Università degli Studi di Firenze

IBIMET

Impacts, adaptation and mitigation roles of typical Mediterranean crops

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ADAPTtoCLIMATE
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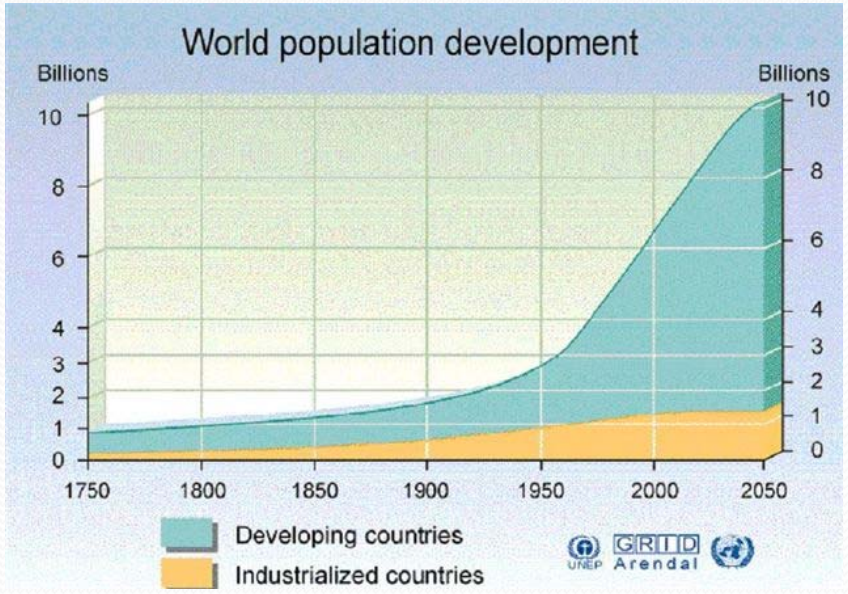
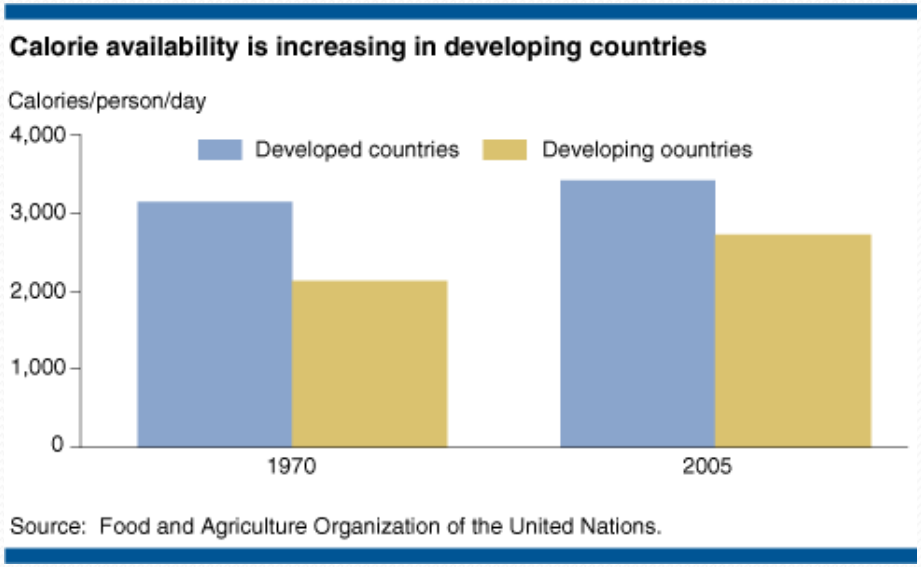
Challenges of agriculture in 21st century

- **to feed the increasing number of people on earth**
- to face with growing scarcity of land and water due to competition with other sectors
- to address increasing demands for bioenergy and biofuels
- **to address the increasing dietary intake in developing countries**



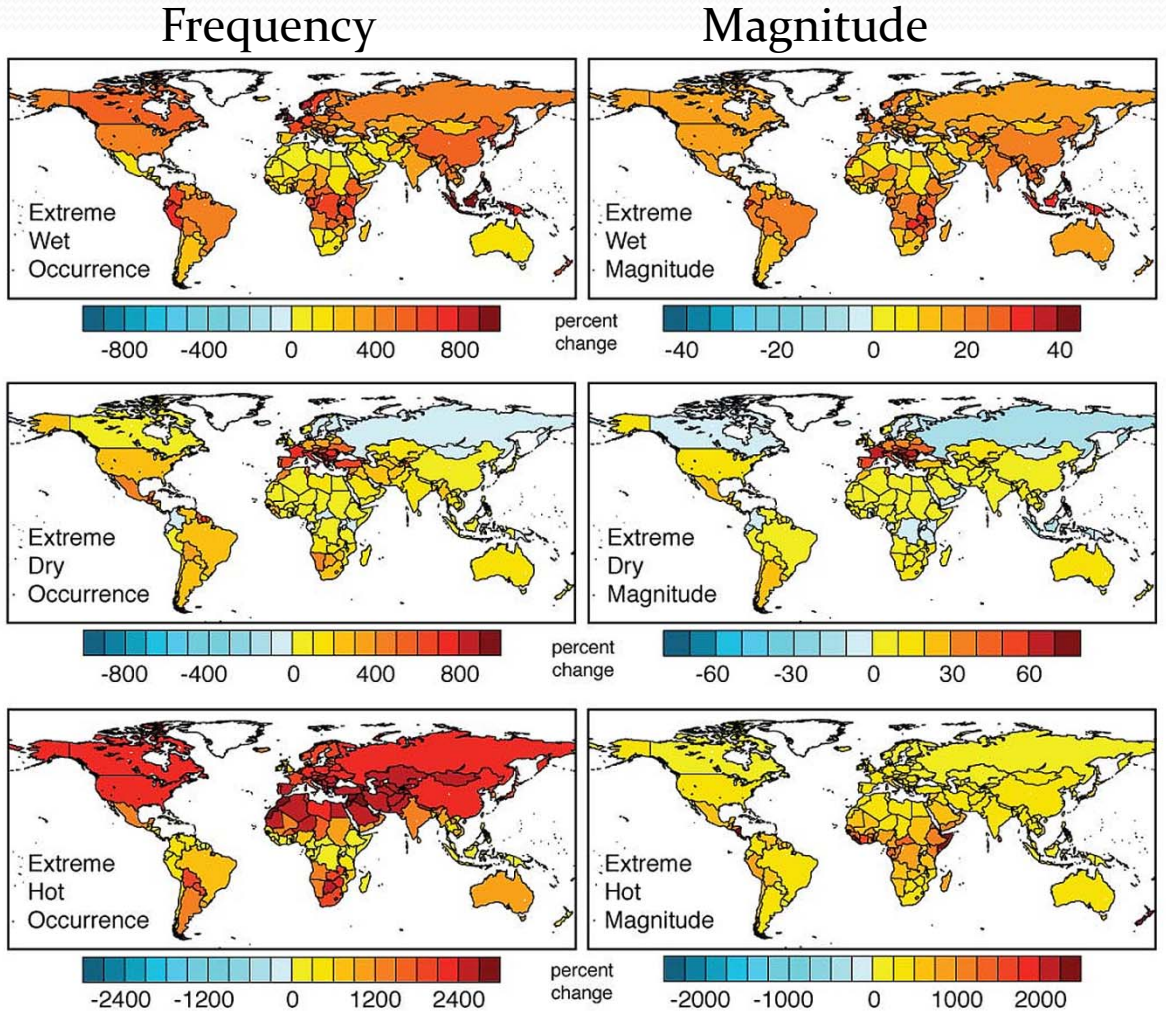


Challenges for European agriculture

- **Increasing production of food and biomass**
  - Increasing food and feed production in Europe for feeding the worlds middle class
  - Increasing biomass for bioenergy, biofuels and biomaterials
- **Maintaining the agricultural resource base (soils and genotypes)**
  - Soil quality (organic matter and drainage)
  - Soil erosion
  - Genotypes of existing and new crop types for use in Europe
- **Reducing environmental impacts**
  - Nitrogen and phosphorus losses to the aquatic environment
  - Atmospheric nitrogen emissions
  - Greenhouse gas emissions
  - Pesticide use and losses
- **Maintaining biodiversity**
  - The agricultural landscape contributes to much of the biodiversity
  - Need for new and more corridors in the landscape (also for adaptation to climate change)

Challenges of agriculture in 21st century

- **to manage changes in mean and extreme climate:**
  - Increasing atmospheric CO_2 concentration
  - Increasing temperatures
  - Changes in rainfall
  - Changes in extreme events
    - **Heat waves**
    - **Droughts**
    - **Floods**
    - Hail
    - Storms



Ahmed et al., 2009

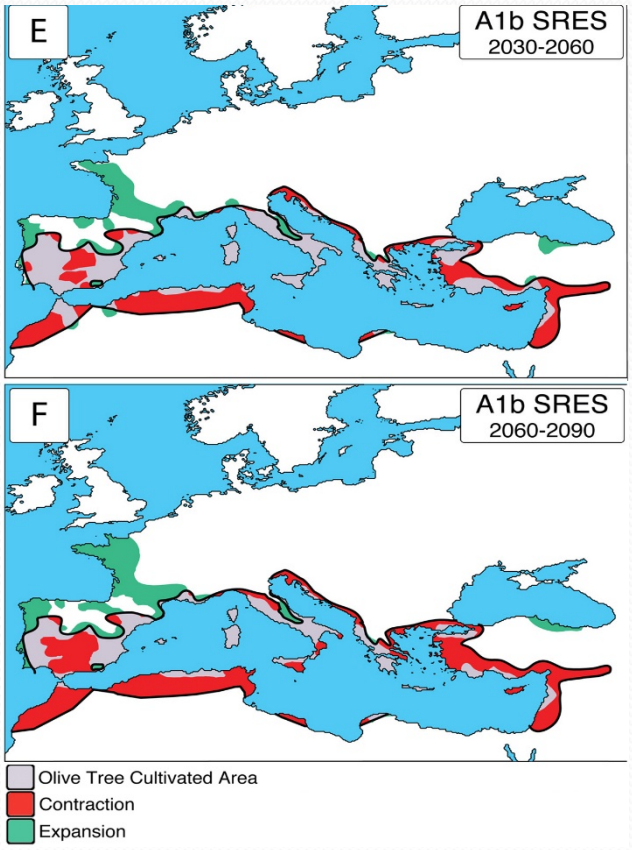
Impacts of climate change to agricultural crops:

- Suitable areas for cultivation
- Length of growth season and time of phenological stages
- Crop yields (quantity and quality)

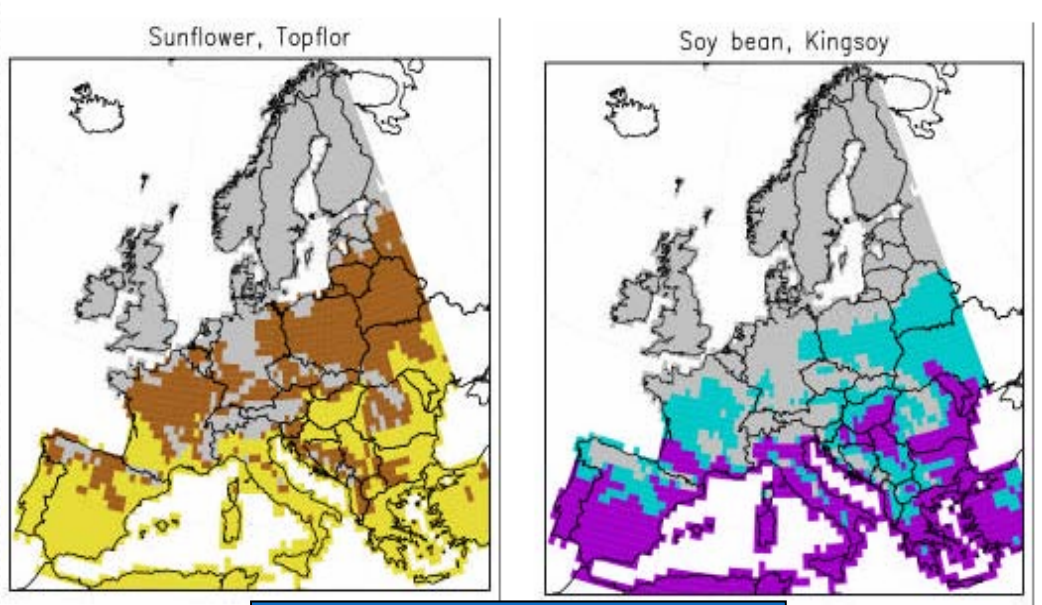
Impacts of climate change to agricultural crops: Suitable areas for cultivation

- Expansion of northern limits
- Contraction of southern limits

Olive



Moriondo et al., 2013

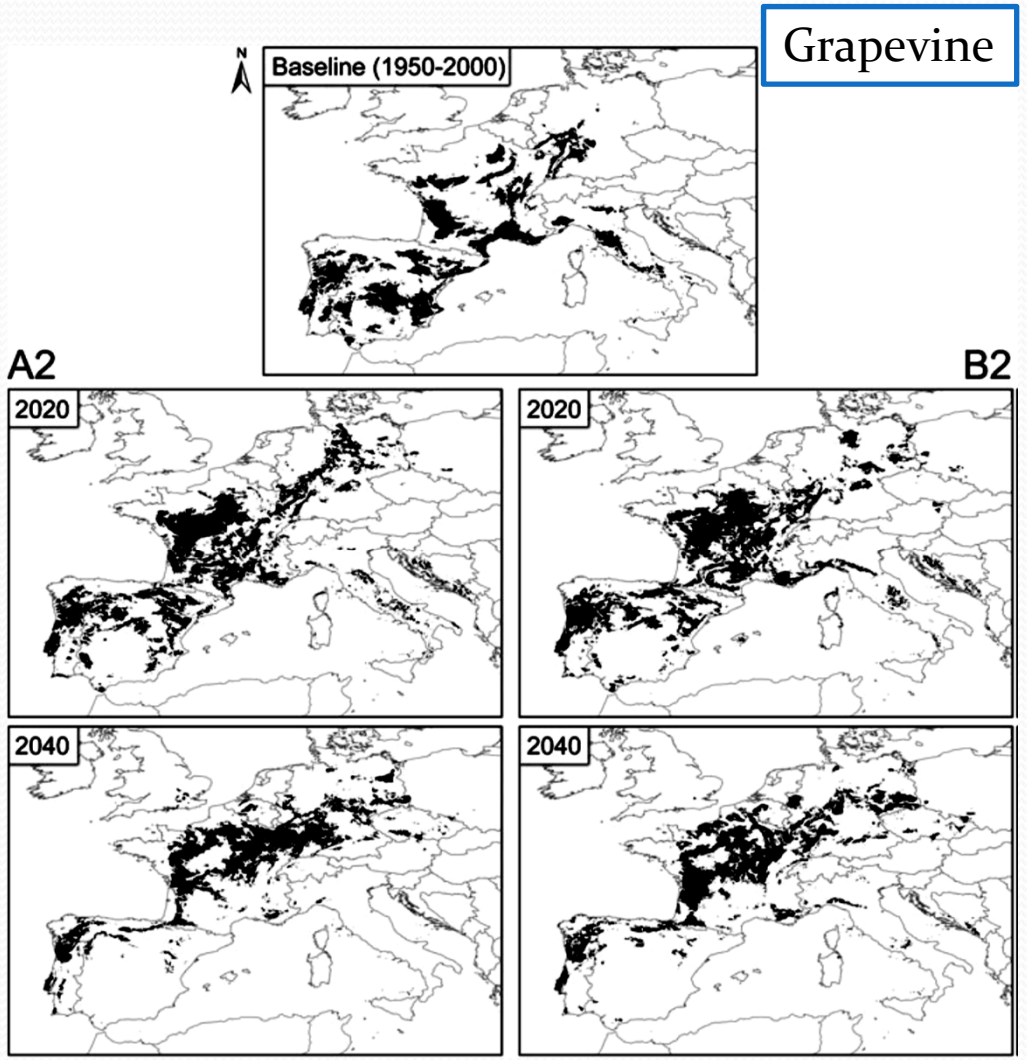


brown/blue: suitability expansion
yellow/purple: baseline 1961-90

Fronzek & Carter, 2007

Impacts of climate change to agricultural crops: Suitable areas for cultivation

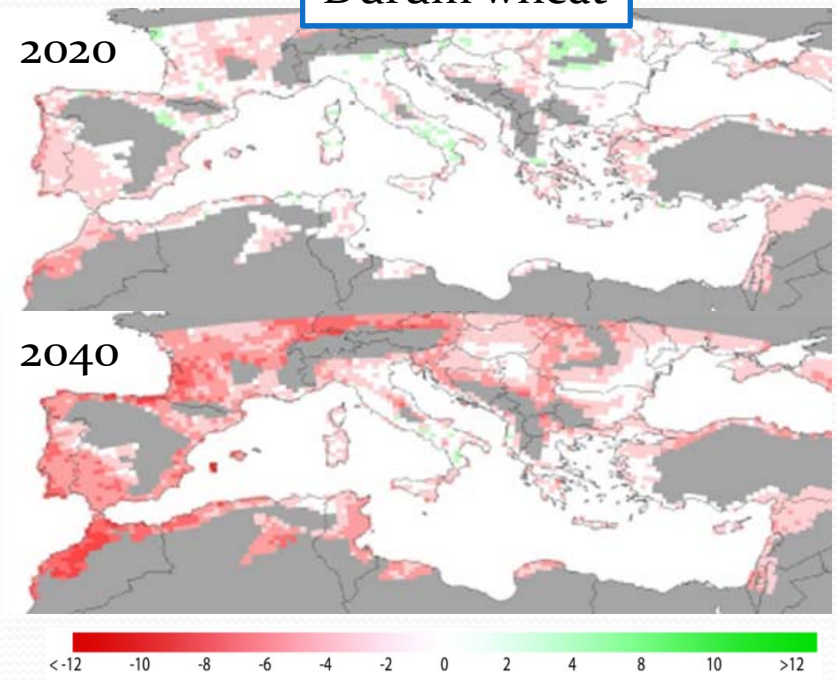
- Expansion of northern limits
- Contraction of southern limits



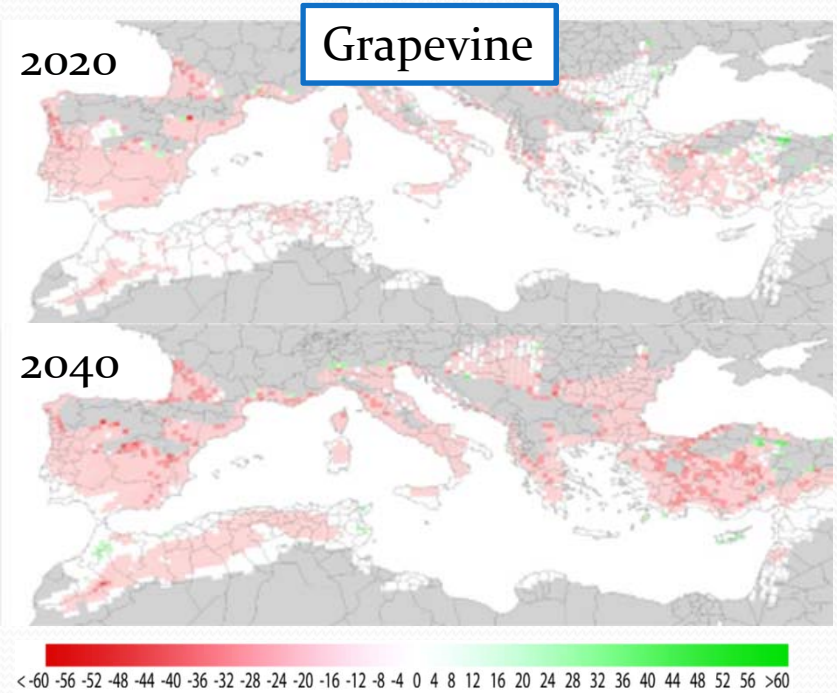
Impacts of climate change to agricultural crops: Length of growth season and time of phenological stages

- Reduction of the growth seasons and advance in maturity stage

Durum wheat



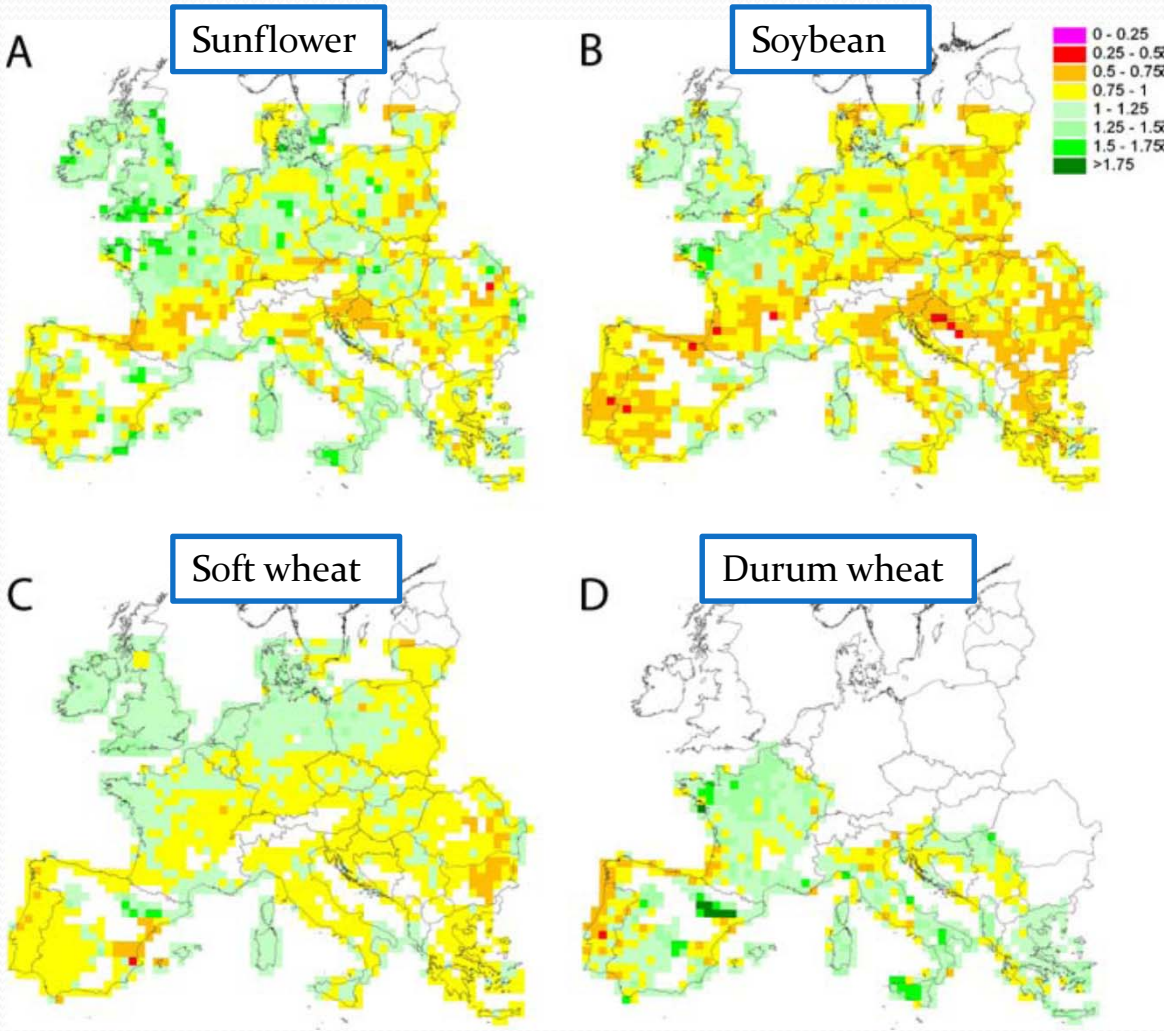
Grapevine



Scenario A1B - Ferrise et al., 2010

Impacts of climate change to agricultural crops: Crop yields

- Prevalent reduction of crop yields in southern areas (mainly in summer crops)

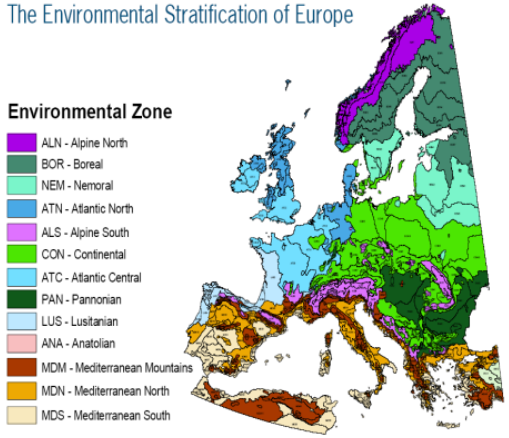


Scenario + 2°C Moriondo et al., 2010

Impacts of climate change to agricultural components: summary from IPCC- AR4

Sectors and Systems	Impact	Area North	Atlantic	Central	Mediterr.	East
Agriculture and fisheries	Suitable cropping area	↑↑↑	↑↑	↑	↓↓	↓
	Agricultural land area	↓↓	↓↓	↓↓	↓↓	↓↓
	Summer crops (maize, sunflower)	↑↑↑	↑↑	↑	↓↓↓	↓↓
	Winter crops (winter wheat)	↑↑↑	↑↑	↑ to ↓	↓↓	↑
	Irrigation needs	na	↑ to ↓	↓↓	↓↓↓	↓
	Energy crops	↑↑↑	↑↑	↑	↓↓	↓
	Livestock	↑ to ↓	↓	↓↓	↓↓	↓↓
	Marine fisheries	↑↑	↑	na	↓	na

Impacts of climate change to agricultural components: Perceived by agronomists (for 2050)



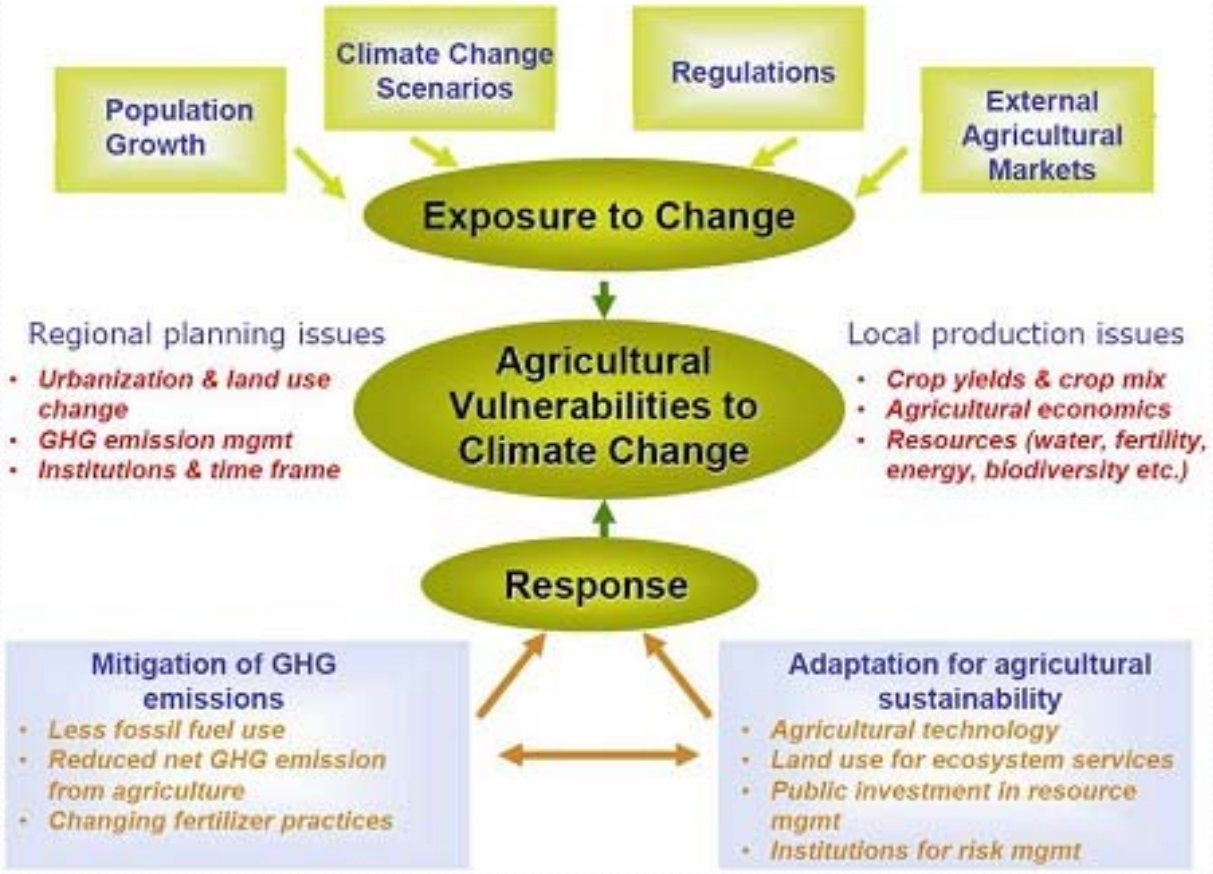
Winter wheat

	Growth Duration	Overwin-tering	Frost	Suitable harv.	Seasonal variability	Drought	Heat stress	Hail	Pest& Diseases	Weeds	Soil erosion	Nitrogen losses
ALN												
BOR	1.5	-1.0	0.0	-0.3	0.0	0.5	0.5	0.0	2.0	1.0	1.0	2.0
NEM	0.3	-0.8	-0.3	1.5	1.3	1.0	1.0	0.5	1.5	0.0	0.3	0.8
ATN	0.2	-0.8	0.0	-0.3	0.3	0.8	1.0	0.5	1.5	1.0	0.8	1.3
ALS	-0.5	1.0	-0.5	1.5	0.0	1.0	1.0	0.0	1.0	0.0	2.0	1.0
CON	-0.2	-0.4	0.0	0.4	0.5	0.4	0.9	0.2	1.4	1.0	0.6	1.3
ATC	-1.0	-0.7	-0.5	-0.3	0.8	0.3	0.3	0.5	0.3	0.5	0.5	0.5
PAN	-0.7	-0.3	0.0	-0.5	1.7	0.7	2.0	1.0	1.3	1.0	0.3	0.8
LUS	-1.0		0.0	1.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	0.0
MDM	-1.0	-1.0	0.0	-1.0	0.0	-1.0	-1.0	-1.0	0.0	1.0	0.0	1.0
MDN	-1.3	-0.5	-0.3	-0.5	0.3	0.8	0.5	0.1	0.5	1.0	0.8	0.8
MDS	-0.8	0.0	-0.3	0.3	0.5	0.8	0.8	0.3	0.0	1.0	0.5	0.5

Negative values imply decreases
Positive values imply increases

from COST 734

Response of agriculture to climate change: mitigation and adaptation strategies

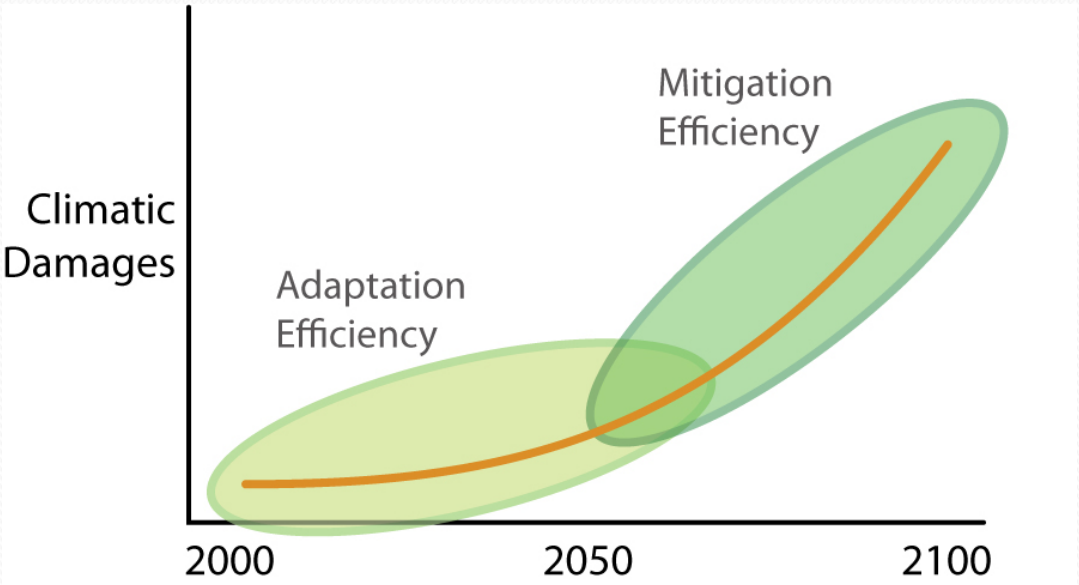


Source: Jackson and Tomich

Efficiency of mitigation and adaptation strategies

- **Mitigation strategies** of climate change (action on the causes: reduction CH_4 and N_xO emissions, and increase CO_2 storage)

- **Adaptation strategies** to climate change (alleviate the effects: improve crop management and increase water retention)



Tubiello, 2007

Agriculture adaptation to climate change: changes, requirements, achievements

Changes:

- Increasing temperatures
- Increasing rainfall intensity
- More frequent droughts
- More variable climate (in many areas)

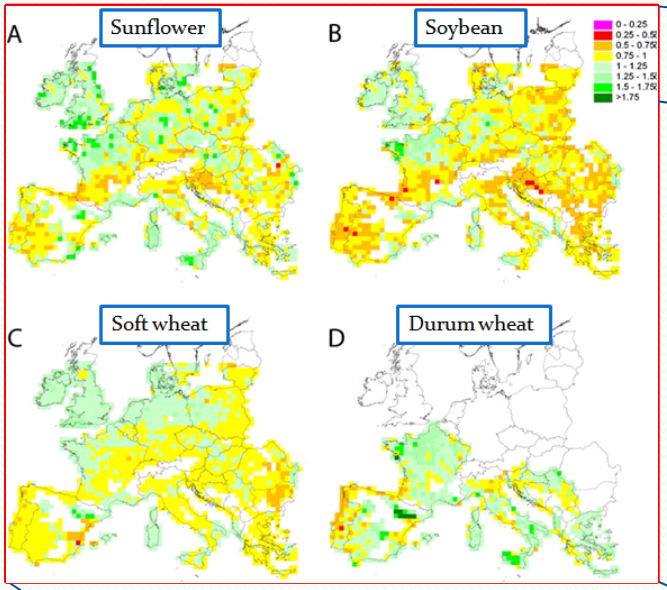
Requirements:

- Higher resilience to climatic variability
- Better use and management of water

Achievements:

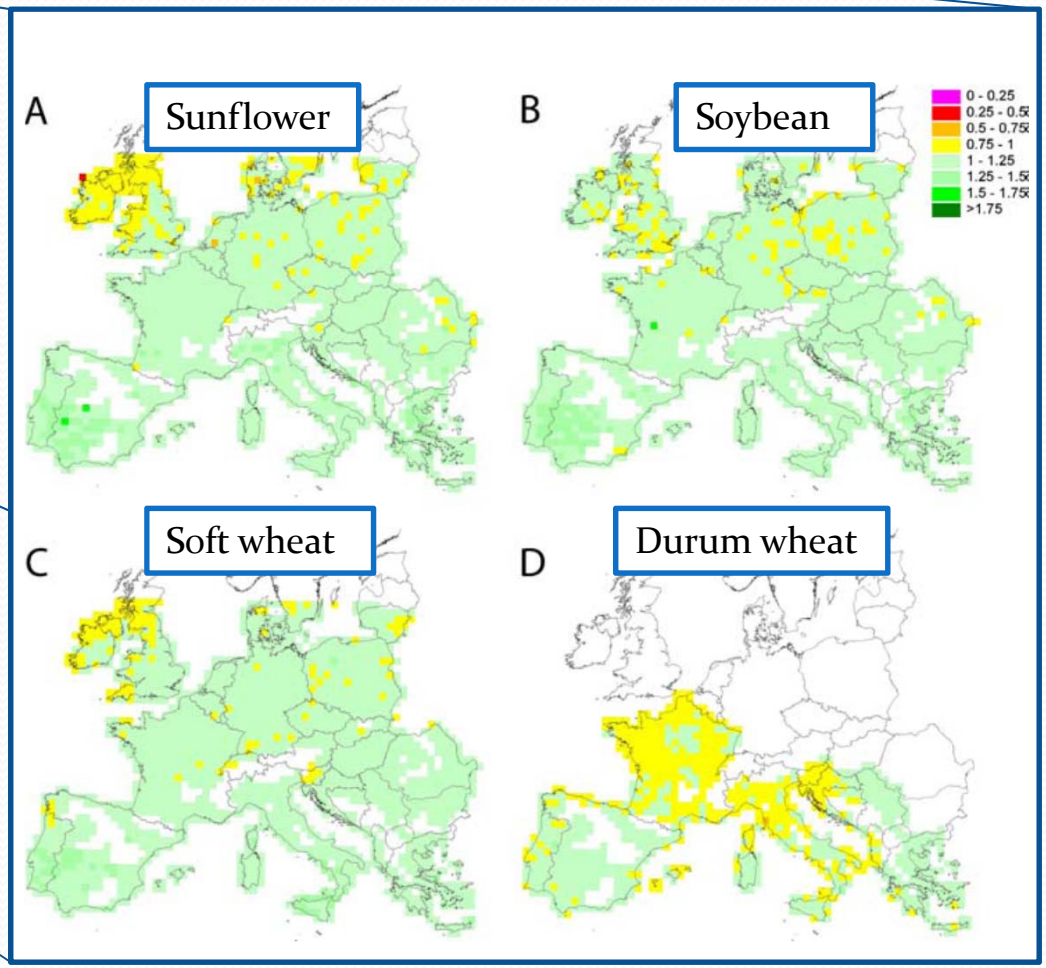
- Maintaining fertile soils with high water holding capacity
- Improving crop genotypes (drought tolerance)
- Diversifying crop rotations and cropping systems
- Cover crops and intercrops to improve fertility/retain nutrients
- Adapting crop management to increase resilience to change

Adaptation strategies: earlier sowing data



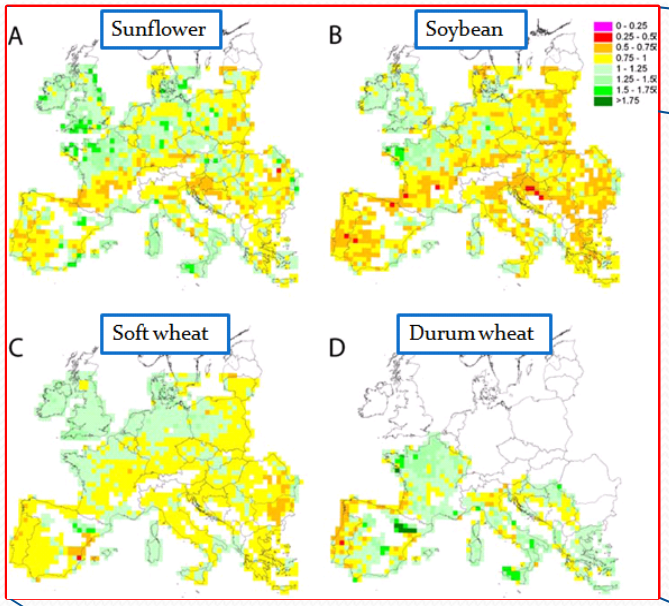
Without adaptation

With adaptation



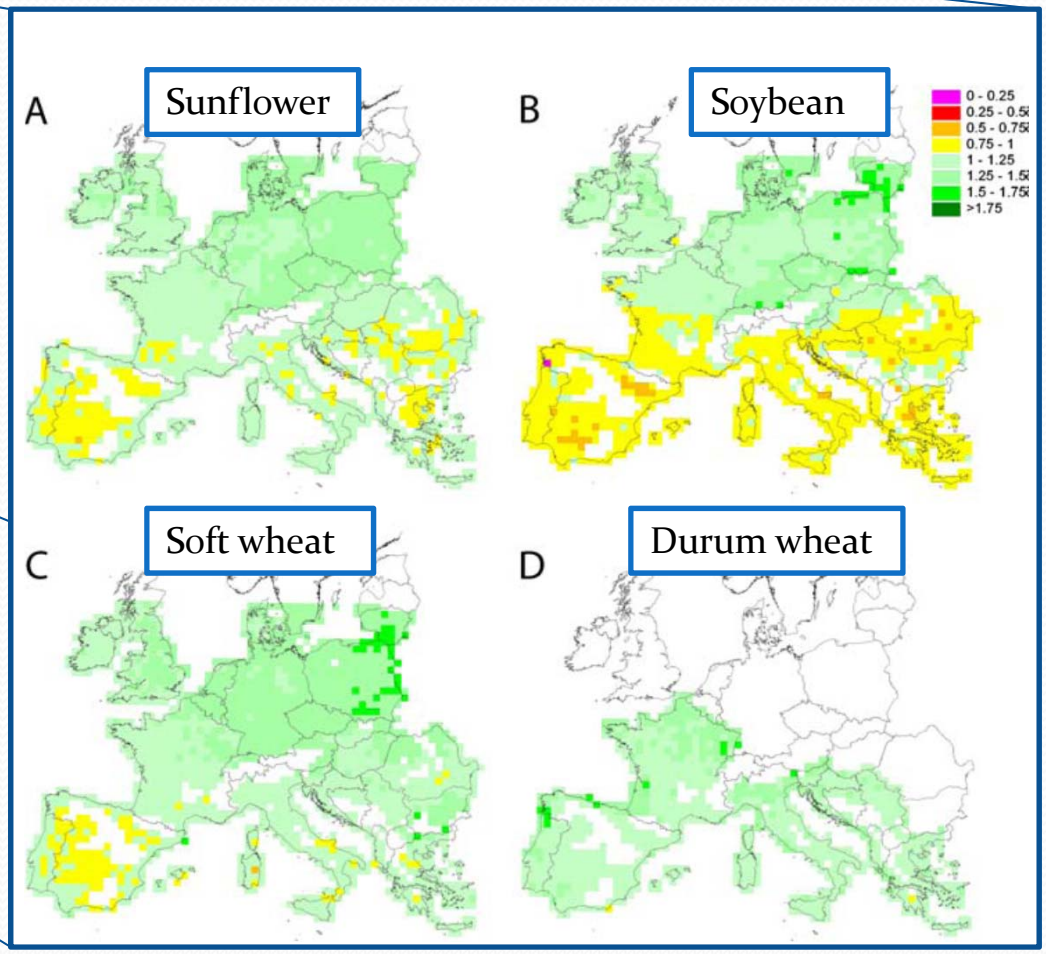
Scenario + 2°C Moriondo et al., 2010

Adaptation strategies: cultivar with longer circle



Without adaptation

With adaptation



Scenario + 2°C Moriondo et al., 2010

Agriculture mitigation to climate change: reductions, requirements, achievements

Reductions:

- Methane from livestock, manure management and paddy rice
- Nitrous oxides from manure and nitrogen fertiliser use
- Carbon dioxide from cultivation of new land and peatlands
- Carbon dioxide from fossil fuel use

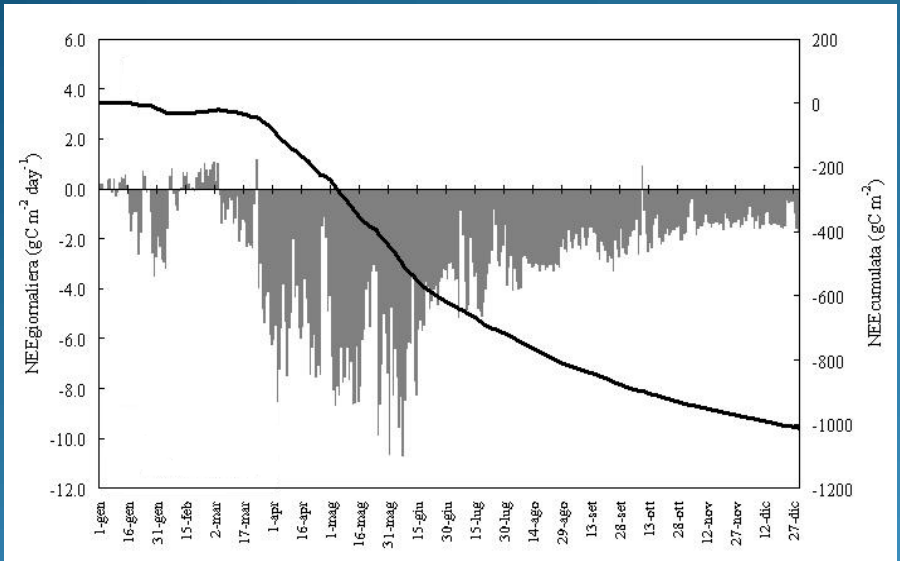
Requirements:

- Increasing efficiencies in the food production chain
- Implementation of new technologies and management
- Prudent production of biofuels (perennial crops, wastes)
- Abandoning certain practices (e.g. cultivation of peatlands)
- Combination of many measures to achieve sufficient effect

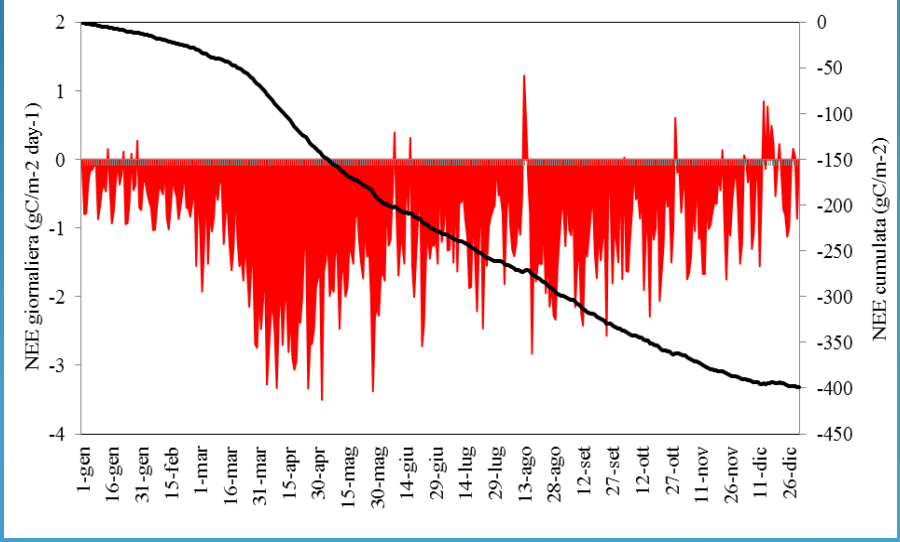
Achievements:

- Directing research, advice and innovation towards these issues
- Focusing existing and new incentive schemes on GHG emissions (financial support, taxation, codes of practice)

Agriculture mitigation to climate change: contribution of agro-ecosytems

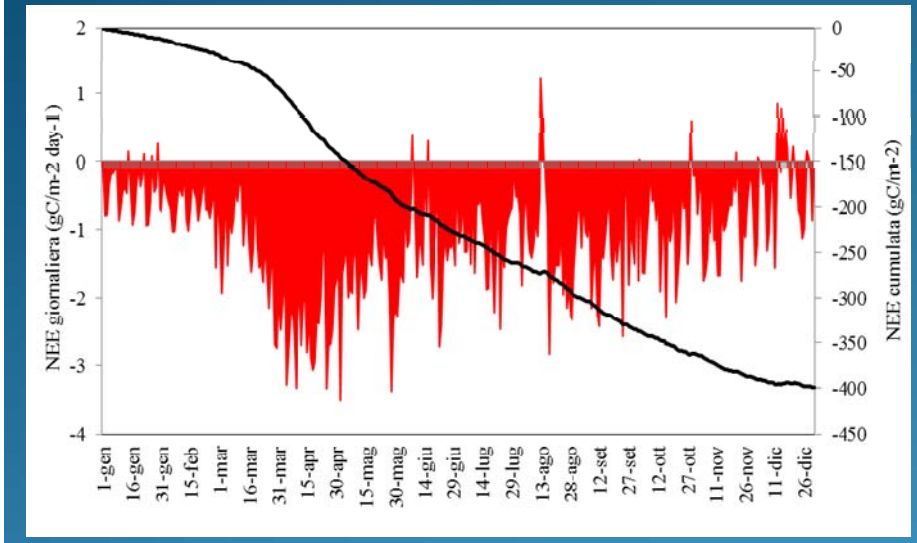


Forestry system
(Matteucci, 2008)

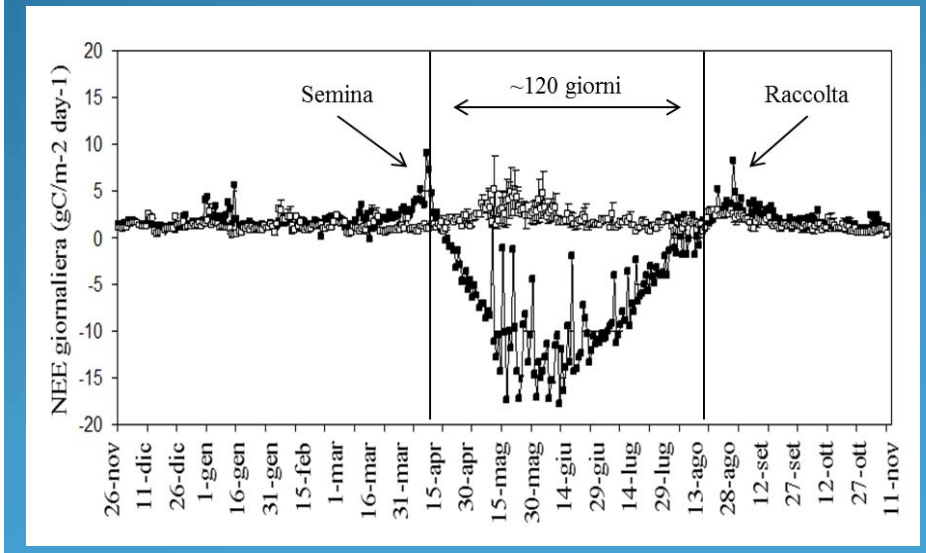


Orchard system
(Brilli et al., 2013)

Agriculture mitigation to climate change: contribution of agro-ecosytems



Orchard system
(Brilli et al., 2013)



Cash crop
(Lugato et al, 2010).

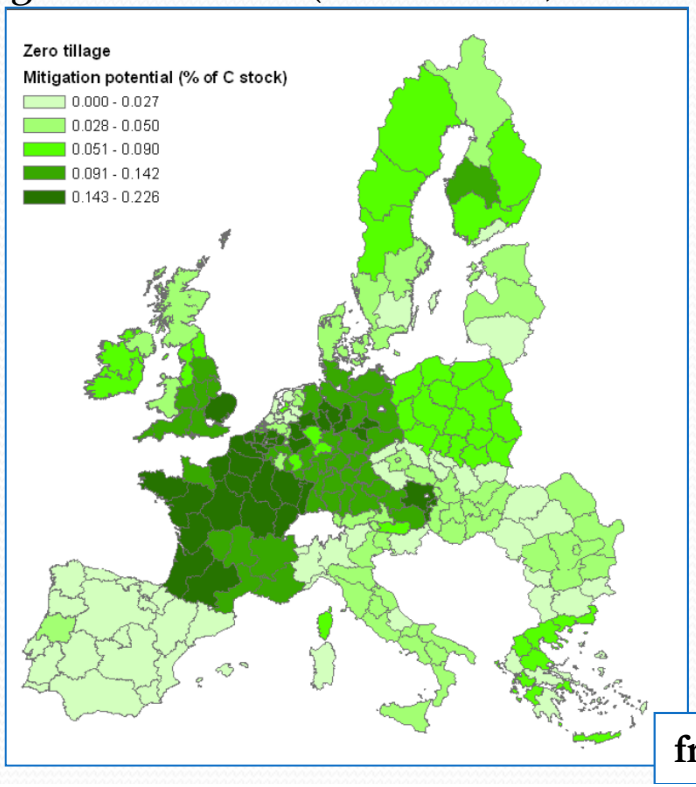
Mitigation strategies: tillage

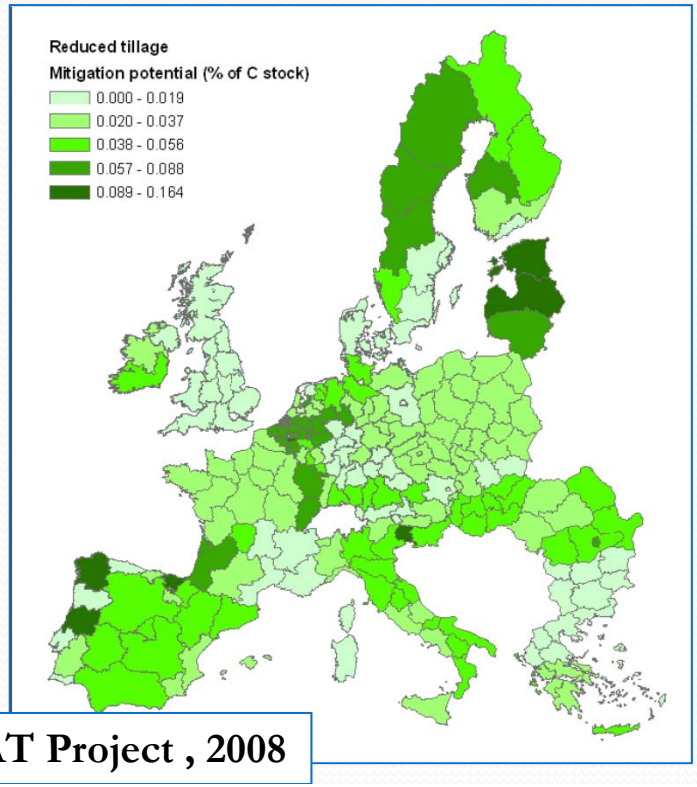
Zero Tillage

- Zero tillage has high mitigation potential for carbon (19.9 Mton CO_2-eq $year^{-1}$) and slightly negative mitigation potential for N2O (-0.50 Mton CO_2-eq $year^{-1}$)
- For the EU27 the current implementation is 2.6% and potential implementation is 16% of all agricultural land (max. France, Germany)

Minimum tillage

- The mitigation potential for carbon is 9.6 Mton CO_2-eq $year^{-1}$ and for N_2O there is no effect
- For the EU27 the current implementation is 13% and potential implementation is 42% of all agricultural land (e.g. min UK, max. Belgium, Baltic Rep.)





from PICCMAT Project , 2008

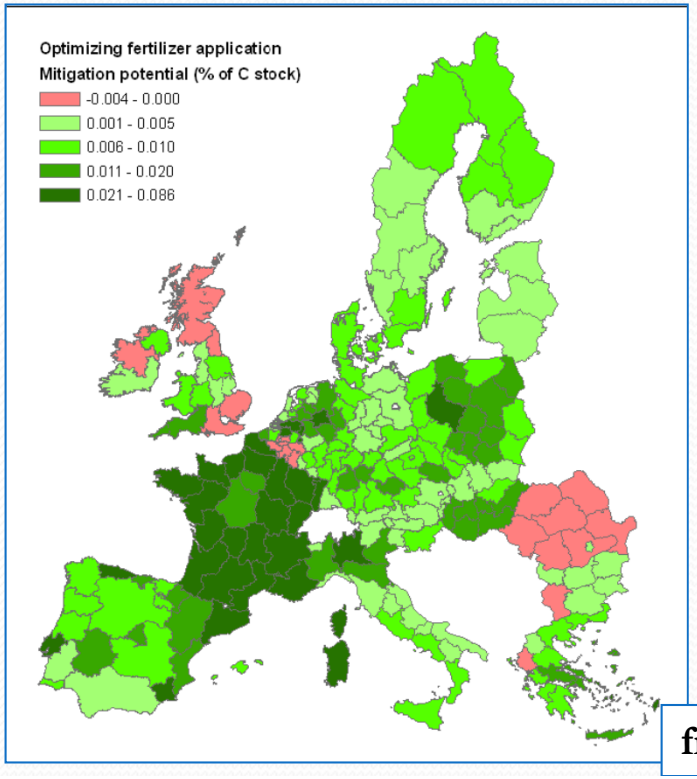
Mitigation strategies: fertilisers

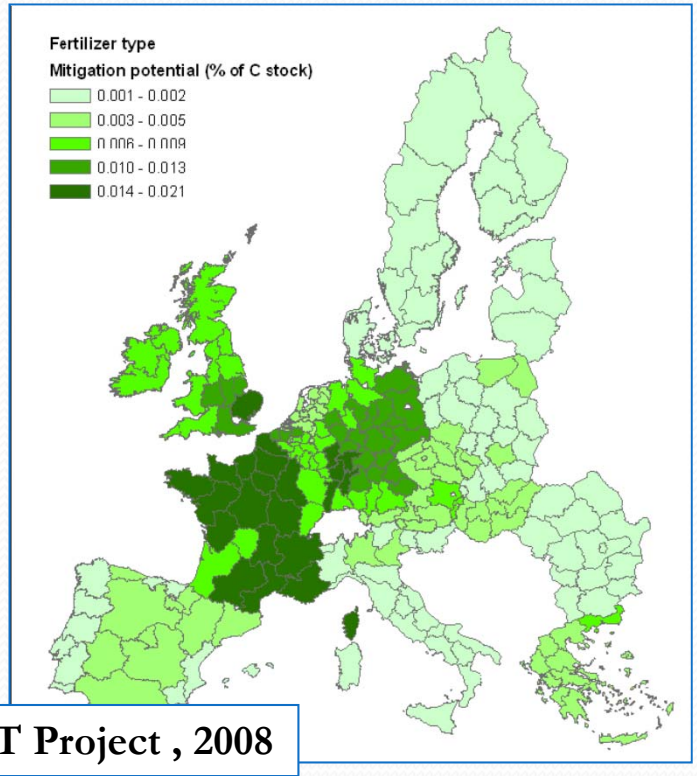
Optimizing fertilizer application

- No effect on carbon and for N2O the mitigation potential is 4.2 Mton CO2-eq year-1
- Good potential implementation (from 54% to 67% of all agricultural land)(e.g. max. France, min. UK, Netherlands and Scandinavian countries where they has been already implemented

Fertilizer type

- No effect on carbon and for N2O the mitigation potential is 2.3 Mton CO2-eq year-1
- Rather good potential implementation (from 29% to 50% of all agricultural land) in the countries with high knowledge of farmers and money to invest (e.g. France, Germany and UK)





from PICCMAT Project , 2008

Adaptation and mitigation options: Interactions

- Mitigation generally concerns enhanced carbon storage and more efficient nitrogen use
- Many adaptation options deal with improved water and nitrogen use, enhanced diversity and resilience to variability
- Improved carbon management will lead to better preservation of soils that assist adaptation (resilience)
- Improved residue management and cover crops will preserve soils against erosion and nutrient losses
- More diverse cropping systems often enhances carbon storage and adds diversity that improves resilience
- There are also antagonistic effects, e.g. cover crops increases the use of water

Mitigation and adaptation: inter-linkages

- **Most categories of mitigation options have positive impacts on adaptation**:
  - **Catch crops** ➔ soil erosion and nutrient losses
  - **Reduced tillage** ➔ soil erosion and soil water conservation
  - **Rotation species** ➔ soil erosion, nutrient losses, genetic diversity
  - **Agroforestry** ➔ soil erosion, nutrient losses and microclimate modification
- **Quantitative inter-linkages are not very well explored**

	Adaptation measure	Soil erosion control	Nutrient loss reduction	Soil water conservation	Genetic	Microclimate modification	Land use change
Mitigation measure							
Catch crops etc		+	+	–			
Reduced tillage		+		+			
Residue management		+		+		–	
Extensification							+
Fertiliser application			+				
Fertiliser type			+				
Rotation species		+	+		+		
Adding legumes		+	+		+		
Permanent crops		+	+	–	+		
Agroforestry		+	+			+	
Grass in orchards, vineyards		+	+	–		–	
Optimising grazing intensity				+			
Length and timing of grazing		+					
Grassland renovation					+		
Application to crops vs grassl				+			
Peatland management							+

from PICCMAT Project , 2008

Future agricultural production systems based on: promotion of adaptation and mitigation and supplying of biomass

- **More permanent crop cover and less intensive soil tillage**
- **Perennial crops to sequester carbon and reduce N2O emissions**
- **Technologies in livestock production to reduce emissions:**
  - Improved feeding practices – better tailored feed crops
  - Manure management technologies – low emissions and high use efficiency
- **Combine bioenergy, feed (food) and biomaterial production:**
  - Highly productive vegetative (perennial) crops
  - Biomass is treated in biorefineries to produce energy, feed and materials
  - Highly efficient nutrient use during production and processing
- **Diversity to improve resilience and increase carbon capture**
- **Cropping systems with improved water use efficiency**
- **Renewed focus on agricultural research, innovation, education, advice and demonstration**