover-crops)**
- **Fertilizers**
- **Pesticides**
- **Exsiccation**
- **Crop yield**

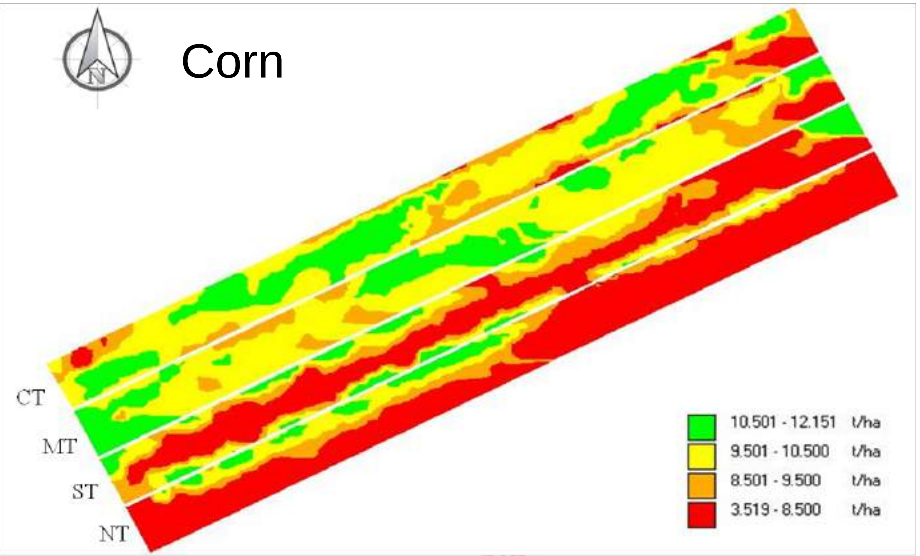
The amount of each class have been converted in "**energetic value**" using average coefficients found in literature (more reliability of the valuation).

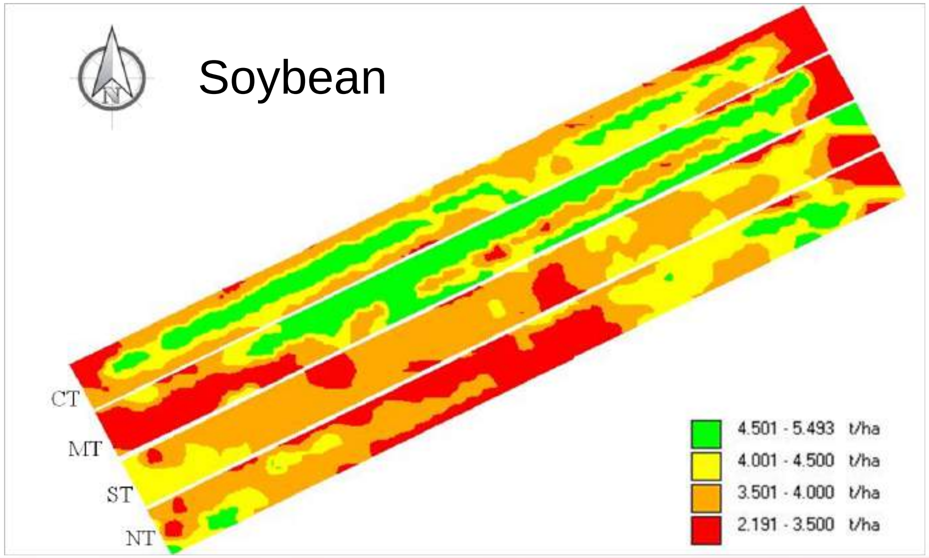
INPUT	Prodotto	VALORE ENERGETICO		Bibliografia		
		unità misura	MJ/unità			
Gasolio		kg	46,20	Sartori et al., 2005	Bertocco et al., 2008	
Olio		kg	78,13	Borin et al., 1997	Sartori et al., 2005	Bertocco et al., 2008
Manodopera		h	1,96	Canakci et al., 2005	Singh et al., 2008	Sarauskis et al.,2014
Macchine agricole		kg	108,00	Kraatz and E Berg, 2008		
Concimi	8-24-24	kg	9,77	Canakci et al.,2005	Bilalis et al.,2013	Mandal et al., 2015
	Nitrato amm	kg	23,27	Borin et al.,1997	Sartori et al., 2005	
	Urea	kg	32,26	Borin et al.,1997		
	Solfato amm	kg	12,26	Singh et al., 2008	Barut et al.,2011	Fore et al.,2011
	0-20-20	kg	4,10	Singh et al., 2008	Fore et al.,2011	Bilalis et al.,2013
Frumento	LG Aubusson	kg	15,70	Canakci et al.,2005	Taghavifar and Mardani, 2015	
Frumento	Venturoli – Hyxo	kg	27,63	Sartori et al., 2005		
Colza	Dekalb - Excalibur	kg	5,83	Miller, Kumar 2013		
Mais	Dekalb 6815	kg	104,65	Borin et al., 1997	Sartori et al., 2005	Bilalis et al.,2013
Soia	Pioneer PR92B63	kg	33,49	Borin et al., 1997	Sartori et al., 2005	
Cover cops	Orzo	kg	5,57	West and Marland, 2002		
Cover crops	Sorgo	kg	43,50	West and Marland, 2002		
Prod. Fitosanitari	Prelude 20 FS	kg	453	Procloraz	Audsley, 2009	
	Glean 75 DF	kg	273,75	Clorsulfuron (75%)	Monti, Venturi, 2003	
	Granstar 50 SX	kg	270,00	Tribenuron metile (50%)	Audsley, 2009	
	Prosaro	kg	12,83	Protioconzolo (12,5 g/l)	Tebuconazolo (12,5 g/l)	Audsley, 2009
	Agil	kg	56,10	Propaquizafop (100 g/l)	Audsley, 2009	
	Butisan S	kg	194,00	Metazaclor (500 g/l)	Audsley, 2009	
	Decis Jet	kg	3,21	Deltametrina (15 g/l)	calcolato	
	Lumax	kg	116,03	Mesotrione (37,5 g/l)	Terbutilazina (187,5 g/l)	Audsley, 2009; Borin et al., 1997
	Coragen	kg	42,80	Chlorantraniliprole (200 g/l)		
	Fedor	kg	310,94	Fuflenacet (42%)	Audsley, 2009	
	Stratos Ultra	kg	27,70	Cycloxidim puro (100 g/l)		
	Roundup platinum	kg	227,52	Glyphosate (480 g/l)	Audsley, 2009	
OUTPUT						
Colza		kg	26,00	Unakitan et al., 2010	Mousavi-Avval et al., 2011	
Frumento		kg	14,70	Singh et al., 2008	Tabatabaeefar et al.,2009	Taghavifar and Mardani, 2015
Mais		kg	14,70	Sartori et al., 2005	Sarauskis et al.,2014	Bilalis et al.,2013
Soia		kg	18,14	Singh et al., 2008		

Preliminary results: Crops yield

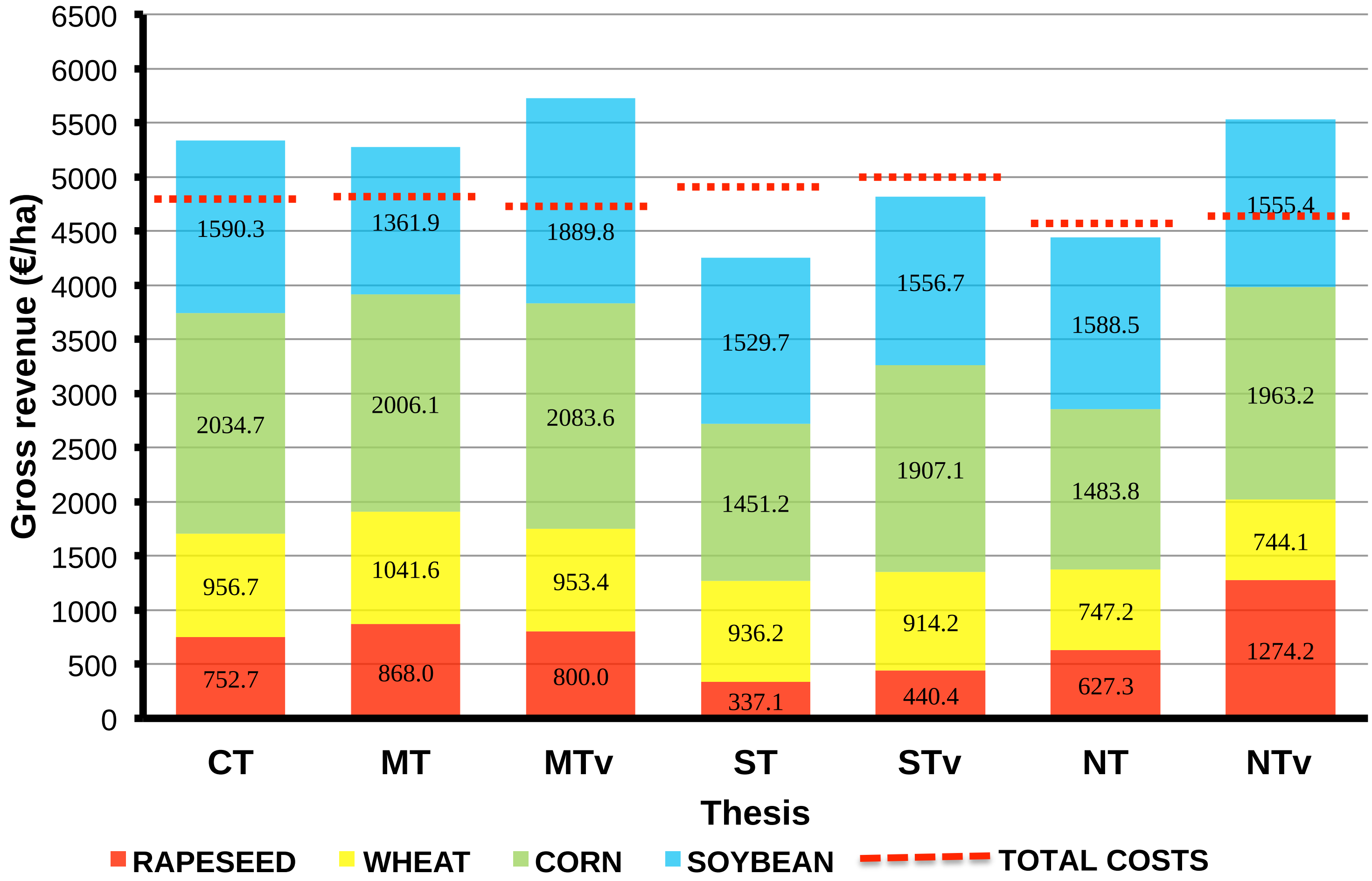




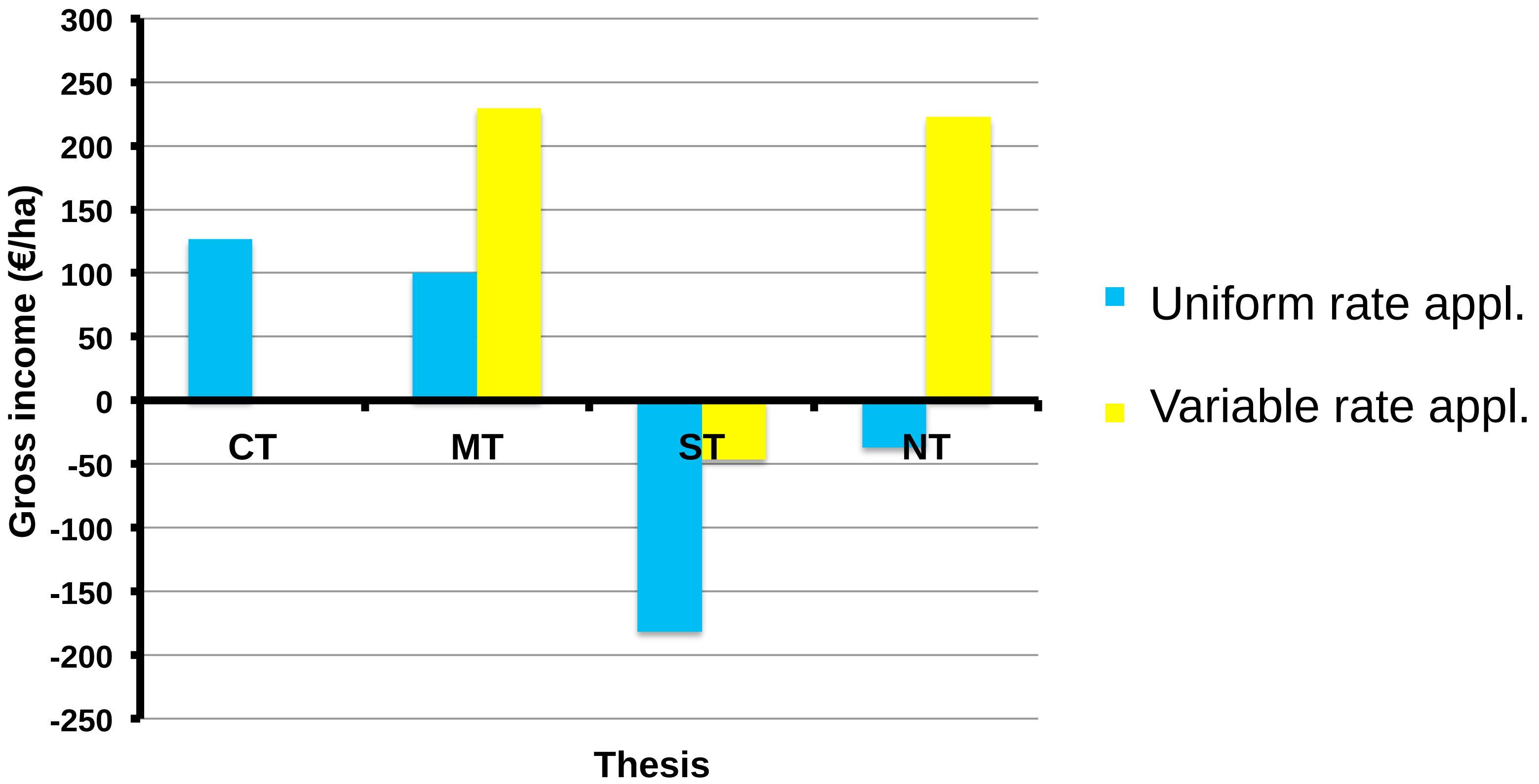




Preliminary results: Gross revenue and total costs



Preliminary results: Economic balance

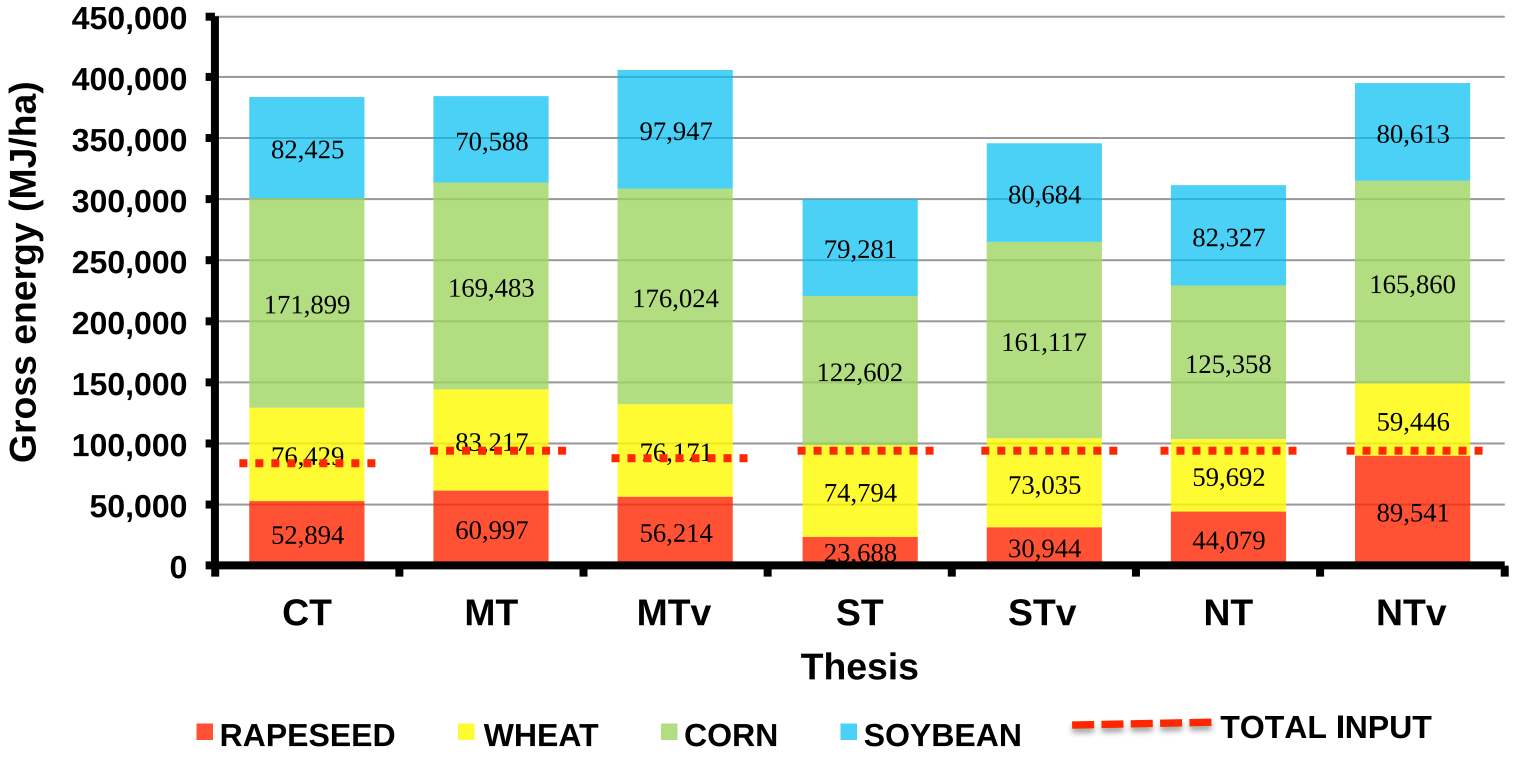


•MT supported by PF obtains gross income higher of 80% than CT

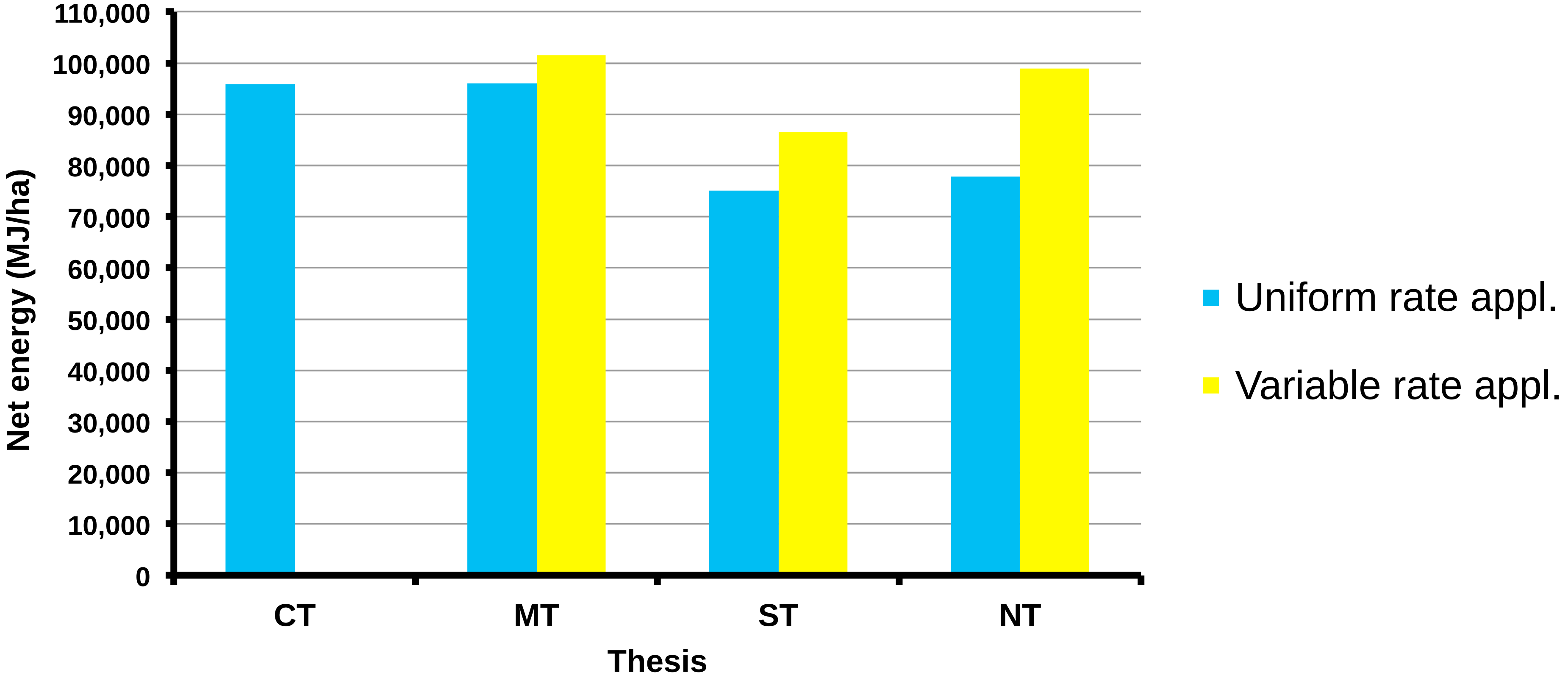
•PF allows ST to get approximately 75% higher gross income than ST Without PF

•NT implemented with PF technologies mitigates low crops yield characterizing this soil tillage techniques

Preliminary results: Total energetic input and output



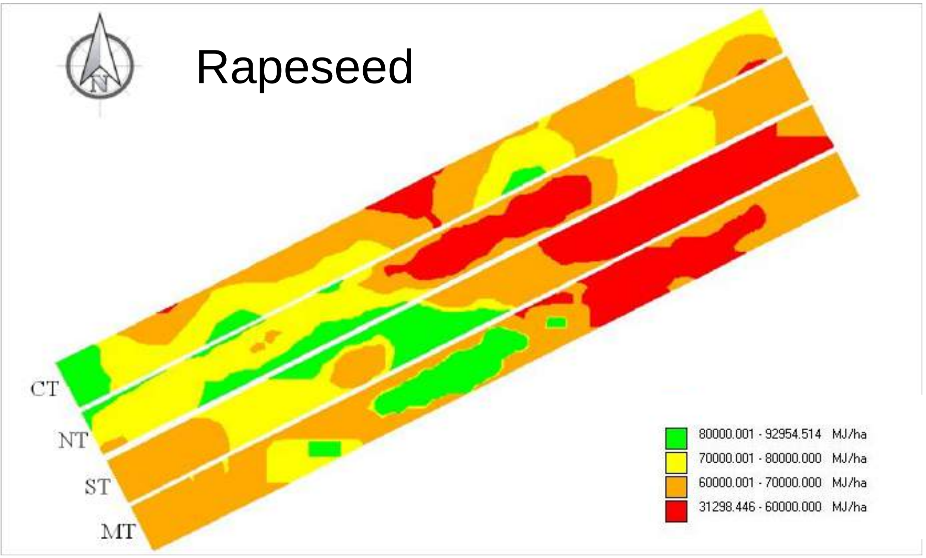
Preliminary results: Net energy

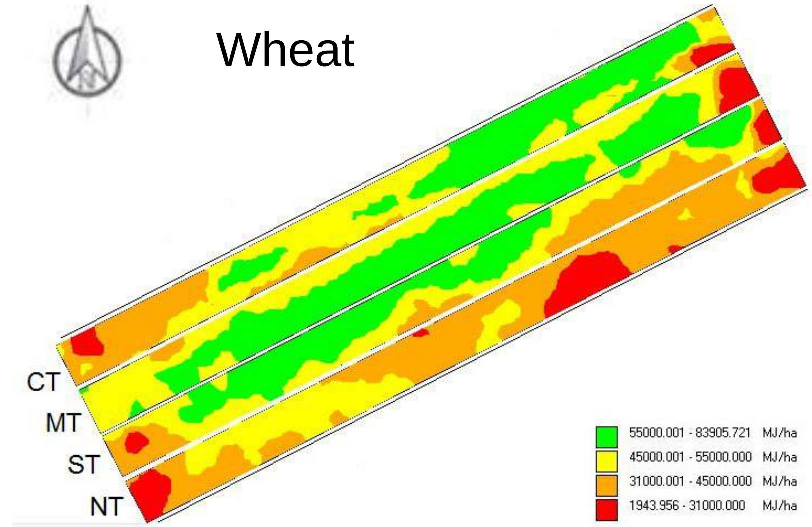


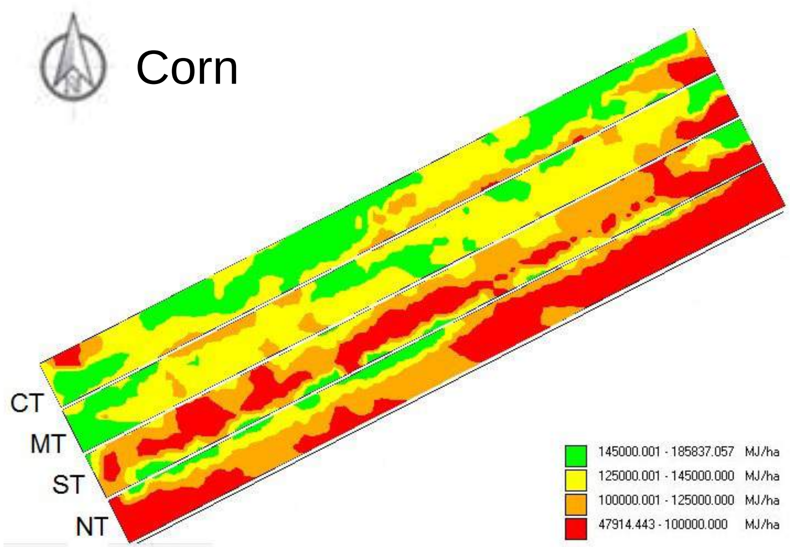
•MT and NT supported by PF reach net energy values Higher than CT respectively of 6% and 3%

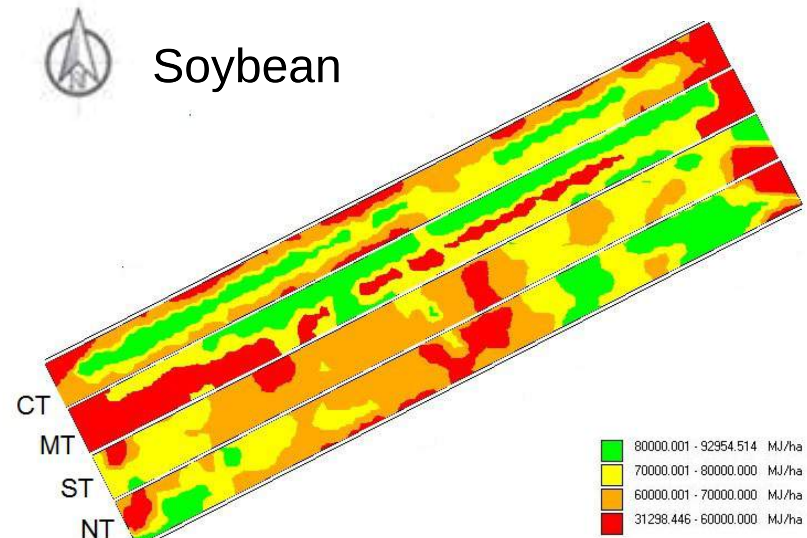
•PF increases net energy of about 15% in ST compared with the same URA technique

Preliminary results: Energetic maps









Conclusions

• Precision Farming increases crops yield in all Conservation tillage techniques enhancing the input use efficiency.

• Minimum tillage and No tillage supported by Precision Farming got higher gross income and net energy than Conventional tillage.

• First year adoption of Strip tillage shown technical complications, but it was observed ample room for improvement.

• At the end of second year of experimentation a CO_2 balance will be performed also considering the mid-long term carbon fixed in the soil.


Thanks for the attention