



4<sup>th</sup> workshop of the 4F CROPS Project  
FUTURE CROPS FOR FOOD, FEED, FIBRE AND FUEL



## Cropping possibilities of non-food crops in EU-Agriculture

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*Towards a successful insertion of the non-food crops in the EU-27 agriculture*

*Lyon, May 4<sup>th</sup> 2010*

# Choice of the non food crops

- Ecology
  - Area of origin
  - Temperature requirements
  - Water requirements
  - Photoperiodic response
  - Nutrients requirements
  - Soil requirements
- Biology
  - Phenology and growing season
  - Growing habit (annual, perennial)
- Crop Physiology
  - Radiation use efficiency
  - Water use efficiency
  - Nutrients use efficiency
- Agronomy
  - Years of cultivation
  - Breeding activity
  - Role in crop rotation
  - Propagation material
  - Abiotic and biotic resistance
  - Mechanisation (sowing, harvest, etc.)



# Some non food crops in temperate climate

## Traditional food and feed crops

Rapeseed  
Maize  
Sunflower (high oleic)  
Hemp  
Flax  
Reed Canary grass  
Switchgrass  
Safflower

## New crops (never or rarely cultivated with high possibility of improvement)

*Miscanthus x giganteus* Greef and Deu  
*Arundo donax* L  
Cardoon (*Cynara cardunculus* L.)  
*Brassica carinata* A. Braun  
Sweet and fiber sorghum  
SRC (poplar, willow, eucalyptus)

## New species

Castor bean (*Ricinus communis* L)  
*Saccharum spontaneum* L

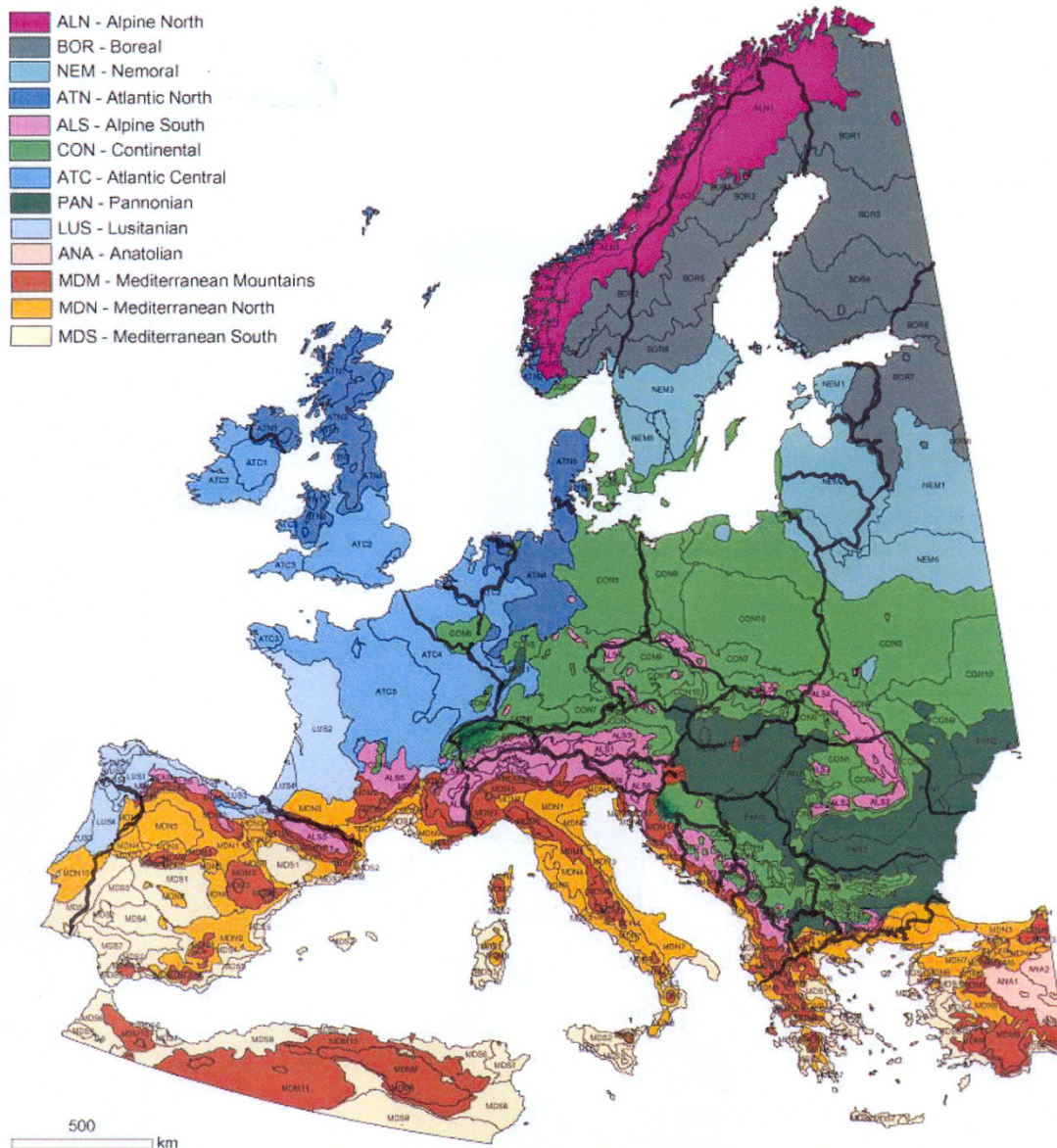


# Environmental stratification of Europe

Environmental Stratification of Europe

**Environmental Zone**

- ALN - Alpine North
- BOR - Boreal
- NEM - Nemoral
- ATN - Atlantic North
- ALS - Alpine South
- CON - Continental
- ATC - Atlantic Central
- PAN - Pannonian
- LUS - Lusitanian
- ANA - Anatolian
- MDM - Mediterranean Mountains
- MDN - Mediterranean North
- MDS - Mediterranean South



# Climatic zones



Environmental zone	Temperature		Rainfall		Months
	Min	Max	Oct-Apr	May-Sept	< 0°C
<b>Nemoral</b>	2.4	9.3	309.8	310.8	4.6
<b>Continental</b>	4.2	13.1	380.9	393.4	4.1
<b>Atlantic North</b>	4.5	11.2	760.7	437.9	1.9
<b>Atlantic Central</b>	6.2	13.6	563.5	349.4	0.2
<b>Lusitanian</b>	8.4	17.4	851.5	321.7	0.0
<b>Mediterranean North</b>	8.2	18.1	477.8	218.1	0.4
<b>Mediterranean South</b>	11.2	21.1	470.1	114.4	0.0



# possible non food crops according to climatic zones

MAIN PRODUCT	CLIMATIC AREA						
	Nemoral	Continental	Atlantic Central	Atlantic North	Lusitanian	Med North	Med South
<b>Oil</b>	<b>Rapeseed</b> ( <i>Brassica napus</i> L. var. <i>oleifera</i> D.C.)	<b>Rapeseed</b> ( <i>Brassica napus</i> L. var. <i>oleifera</i> D.C.)	<b>Rapeseed</b> ( <i>Brassica napus</i> L. var. <i>oleifera</i> D.C.)	<b>Rapeseed</b> ( <i>Brassica napus</i> L. var. <i>oleifera</i> D.C.)	<b>Rapeseed</b> ( <i>Brassica napus</i> L. var. <i>oleifera</i> D.C.)	<b>Sunflower</b> ( <i>Helianthus annuus</i> L.)	<b>Ethiopian mustard</b> ( <i>Brassica carinata</i> A. Braun)
<b>Fiber</b>	<b>Flax</b> ( <i>Linum usitatissimum</i> L.)	<b>Flax</b> ( <i>Linum usitatissimum</i> L.)	<b>Flax</b> ( <i>Linum usitatissimum</i> L.)	<b>Hemp</b> ( <i>Cannabis sativa</i> L.)	<b>Hemp</b> ( <i>Cannabis sativa</i> L.)	<b>Hemp</b> ( <i>Cannabis sativa</i> L.)	<b>Flax</b> ( <i>Linum usitatissimum</i> L.)
<b>SRF</b>	<b>Poplar</b> ( <i>Populus</i> spp.)	<b>Willow</b> ( <i>Salix humilis</i> Marsh.)	<b>Poplar</b> ( <i>Populus</i> spp.)	<b>Willow</b> ( <i>Salix humilis</i> Marsh.)	<b>Willow</b> ( <i>Salix humilis</i> Marsh.) <b>Eucalyptus</b> ( <i>Eucalyptus</i> spp.)	<b>Poplar</b> ( <i>Populus</i> spp.)	<b>Eucalyptus</b> ( <i>Eucalyptus</i> spp.)
<b>Lignocellulosic</b>	<b>Reed canary grass</b> ( <i>Phalaris arundinacea</i> L.)	<b>Miscanthus</b> ( <i>Miscanthus x giganteus</i> Greef. et Deu.)	<b>Miscanthus</b> ( <i>Miscanthus x giganteus</i> Greef. et Deu. Switchgrass ( <i>Panicum virgatum</i> L.)		<b>Miscanthus</b> ( <i>Miscanthus x giganteus</i> Greef. et Deu.)	<b>Giant reed</b> ( <i>Arundo donax</i> L.)	<b>Cardoon</b> ( <i>Cynara cardunculus</i> L. var. <i>altilis</i> )
<b>Sugar</b>	-	<b>Sugar beet</b> ( <i>Beta vulgaris</i> L.)	<b>Sugar beet</b> ( <i>Beta vulgaris</i> L.)	-	<b>Sweet Sorghum</b> ( <i>Sorghum bicolor</i> L. Moench)	<b>Sweet Sorghum</b> ( <i>Sorghum bicolor</i> L. Moench)	<b>Sweet Sorghum</b> ( <i>Sorghum bicolor</i> L. Moench)

# Cropping systems

Factors taken into account:

- Environment (temperature, precipitation, etc.)
- Role of the crop in the rotation
- Avoidance of mono-cropping
- Perennials and annual crops

We considered 4 scenarios deriving from:

- Type of soil (marginal or agricultural soil)
- Input (conventional or reduction)

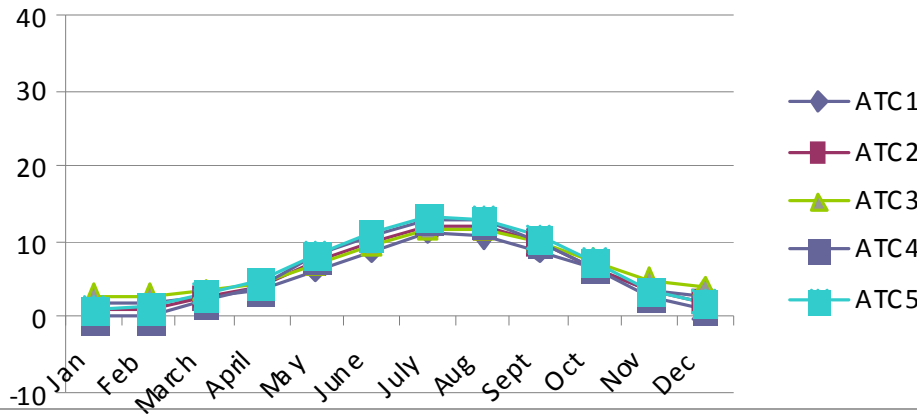
**Marginal land**: land that for one or more constraints (slope, stones, nature of soil, salt concentration, pH, depth, drought, etc.) is not fertile



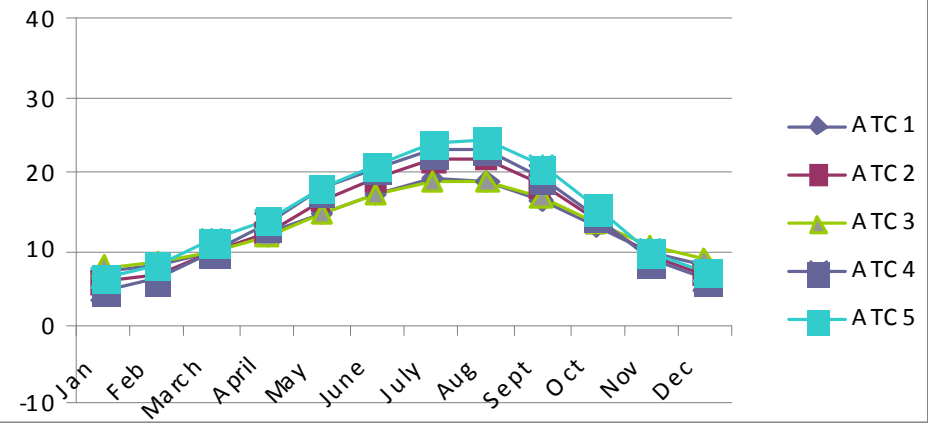


# Atlantic Central Cropping system

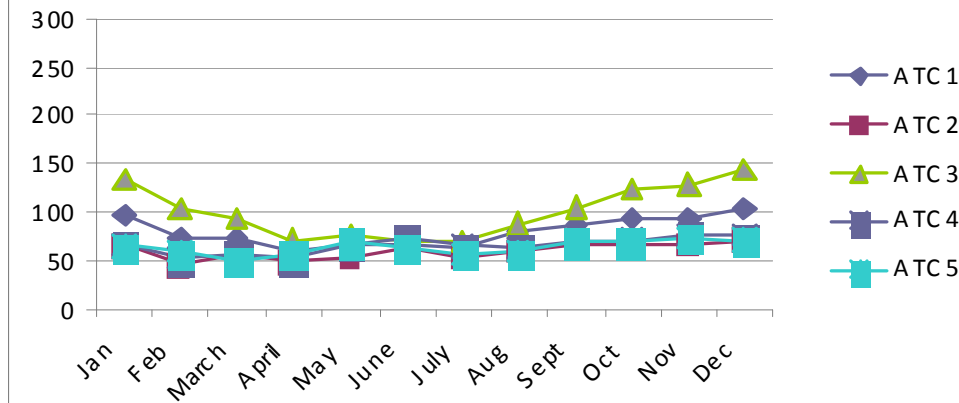
## Minimum Temperature (°C)



## T max (°C) Atlantic central



## Rainfalls (mm) Atlantic central



# Atlantic Central Cropping system

- Poliennial:

- Miscanthus

- Poplar

- Willow

- Switchgrass

- Annual crop rotation:

- Sugar beet-Wheat-Pea

- Rapeseed-Wheat-Pea-Rapeseed

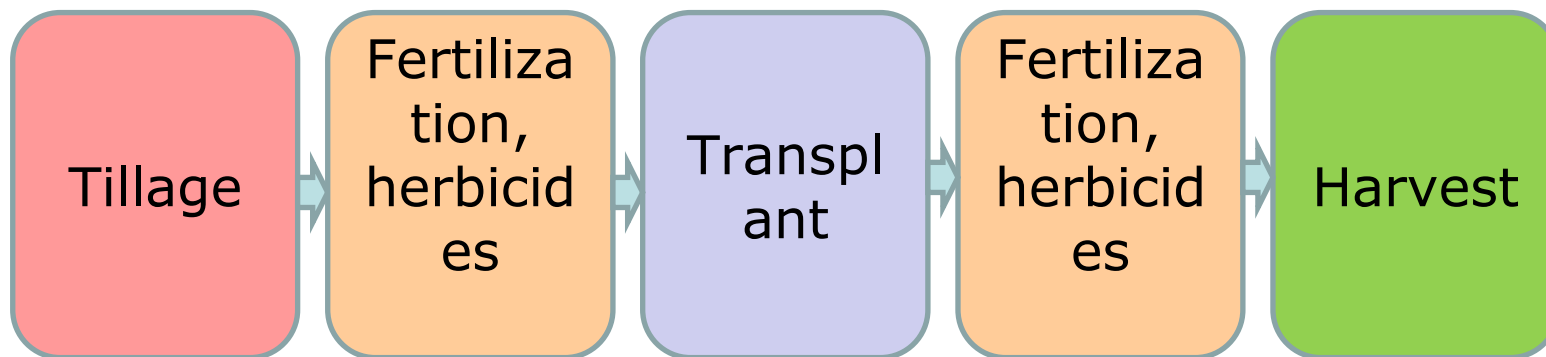
- Flax-Wheat-Pea

- Rapeseed-Flax-Red clover

# Atlantic Central Cropping system

## Poplar

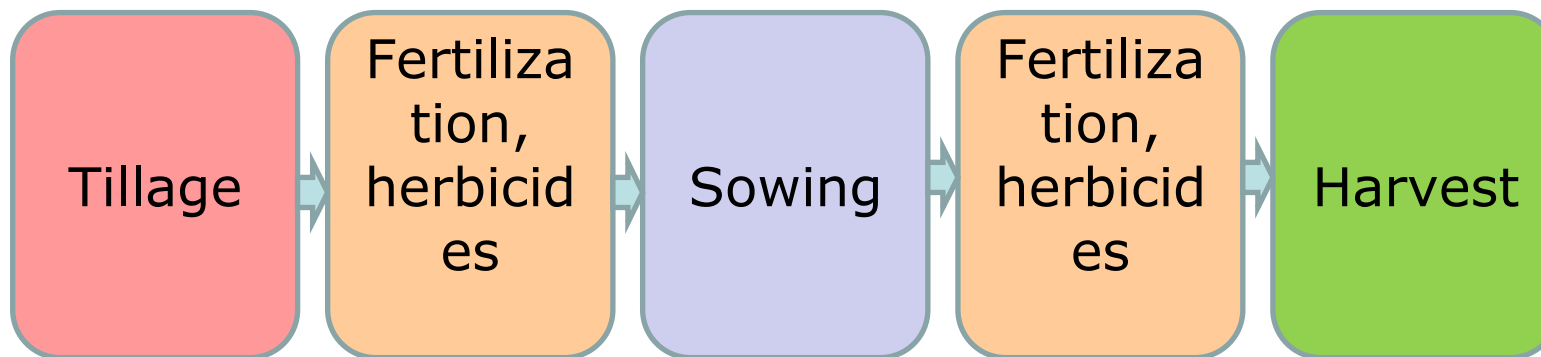
I			II-III						III-IV						V																				
1 <sup>st</sup> year						2-3 <sup>rd</sup> year						5 <sup>th</sup> year																							
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Atlantic Central Cropping system

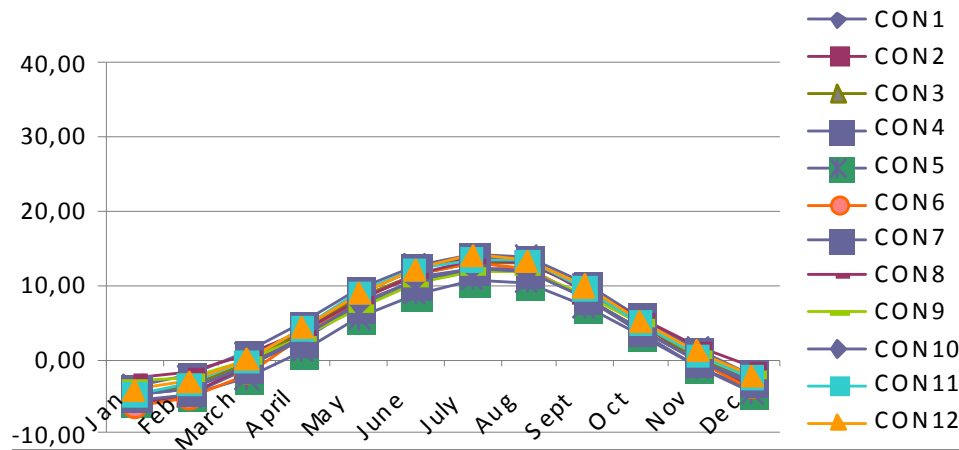
## Sugarbeet-Barley-Pea

I						II						III																	
Sugarbeet						Barley						Pea																	
M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A

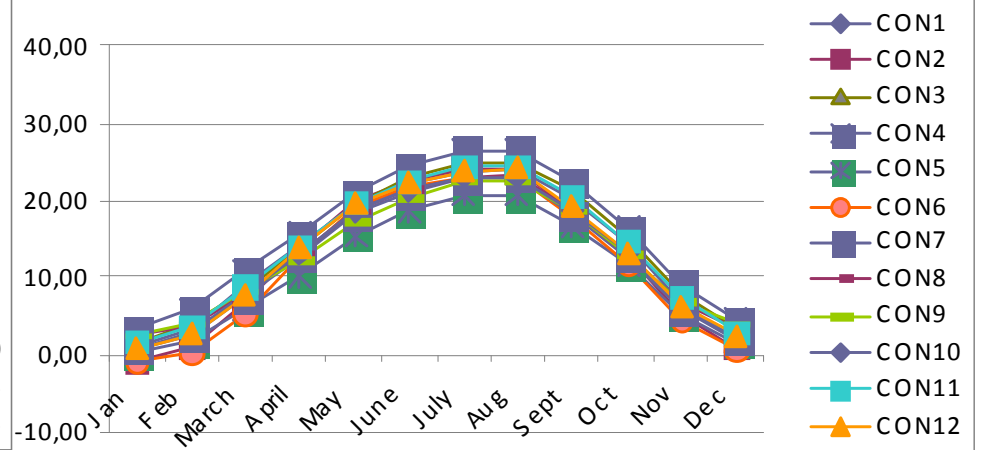


# Continental Cropping system

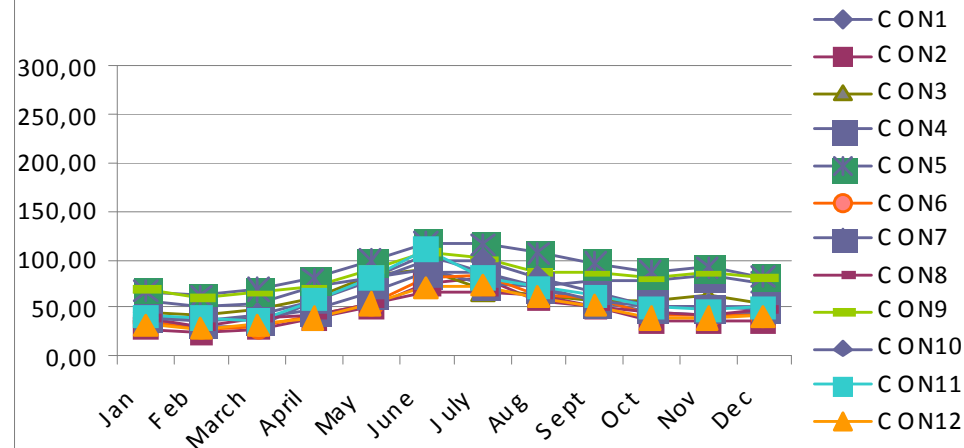
## Minimum Temperature (°C)



## Maximum Temperature (°C)



## Rainfalls (mm)



# Continental Cropping system

- Poliennial:

- Willow

- Poplar

- Miscanthus

- Annual crop rotation:

- Wheat-Maize-Sunflower-Sorghum-Red clover

- Pea-Maize-Sunflower-Sorghum- Red clover

- Flax-Wheat-Pea

- Maize-Sugar beet-Sorghum

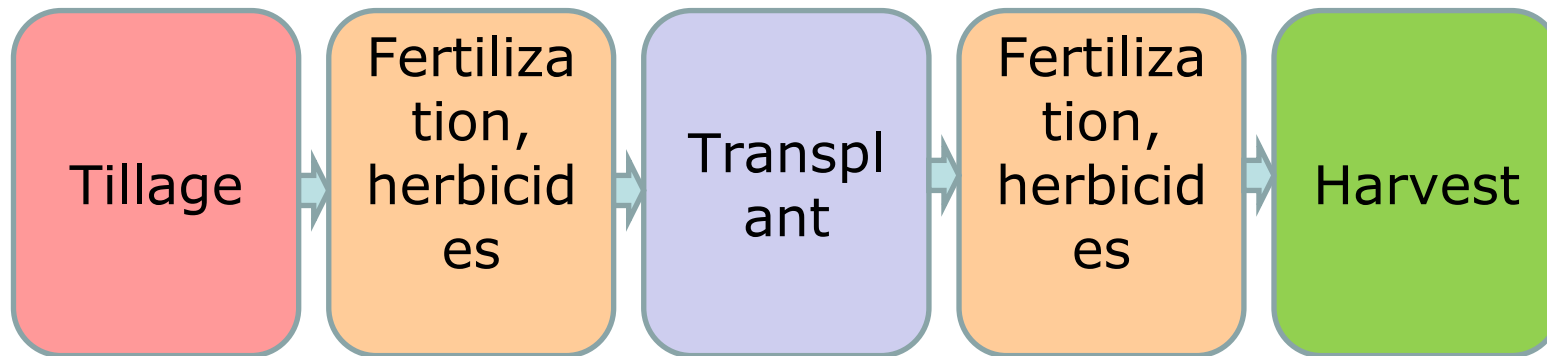
- Rapeseed- Flax- Sunflower

- Red clover-Rapeseed-Wheat-Flax

# Continental Cropping system

## Willow

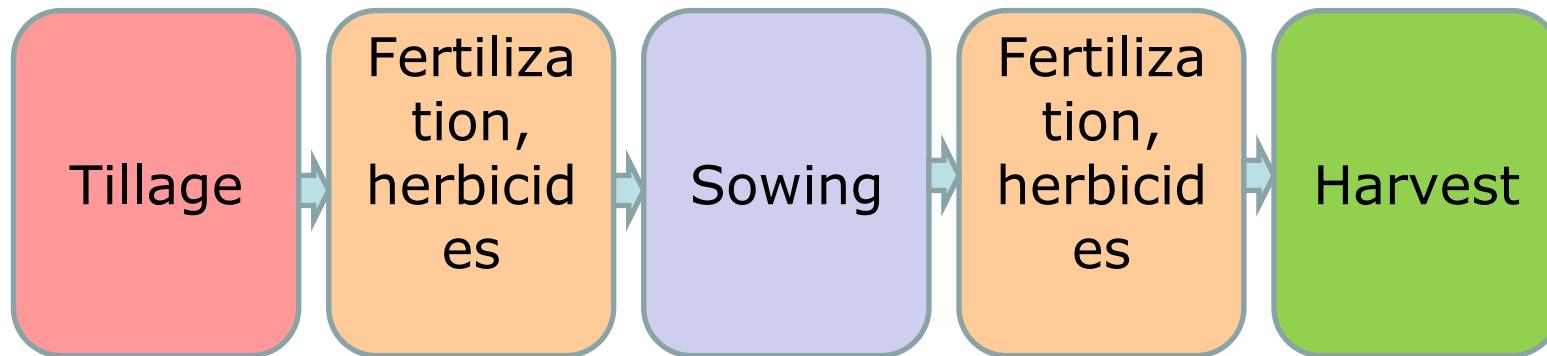
I			II-III						III-IV						V								
1 <sup>st</sup> year						2-3 <sup>rd</sup> year						5 <sup>th</sup> year											
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Continental Cropping system

## Rapeseed- Flax- Sunflower

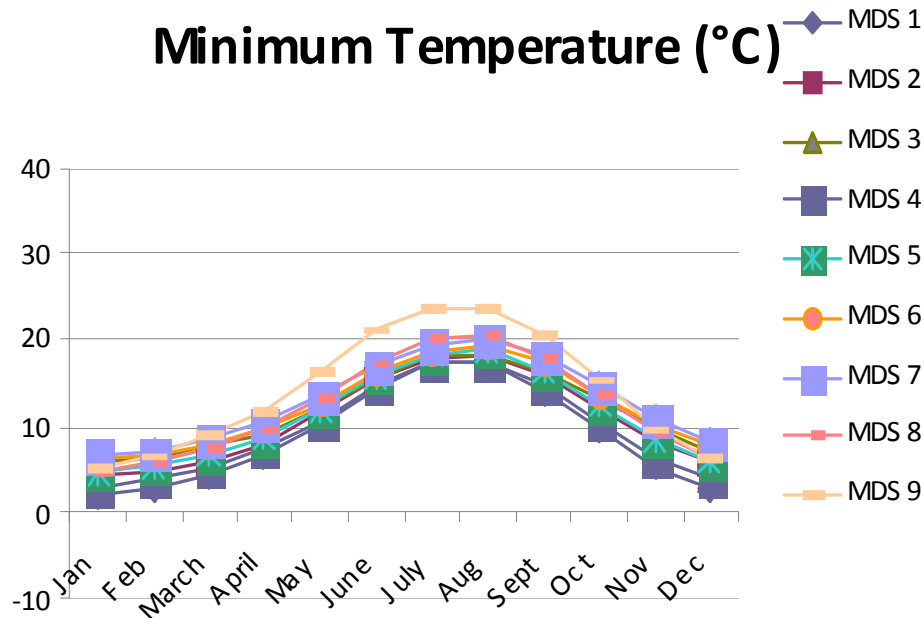
I										II										III										
Rapeseed										Flax										Sunflower										
F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



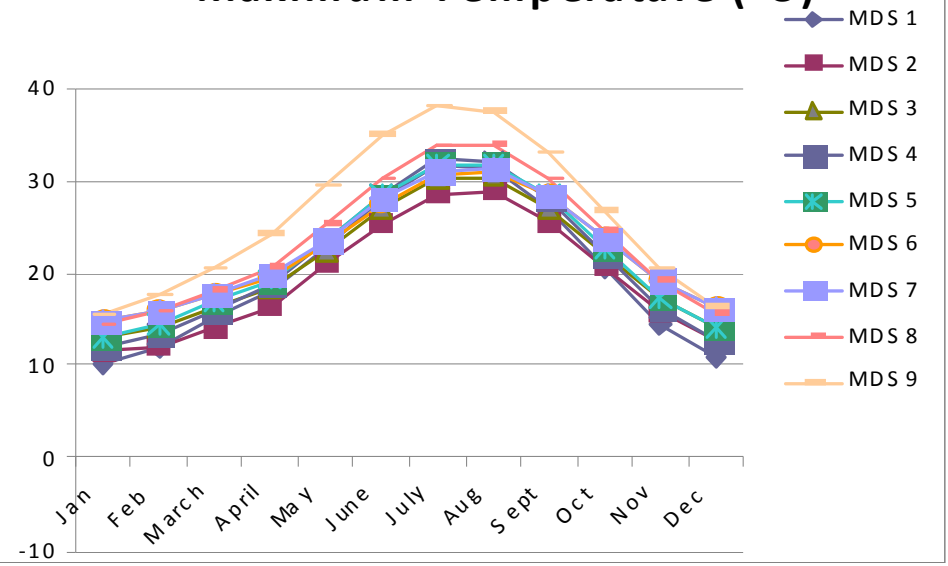


# Mediterranean South Cropping system

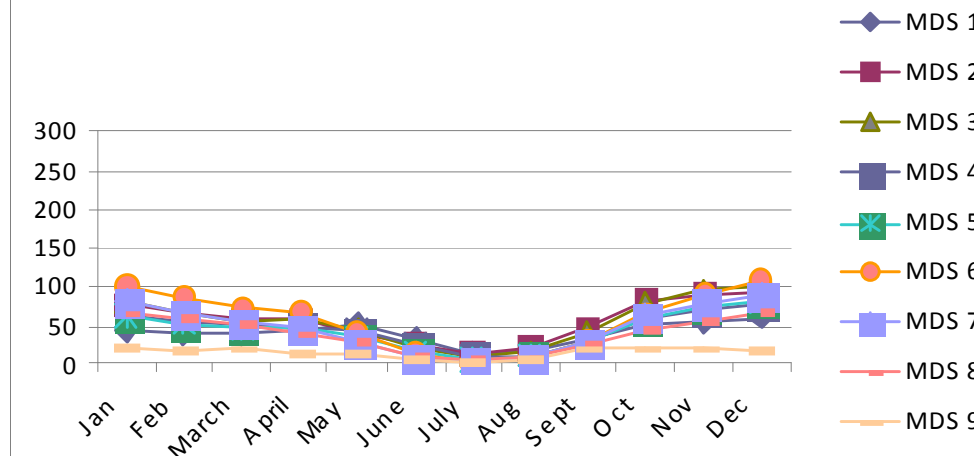
## Minimum Temperature (°C)



## Maximum Temperature (°C)



## Rainfalls (mm)



# Mediterranean South Cropping system

- Perennial:

- Giant reed
- Cardoon
- Eucalyptus

- Annual crop rotation:

- Ethiopian mustard-Wheat-Legume<sup>a</sup>- Sweet sorghum
- Faba bean-Cereal<sup>b</sup> -Brassica<sup>c</sup> -Sweet sorghum
- Flax-Wheat- Legume<sup>a</sup>

<sup>a</sup> (Faba bean, Chick pea, Sweet vetch)

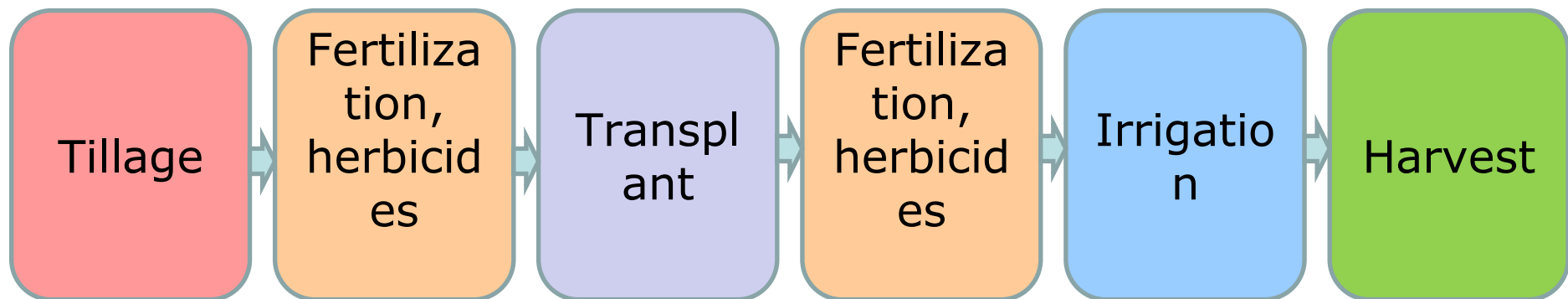
<sup>b</sup> (Barley, Wheat)

<sup>c</sup> (Ethiopian mustard, Rapeseed)

# Mediterranean South Cropping system

## Giant reed

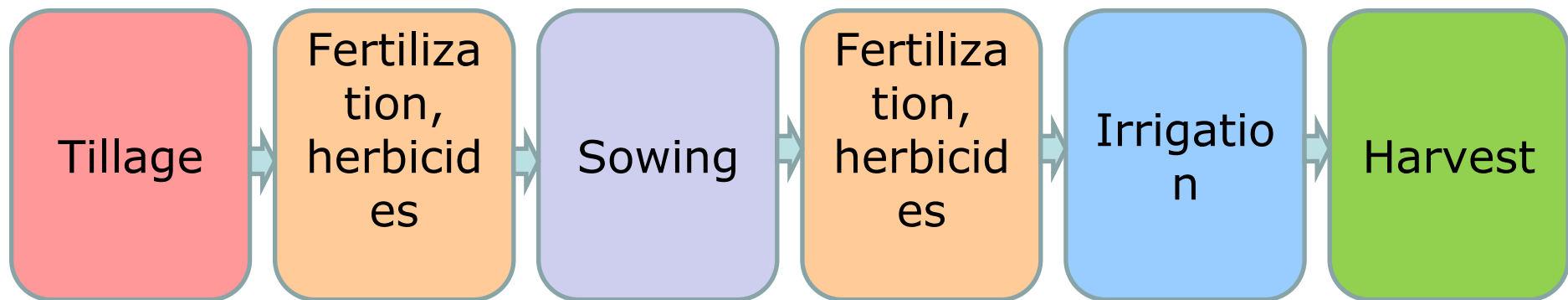
I			II						III						IV								
1 <sup>st</sup> year									2 <sup>nd</sup> year						3 <sup>rd</sup> year								
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Mediterranean South Cropping system

Ethiopian mustard-Wheat-Faba bean-Sweet sorghum

I				II								III								IV																	
Ethiopian mustard				Wheat								Faba bean				Sorghum																					
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O



# Mediterranean North Cropping system

- Poliennial:

- Poplar
- Miscanthus
- Giant reed

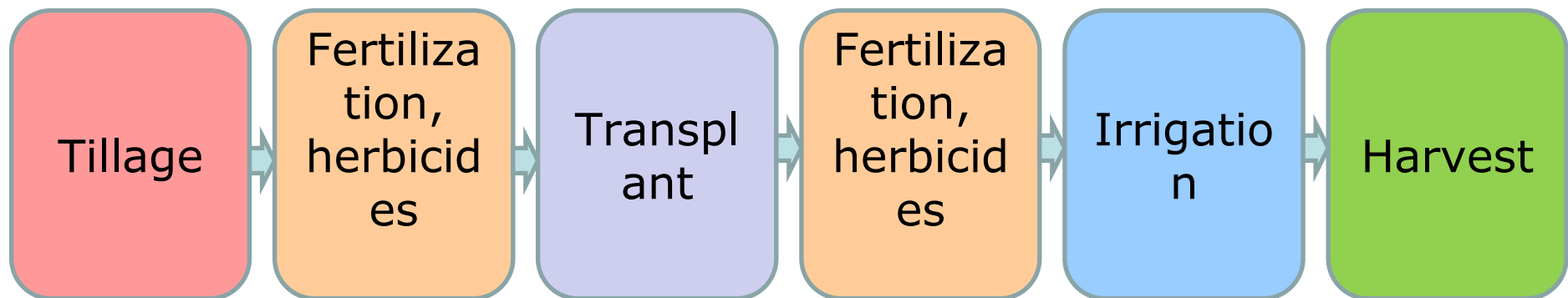
- Annual crop rotation:

- Wheat-Maize-Sunflower-Sorghum-fallow
- Pea-Maize-Sunflower-Sorghum-fallow
- Flax-Wheat-Pea
- Maize-Sugar beet-Sorghum
- Soybean-Ethiopian mustard-Sunflower
- Rapeseed-Flax-Safflower
- Sorghum-Soybean-Wheat-Kenaf

# Mediterranean North Cropping system

## Miscanthus

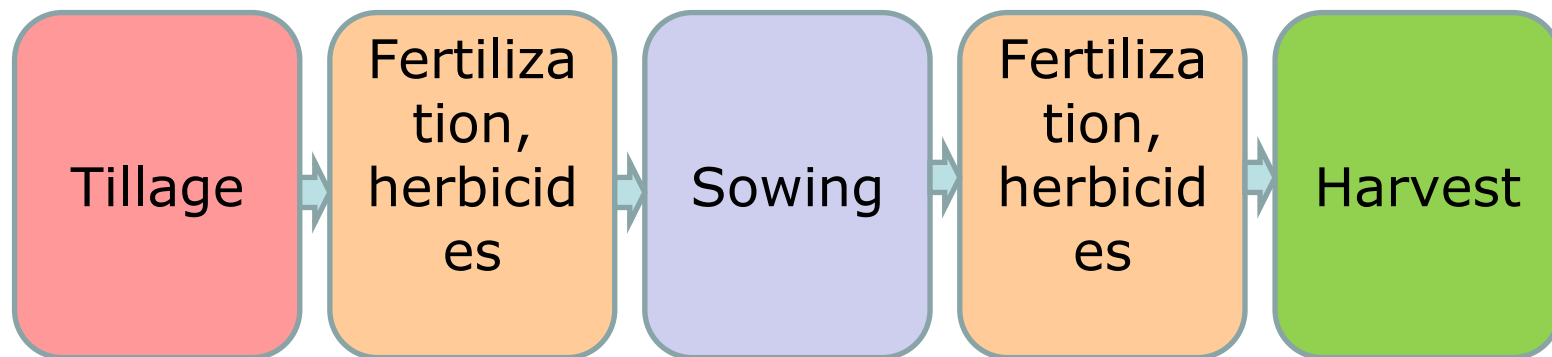
I			II						III						IV								
1 <sup>st</sup> year									2 <sup>nd</sup> year						3 <sup>rd</sup> year								
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Mediterranean North Cropping system

## Flax-Wheat-Pea

I							II							III													
Flax							Wheat							Pea													
F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M



# Continental: Miscanthus

Yr	Continental		Cropping system 3: Miscanthus			
			Marginal land		Agricultural land	
			High input	Low input	High input	Low input
Miscanthus I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-40 cm 2.95 883.32	0-20 cm 2.1 883.32	0-40 cm 2.3 883.32	0-20 cm 1.6 883.32
Miscanthus I	<u>Sowing (transplant)</u>	Season: Amount: Planter h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 10000 rhiz. ha <sup>-1</sup> 2.9 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.9 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.2 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.2 380.73
Miscanthus I	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 80-40-40-40 1.0 218.99 1.2 0.5 218.99	Sowing 50-20-20-20 0.8 218.99 1.2 0.5 218.99	Sowing 70-30-30-30 0.8 218.99 1.2 0.3 218.99	Sowing 40-15-15-15 0.6 218.99 1.2 0.3 218.99
Miscanthus I	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 9.0 40	Spring 1.1 825.55 7.5 40	Spring 1.0 825.55 12.9 40	Spring 0.8 825.55 9.0 40
Miscanthus II	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 50-0-0-0 0.9 218.99		Top dressing 50-0-0-0 0.7 218.99	
Miscanthus II	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 24.0 40	Spring 1.1 825.55 20.0 40	Spring 1.0 825.55 34.6 40	Spring 0.8 825.55 24.0 40
Miscanthus III	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 50-0-0-0 0.9 218.99		Top dressing 50-0-0-0 0.7 218.99	
Miscanthus III	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 30.0 40	Spring 1.1 825.55 25.0 40	Spring 1.0 825.55 43.3 40	Spring 0.8 825.55 30.0 40



# Continental: Maize – Sugar beet – Sorghum

Yr	Continental					Cropping system 6: Maize-Sugar beet-Sorghum				
						Marginal land		Agricultural land		
						High input	Low input	High input	Low input	
Maize I	Tillage	Plough and disk harrow:			30-40 cm	0-20 cm	30-40 cm	0-20 cm		
		h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			2.9 883.32	2.1 883.32	2.2 883.32	1.6 883.32		
Maize I	Sowing	Season:			Spring	Spring	Spring	Spring		
		Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			25 kg ha <sup>-1</sup> 0.4 380.73	25 kg ha <sup>-1</sup> 0.4 380.73	25 kg ha <sup>-1</sup> 0.2 380.73	25 kg ha <sup>-1</sup> 0.2 380.73		
Maize I	Crop practices				Sow.+Top dress.	Sow.+Top dress.	Sow.+Top dress.	Sow.+Top dress.		
	Fertilization:				200-100-80-0	100-50-40-0	200-100-80-0	100-50-40-0		
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :				1.1	1.0	0.9	0.7		
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				202.19	202.19	202.19	202.19		
	Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				2	2	2	2		
	Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				0	0	0	0		
Maize I	Harvest	Season:			Autumn	Autumn	Autumn	Autumn		
		Maize chopper h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			1.0 825.55	0.9 825.55	0.8 825.55	0.6 825.55		
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):			4.1	2.5	7.3	4.3		
		Water content (%):			14	14	14	14		
		Tillage				40-50 cm	20-25 cm	40-50 cm	20-25 cm	
		h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				3.8 883.32	2.1 883.32	2.9 883.32	1.6 883.32	
Sugar beet II	Sowing	Season:			Spring	Spring	Spring	Spring		
		Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			1 kg ha <sup>-1</sup> 0.4 380.73	1 kg ha <sup>-1</sup> 0.4 380.73	1 kg ha <sup>-1</sup> 0.2 380.73	1 kg ha <sup>-1</sup> 0.2 380.73		
Sugar beet II	Crop practices				Sowing	Sowing	Sowing	Sowing		
	Fertilization:				140-180-200-40	60-100-100-25	140-180-200-40	60-100-100-25		
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :				1.1	1.0	0.9	0.7		
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				202.19	202.19	202.19	202.19		
	Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				3	3	3	3		
	Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				0.5	0.5	0.3	0.3		
Sugar beet II	Harvest	Season:			Summer	Summer	Summer	Summer		
		Beet harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			1.5 883.32	1.3 883.32	1.5 883.32	1.2 883.32		
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):			78	66	90	78		
		Water content (%):			75	75	75	75		
		Tillage				0-25 cm	No tillage	0-25 cm	No tillage	
		h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				2.1 883.32		1.6 883.32		
Sorghum III	Sowing	Season:			Spring	Spring	Spring	Spring		
		Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			10 kg ha <sup>-1</sup> 0.4 380.73	10 kg ha <sup>-1</sup> 0.5 380.73	10 kg ha <sup>-1</sup> 0.2 380.73	10 kg ha <sup>-1</sup> 0.3 380.73		
Sorghum III	Crop practices				Sow.+Top dress.	Sow.+Top dress.	Sow.+Top dress.	Sow.+Top dress.		
	Fertilization:				100-100-60-0	75-75-20-0	100-100-60-0	75-75-20-0		
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :				1.1	1.0	0.9	0.7		
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				202.19	202.19	202.19	202.19		
	Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				1.8	1.8	1.8	1.8		
	Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):				0	0	0	0		
Sorghum III	Harvest	Season:			Autumn	Autumn	Autumn	Autumn		
		Maize chopper h ha <sup>-1</sup> : MJ h <sup>-1</sup> :			1.0 825.55	0.9 825.55	0.8 825.55	0.6 825.55		
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):			83	53	100	83		
		Water content (%):			70	70	70	70		
		Tillage				0-25 cm	No tillage	0-25 cm	No tillage	
		h ha <sup>-1</sup> : MJ h <sup>-1</sup> :				2.1 883.32		1.6 883.32		

# Atlantic Central: Switchgrass

Yr	Atlantic Central		Cropping system 4: Switchgrass			
			Marginal land		Agricultural land	
			High input	Low input	High input	Low input
Switch grass I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	30-40 cm 2.9 883.32	0-20 cm 2.1 883.32	30-40 cm 2.2 883.32	0-20 cm 1.6 883.32
Switch grass I	<u>Sowing</u>	Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 11 kg ha <sup>-1</sup> 0.4 380.73	Spring 11 kg ha <sup>-1</sup> 0.4 380.73	Spring 11 kg ha <sup>-1</sup> 0.2 380.73	Spring 11 kg ha <sup>-1</sup> 0.2 380.73
Switch grass I	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 70-120-120-0 1.1 218.99 1.2 0.5 218.99	Sow.+Top dress. 35-60-60-0 1.0 218.99 1.2 0.5 218.99	Sow.+Top dress. 70-120-120-0 0.9 218.99 1.2 0.3 218.99	Sow.+Top dress. 35-60-60-0 0.7 218.99 1.2 0.3 218.99
Switch grass I	<u>Harvest</u>	Season: Maize chopper h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Autumn 1.2 825.55 7.0 15	Autumn 1.1 825.55 4.7 15	Autumn 1.0 825.55 9.0 15	Autumn 0.8 825.55 7.0 15
Switch grass II	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 30-0-0-0 0.9 218.99		Top dressing 30-0-0-0 0.7 218.99	
Switch grass II	<u>Harvest</u>	Season: Maize chopper h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Autumn 1.2 825.55 14.0 15	Autumn 1.1 825.55 9.4 15	Autumn 1.0 825.55 17.9 15	Autumn 0.8 825.55 14.1 15
Switch grass III	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 30-0-0-0 0.9 218.99		Top dressing 30-0-0-0 0.7 218.99	
Switch grass III	<u>Harvest</u>	Season: Maize chopper h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Autumn 1.2 825.55 17.6 15	Autumn 1.1 825.55 11.8 15	Autumn 1.0 825.55 22.4 15	Autumn 0.8 825.55 17.6 15

# Atlantic Central: Flax – Cereal – Pea

Atlantic Central		Cropping system 7: Flax-Cereal (wheat)-Pea			
Yr		Marginal land		Agricultural land	
		High input	Low input	High input	Low input
Flax I	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.5 883.32	0-10 cm 2.0 883.32	0-30 cm 1.9 883.32	0-10 cm 1.6 883.32
Flax I	<u>Sowing</u> Season: Seed drill Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 100 kg ha <sup>-1</sup> 0.4 380.73	Spring 100 kg ha <sup>-1</sup> 0.4 380.73	Spring 100 kg ha <sup>-1</sup> 0.2 380.73	Spring 100 kg ha <sup>-1</sup> 0.2 380.73
Flax I	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 100-150-75-0 1.1 202.19 1.5 0.5 202.19	Sow.+Top dress 70-100-50-0 1.0 202.19 1.5 0.5 202.19	Sowing 100-150-75-0 0.9 202.19 1.5 0.3 202.19	Sow.+Top dress 70-100-50-0 0.7 202.19 1.5 0.3 202.19
Flax I	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Late summer/autumn 0.8 825.55 5.4 20	Late summer/autumn 0.7 825.55 4.1 20	Late summer/autumn 0.6 825.55 6.8 20	Late summer/autumn 0.5 825.55 5.7 20
Wheat II	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 2.1 883.32	No tillage	0-25 cm 1.6 883.32	No tillage
Wheat II	<u>Sowing</u> Season: Seed drill Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 230 kg ha <sup>-1</sup> 0.4 380.73	Autumn 250 kg ha <sup>-1</sup> 0.5 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.3 380.73
Wheat II	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 100-140-0-0 1.1 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 50-65-0 1.0 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 100-130-0-0 0.9 202.19 0.27 0 0.3 202.19	Sow.+Top dress. 50-65-0-0 0.7 202.19 0.27 0 0.3 202.19
Wheat II	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 9.9 16.0 6.0 13 3.9 20	Spring/Summer 0.7 825.55 9.4 16.0 5.7 13 3.7 20	Spring/Summer 0.6 825.55 11.6 16.0 7.0 13 4.6 20	Spring/Summer 0.5 825.55 10.4 16.0 6.3 13 4.1 20
Pea III	<u>Tillage</u> Cultivator: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 1.2 323.50	0-15cm 0.8 323.50	0-25 cm 0.9 323.50	0-15 cm 0.7 323.50
Pea III	<u>Sowing</u> Season: Seed drill Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73
Pea III	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 0-100-0-0 0.9 202.19 0.27 0.5 202.19	Sowing 0-70-0-0 0.7 202.19 0.27 0.5 202.19	Sowing 0-100-0-0 0.6 202.19 0.27 0.3 202.19	Sowing 0-70-0-0 0.5 202.19 0.27 0.3 202.19
Pea III	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 7.5 18/24	Spring/Summer 0.7 825.55 4.2 18/24	Spring/Summer 0.6 825.55 9.2 18/24	Spring/Summer 0.5 825.55 7.5 18/24

# Mediterranean North: Miscanthus

Yr	Mediterranean North		Cropping system 2: Miscanthus			
			Marginal land		Agricultural land	
			High input	Low input	High input	Low input
Miscanthus I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-40 cm 2.9 883.32	0-20 cm 2.1 883.32	0-40 cm 2.3 883.32	0-20 cm 1.6 883.32
Miscanthus I	<u>Sowing (transplant)</u>	Season: Amount: Planter h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 10000 rhiz. ha <sup>-1</sup> 2.9 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.9 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.2 380.73	Spring 10000 rhiz. ha <sup>-1</sup> 2.2 380.73
Miscanthus I	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 80-40-40-40 1.0 218.99 1.2 0.5 218.99	Sowing 50-20-20-20 0.8 218.99 1.2 0.5 218.99	Sowing 70-30-30-30 0.8 218.99 1.2 0.3 218.99	Sowing 40-15-15-15 0.6 218.99 1.2 0.3 218.99
Miscanthus I	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 10.5 45	Spring 1.1 825.55 8.7 45	Spring 1.0 825.55 12.9 45	Spring 0.8 825.55 11.1 45
Miscanthus II	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 50-0-0-0 0.9 218.99		Top dressing 50-0-0-0 0.7 218.99	
Miscanthus II	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 28.0 45	Spring 1.1 825.55 23.2 45	Spring 1.0 825.55 34.4 45	Spring 0.8 825.55 29.6 45
Miscanthus III	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 50-0-0-0 0.9 218.99		Top dressing 50-0-0-0 0.7 218.99	
Miscanthus III	<u>Harvest</u>	Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring 1.2 825.55 35.0 45	Spring 1.1 825.55 29.0 45	Spring 1.0 825.55 43.0 45	Spring 0.8 825.55 37.0 45

# Mediterranean North: Soybean- Ethiop.Must.-Sunflower

Yr	Mediterranean North					Cropping system 7: Soybean-Ethiopian mustard-Sunflower				
						Marginal land		Agricultural land		
						High input	Low input	High input	Low input	
Soybean I	<u>Tillage</u>	Plough and disk harrow:				25-40 cm	15-25 cm	25-40 cm	15-25 cm	
		h ha <sup>-1</sup> :	2.9		2.1			2.2	1.6	
		MJ h <sup>-1</sup> :	883.32		883.32			883.32	883.32	
Soybean I	<u>Sowing</u>	Season:				Spring/Summer	Spring/Summer	Spring/Summer	Spring/Summer	
		Amount (kg ha <sup>-1</sup> ):	80		80			80	80	
		h ha <sup>-1</sup> :	0.4		0.4			0.2	0.2	
		Seed drill	h ha <sup>-1</sup> :	380.73	380.73			380.73	380.73	
		MJ h <sup>-1</sup> :								
Soybean I	<u>Crop practices</u>									
		Fertilization:				Sow.+Top dress	Sow.+Top dress	Sow.+Top dress	Sow.+Top dress	
		Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	60-60-70-0		30-30-35-0			60-60-70-0	30-30-35-0	
		Fertilizer distributor	h ha <sup>-1</sup> :	1.1	1.0			0.9	0.7	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
		Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):	0.35		0.35			0.35	0.35	
		Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):								
		Crop sprayer	h ha <sup>-1</sup> :	0.5	0.5			0.3	0.3	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
Soybean I	<u>Harvest</u>	Season:				Autumn	Autumn	Autumn	Autumn	
		Combine harvester:	h ha <sup>-1</sup> :	0.8	0.7			0.6	0.5	
		MJ h <sup>-1</sup> :	825.55		825.55			825.55	825.55	
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):	2.7		2.0			3.5	2.3	
		Water content (%):	12-14		12-14			12-14	12-14	
Ethiopian mustard II	<u>Tillage</u>	Plough and disk harrow:				0-30 cm	0-10 cm	0-30 cm	0-10 cm	
		h ha <sup>-1</sup> :	2.9		2.1			2.3	1.6	
		MJ h <sup>-1</sup> :	883.32		883.32			883.32	883.32	
Ethiopian mustard II	<u>Sowing</u>	Season:				Autumn	Autumn	Autumn	Autumn	
		Amount:	5/7 kg ha <sup>-1</sup>		5/7 kg ha <sup>-1</sup>			5/7 kg ha <sup>-1</sup>	5/7 kg ha <sup>-1</sup>	
		h ha <sup>-1</sup> :	0.4		0.4			0.2	0.2	
		Seed drill	MJ h <sup>-1</sup> :	380.73	380.73			380.73	380.73	
Ethiopian mustard II	<u>Crop practices</u>									
		Fertilization:				Sow.+Top dress	Sow.+Top dress	Sow.+Top dress	Sow.+Top dress	
		Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	170-80-70-0		80-40-40-0			170-80-70-0	80-40-40-0	
		Fertilizer distributor	h ha <sup>-1</sup> :	1.1	1.0			0.9	0.7	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
		Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):	2.0		2.0			2.0	2.0	
		Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):								
		Crop sprayer	h ha <sup>-1</sup> :	0.5	0.5			0.3	0.3	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
Ethiopian mustard II	<u>Harvest</u>	Season:				Spring/Summer	Spring/Summer	Spring/Summer	Spring/Summer	
		Combine harvester:	h ha <sup>-1</sup> :	0.8	0.7			0.6	0.5	
		MJ h <sup>-1</sup> :	825.55		825.55			825.55	825.55	
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):	1.7		0.8			3.1	2.0	
		Water content (%):	15		15			15	15	
Sunflower III	<u>Tillage</u>	Cultivator:				25-40 cm	15-25 cm	25-40 cm	15-25 cm	
		h ha <sup>-1</sup> :	2.9		2.1			2.2	1.6	
		MJ h <sup>-1</sup> :	883.32		883.32			883.32	883.32	
Sunflower III	<u>Sowing</u>	Season:				Spring	Spring	Spring	Spring	
		Amount (kg ha <sup>-1</sup> ):	6		5			6	5	
		h ha <sup>-1</sup> :	0.4		0.4			0.2	0.2	
		Seed drill	MJ h <sup>-1</sup> :	380.73	380.73			380.73	380.73	
Sunflower III	<u>Crop practices</u>									
		Fertilization:				Sow.+Top dressing	Sow.+Top dressing	Sow.+Top dressing	Sow.+Top dressing	
		Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	120-90-200-0		60-50-100-0			120-90-200-0	70-50-100-0	
		Fertilizer distributor	h ha <sup>-1</sup> :	1.1	1.0			0.9	0.7	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
		Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):	1.5		1.5			1.5	1.5	
		Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):								
		Crop sprayer	h ha <sup>-1</sup> :	0.5	0.5			0.3	0.3	
		MJ h <sup>-1</sup> :	202.19		202.19			202.19	202.19	
Sunflower III	<u>Harvest</u>	Season:				Summer	Summer	Summer	Summer	
		Combine harvester:	h ha <sup>-1</sup> :	0.8	0.7			0.6	0.5	
		MJ h <sup>-1</sup> :	825.55		825.55			825.55	825.55	
		Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):	2.8		2.3			3.5	3.0	
		Water content (%):	12-13		12-13			12-13	12-13	

# Future scenario of crop yields

## Direct causes of climate changes

- Atmospheric CO<sub>2</sub>
- Tropospheric ozone

## Consequence of climate changes on climate

- Air temperature raising
- Water resources increase or decrease
- Extreme meteorological events

## Consequence of climate changes on crop yields

- Variation of pest, weed and diseases
- Variation of length of growing season
- Variation of yield
- Increase of photosynthesis
- Increase of water stress



# Future scenario and mitigation

- Crop breeding of new genotypes
- New soil management techniques
- Nutrient management
- Changes in farming systems

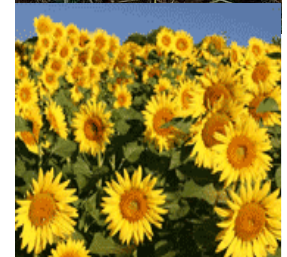


# Future scenario (2020 and 2030)

Factors taken into account:

- Technological developments (crop management, breeding, etc.)
- Climate changes ( $\text{CO}_2$ , temperature, rainfall, etc.)

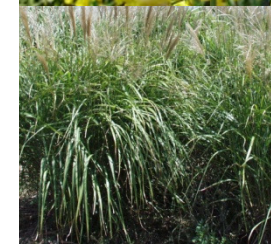
Both factors were considered in water limited condition (soil moisture determines whether the crop growth is limited by drought stress).





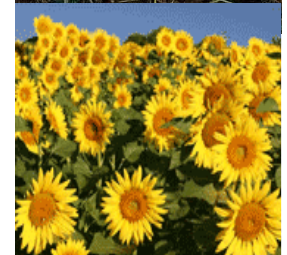
# Annual yield growth rates (%) for main agricultural crops (DG Agriculture)

	Average for EU-27	Average for EU-15	Average for EU-12	Comment
<b>Cereals</b>	<b>0,80</b>	<b>0,50</b>	<b>1,10</b>	<b>DG Agriculture <sup>6</sup></b>
<b>Maize grain</b>	<b>0,40</b>	<b>0,25</b>	<b>0,55</b>	<b>DG Agriculture <sup>6</sup></b>
<b>Rapeseed</b>	<b>0,80</b>	<b>0,50</b>	<b>1,10</b>	<b>Own estimation</b>
<b>Other crops</b>	<b>0,80</b>	<b>0,50</b>	<b>1,10</b>	<b>Own estimation</b>



# Technological development of each climatic zone

Climatic zone	Annual increase (%)
Nemoral	0.83
Continental	0.88
Atlantic Central	0.50
Atlantic North	0.50
Lusitanian	0.50
Mediterranean North	0.58
Mediterranean South	0.50



# Relative increase coefficients (%) for scenarios of climate change for year 2050 and for a doubling of atmospheric CO<sub>2</sub> concentration (Olesen and Bindi 2002)

Crop	2050		2 × CO <sub>2</sub>		Source
	North	South	North	South	
<i>Rainfed</i>					
Wheat	22	18	23	-16	c, e, g, h, i
Grain maize	104	-28	140	-36	b, e
Sunflower	-25	-38	-40	-14	a, i
Soybean	65	45	-	-	j
Potato	20	8	-	-	k
Grapevine	24	12	-	-	f, g
<i>Irrigated</i>					
Grain maize	158	-11	231	-21	b, i
Soybean	81	17	-	13	i, j
Potato	23	1	-	-	k

- **(a)** Harrison, P.A., Butterfield, R., Downing, T., 1995
- **(b)** Wolf, J., van Diepen, C.A., 1995.
- **(c)** Semenov, M.A., Wolf, J., Evans, L.G., Eckersten, H., Iglesias, A., 1996.
- **(d)** Hulme, M., Barrow, E.M., Arnell, N.W., Harrison, P.A., Johns, T.C., Downing, T.E., 1999.
- **(e)** Alexandrov, V.A., Hoogenboom, G., 2000.
- **(f)** Bindi, M., Fibbi, L., Maselli, F., Miglietta, F., 2000.
- **(g)** Harrison, P.A., Butterfield, R.E., Orr, J.L., 2000°.
- **(h)** Iglesias, A., Rosenzweig, C., Pereira, D., 2000.
- **(i)** Tubiello, F.N., Donatelli, M., Rosenzweig, C., Stockle, C.O., 2000.
- **(j)** Wolf, J., 2000a.
- **(k)** Wolf, J., 2000b.

# Climate changes

Europe has been divided in two macroareas (Olesen and Bindi, 2002):

## North:

- Nemoral
- Continental
- Atlantic Central
- Atlantic North
- Lusitanian

## South:

- Mediterranean North
- Mediterranean South



# Climate changes

*Further crops other than Olesen and Bindi paper:*

- Rapeseed, Ethiopian mustard and cardoon were presumed as wheat;
- Hemp, Kenaf and flax were presumed as sunflower;
- Sugar beet was presumed as potato;
- Willow, Poplar, Eucalyptus, Miscanthus, reed canarygrass, giant reed, switchgrass and sorghum were assumed as maize.



# Climate changes

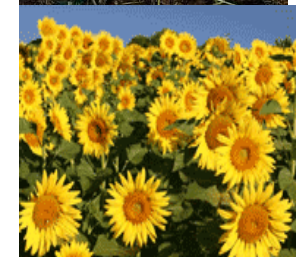
Annual increment (+) or decrement (-) according to Olesen and Bindi

<b>Crop</b>	<b>Climatic area</b>						
	<i>NEM</i>	<i>CON</i>	<i>ATC</i>	<i>ATN</i>	<i>LUS</i>	<i>MDN</i>	<i>MDS</i>
Wheat	0.33	0.33	0.33	0.33	0.28	0.28	0.28
Maize	1.20	1.20	1.20	1.20	-0.55	-0.55	-0.55
Sunflower	-0.48	-0.48	-0.48	-0.48	-0.79	-0.79	-0.79
Rapeseed, Ethiopian m.	0.33	0.33	0.33	0.33	0.28	0.28	0.28
Sugar beet	0.33	0.33	0.33	0.33	0.13	0.13	0.13
Sorghum	1.20	1.20	1.20	1.20	-0.55	-0.55	-0.55
Hemp	-0.48	-0.48	-0.48	-0.48	-0.79	-0.79	-0.79
Flax	-0.48	-0.48	-0.48	-0.48	-0.79	-0.79	-0.79
Herbaceous perennial	1.20	1.20	1.20	1.20	-0.55	-0.55	-0.55
Cardoon	0.33	0.33	0.33	0.33	0.28	0.28	0.28
Woody	1.20	1.20	1.20	1.20	-0.55	-0.55	-0.55
Soybean	0.84	0.84	0.84	0.84	0,62	0,62	0,62
Potato	0.33	0.33	0.33	0.33	0,13	0,13	0,13

# Yield increase expressed as annual growth rates (%)

## Technological and climate change

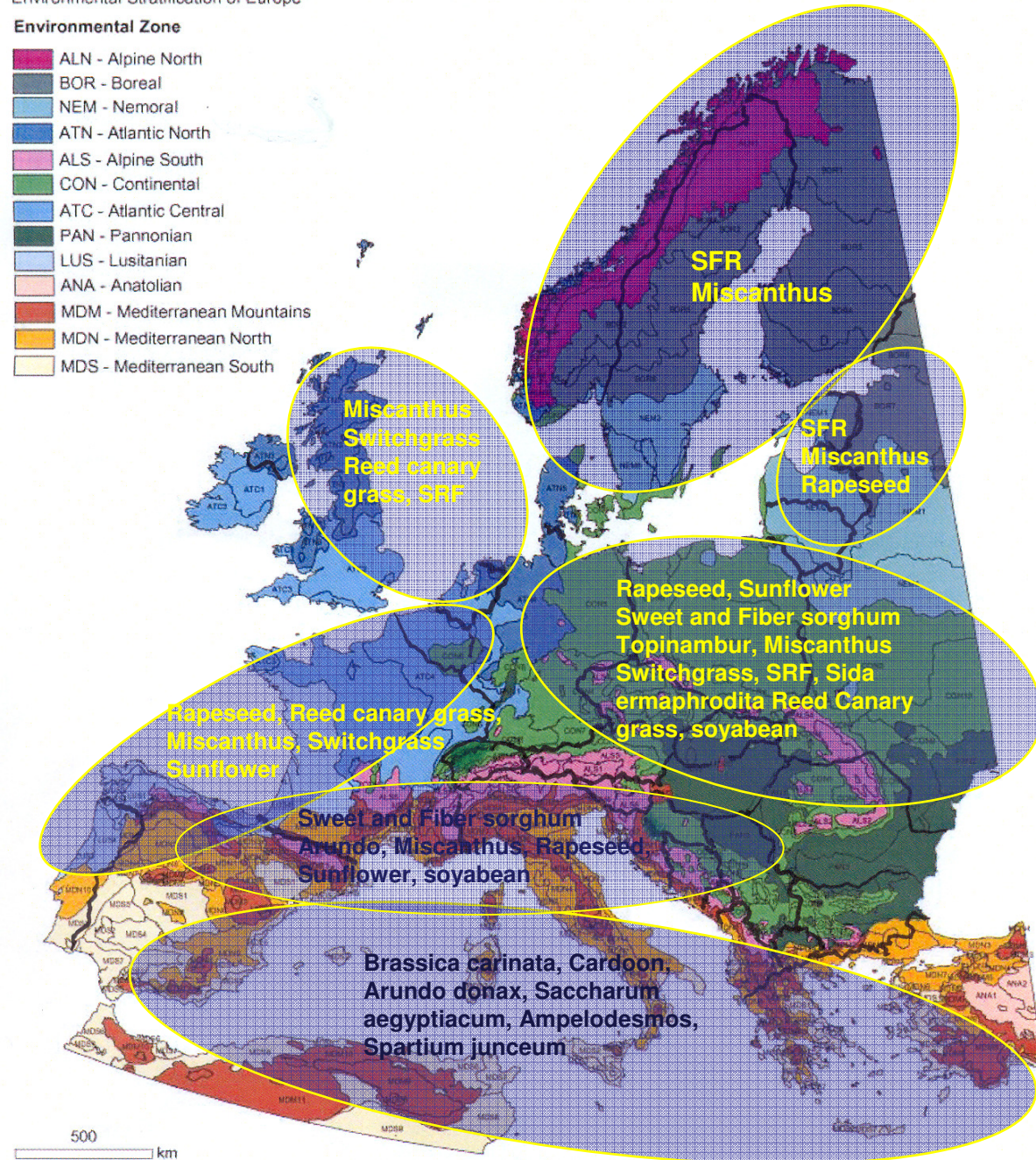
Crop	Climatic area						
	Nemoral	Continental	Atlantic Central	Atlantic North	Lusitanian	Mediterranean North	Mediterranean South
Wheat	1.23	1.28	0.83	0.83	0.83	0.88	0.78
Maize	-	1.67	1.45	-	1.45	-0.25	-
Sunflower	-	0.47	0.02	-	0.02	-0.19	-
Rapeseed	1.23	1.28	0.83	0.83	0.83	0.88	-
Ethiopian m.	-	-	-	-	-	0.88	0.78
Sugar beet	1.23	1.28	0.83	0.83	0.83	0.73	-
Sorghum	-	2.15	-	-	1.70	0.05	-0.05
Hemp	-	0.47	0.02	-	0.02	-0.19	-
Flax	0.42	0.47	0.02	0.02	0.02	-0.19	-0.29
Herbaceous perennial	2.10	2.15	1.70	1.70	1.70	0.05	-0.05
Cardoon	-	-	-	-	-	0.88	0.78
Woody	2.10	2.15	1.70	1.70	1.70	0.05	-0.05



Environmental Stratification of Europe

**Environmental Zone**

- ALN - Alpine North
- BOR - Boreal
- NEM - Nemoral
- ATN - Atlantic North
- ALS - Alpine South
- CON - Continental
- ATC - Atlantic Central
- PAN - Pannonian
- LUS - Lusitanian
- ANA - Anatolian
- MDM - Mediterranean Mountains
- MDN - Mediterranean North
- MDS - Mediterranean South







4<sup>th</sup> workshop of the 4F CROPS Project  
FUTURE CROPS FOR FOOD, FEED, FIBRE AND FUEL



## Cropping possibilities of non-food crops in EU-Agriculture

*Thank you for your kind attention*



*Towards a successful insertion of the non-food crops in the EU-27 agriculture*

*Lyon, May 4<sup>th</sup> 2010*

## Yearly coefficients of crop yields (%)

In Mediterranean South, which could be the most affected of climate changes due to the increasing dry season, a different approach was made (Giannakopoulos et al., 2009).

Adaption management strategies (irrigation) have been take into account for those crops susceptible to drought stress (maize, sorghum, potato, sugar beet and lignocellulosic herbaceous perennial).

# Percentage changes of crop yields for main Mediterranean regions

Percentage changes of crop yields for the main Mediterranean regions: N-W = Portugal, Spain, France and Italy, N-E = Serbia, Greece and Turkey, S-E = Jordan, Egypt and Libya, S-W = Tunisia, Algeria and Morocco.

	C4 summer		Legumes		C3 summer		Tubers		Cereals	
	A2-A	B2-A	A2-A	B2-A	A2-A	B2-A	A2-A	B2-A	A2-A	B2-A
N-W	4.2	8.8	-14.4	-4.9	-12.4	-2.8	4.9	7.5	-0.3	4.7
N-E	-0.6	0.2	-7.2	0.9	-5.4	0.9	-9.3	4.4	4.4	12.5
S-E	-7.9	-6.7	-23.3	-30.1	3.7	-0.4	-4.3	-5.7	-4.9	-10.1
S-W	-9.4	-6.4	-23.9	-18.5	-10.3	-4.3	-13.3	-1.5	-3.4	-3.8

A2-A = 520 ppm [CO<sub>2</sub>]

B2-A = 470 ppm [CO<sub>2</sub>]

C. Giannakopoulos et al. / Global and Planetary Change 68 (2009) 209–224

# Yearly coefficients of crop yields (%)

Crop	Climatic area							
	<i>NEM</i> <i>Rainfed</i>	<i>CON</i> <i>Rainfed</i>	<i>ATC</i> <i>Rainfed</i>	<i>ATN</i> <i>Rainfed</i>	<i>LUS</i> <i>Rainfed</i>	<i>MDN</i> <i>Rainfed</i>	<i>Irr.</i>	<i>MDS</i> <i>Rainfed</i>
Wheat	1.16	1.21	0.83	0.83	0.78	0.86		0.24
Maize	2.03	2.08	1.70	1.70	-0.05	0.03	0.13	-0.05
Sunflower	0.35	0.40	0.02	0.02	-0.29	-0.21		-0.29
Rapeseed, Ethiop. m.	1.16	1.21	0.83	0.83	0.78	0.86		0.24
Sugar beet	1.16	1.21	0.83	0.83	0.63	0.71	0.17	
Sorghum	2.03	2.08	1.70	1.70	-0.05	0.03	0.13	-0.05
Hemp	0.35	0.40	0.02	0.02	-0.29	-0.21		-0.29
Flax	0.35	0.40	0.02	0.02	-0.29	-0.21		-0.29
Herbaceous peren.	2.03	2.08	1.70	1.70	-0.05	0.03	0.13	-0.05
Cardoon	1.16	1.21	0.83	0.83	0.78	0.86		0.24
Woody	2.03	2.08	1.70	1.70	-0.05	0.03		-0.05
Soybean	1.67	1.72	1.34	1.34	1.12	1.20		-0.08
Potato	1.16	1.21	0.83	0.83	0.63	0.71	0.17	

## Yearly coefficients of crop yields (%)

For each climatic area and crop studied a single coefficient was assumed taking into account both technological development and climate change effects on crop yields.

Climat. Change coeff. + Technol. Develop. Coeff.

Example:

$$\text{Willow in Nemoral} = 1.195 + 0.83 = 2.03$$

$$\text{Sunflower in Continental} = -0.478 + 0.88 = 0.40$$

$$\text{Rapeseed in Atlantic Central} = 0.33 + 0.50 = 0.83$$

$$\text{Soybean in Atlantic North} = 0.838 + 0.50 = 1.34$$

$$\text{Sorghum in Lusitanian} = -0.546 + 0.50 = -0.05$$

$$\text{Sugarbeet in Mediterranean North} = 0.332 + 0.58 = 0.71$$

$$\text{Hemp in Mediterranean South} = -0.794 + 0.50 = -0.29$$

# Nemoral Cropping system

- Poliennial:

- Poplar

- Reed canary grass

- Annual crop rotation:

- Pea-Barley-Rapeseed

- Hemp-Rapeseed-Pea

- Rapeseed-Cereal-Pea-Rapeseed

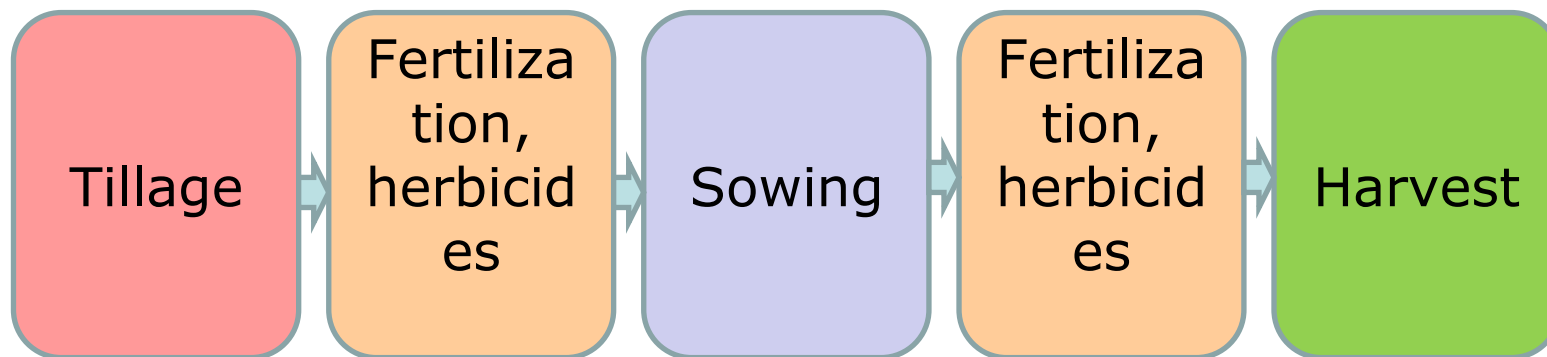
- Rapeseed-Flax-Sunflower

- Red clover-Rapeseed-Flax

# Nemoral Cropping system

## Reed canary grass

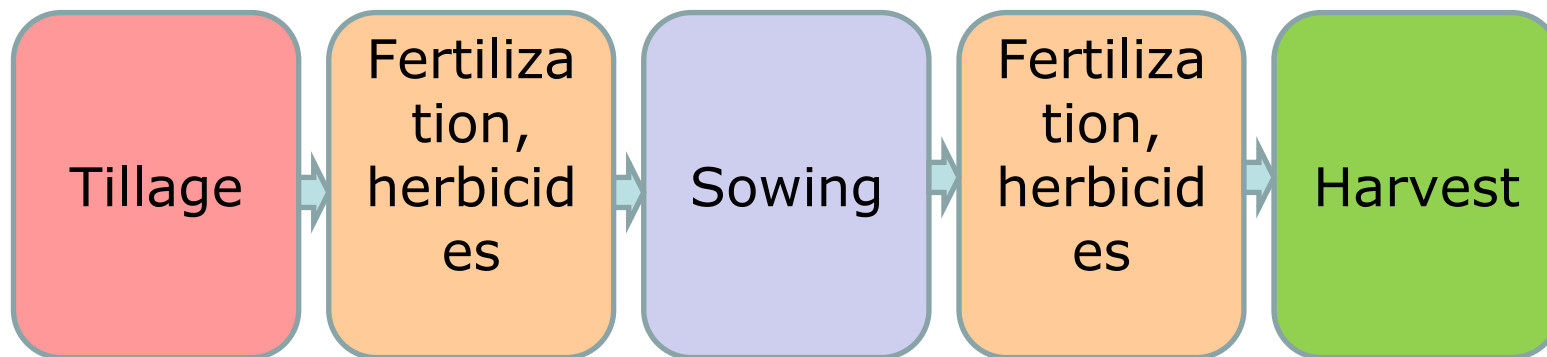
I				II-III								III-IV								V															
1 <sup>st</sup> year												2 <sup>nd</sup> year												3 <sup>rd</sup> year											
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Nemoral Cropping system

## Rapeseed- Flax- Sunflower

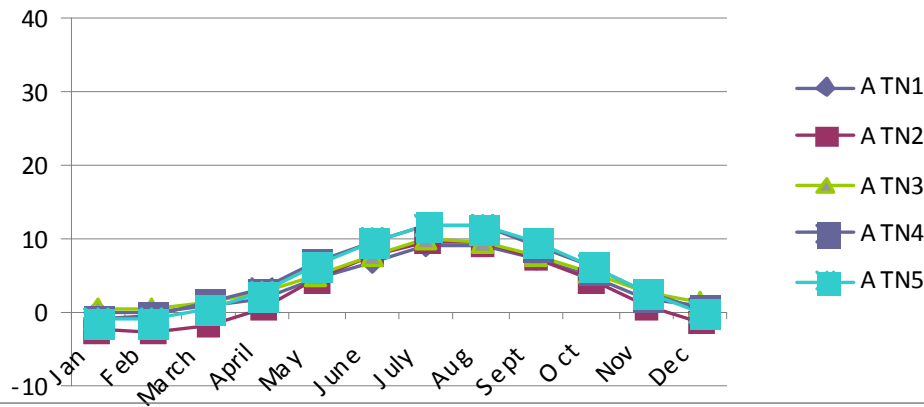
I											II											III										
Rapeseed											Flax											Sunflower										
M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S		



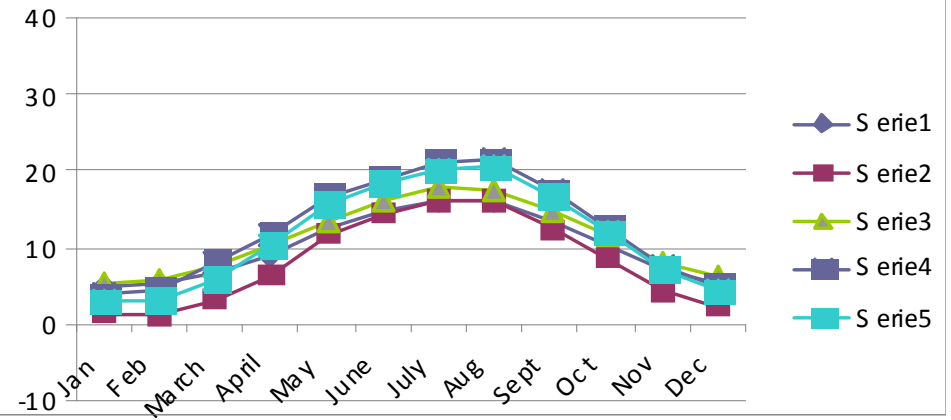


# Atlantic North Cropping system

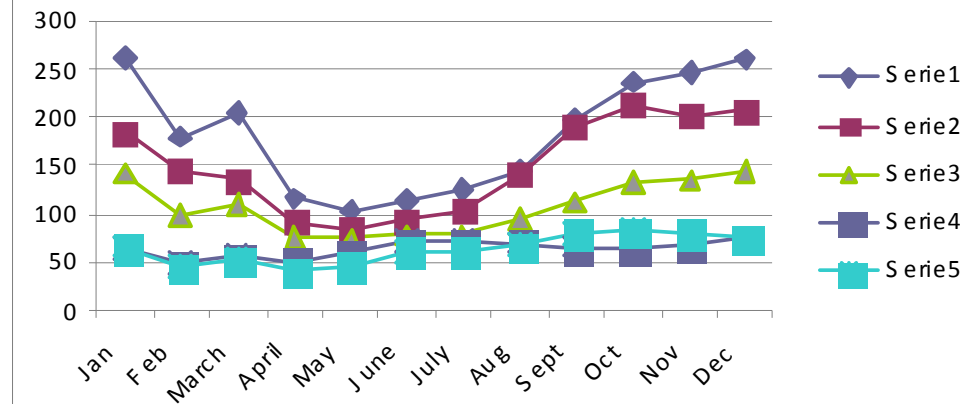
## Minimum Temperature (°C)



## T max(°C) Atlantic North



## Rainfalls (mm)



# Atlantic North Cropping system

- Poliennial:

- Willow

- Poplar

- Miscanthus

- Switchgrass

- Annual crop rotation:

- Rapeseed-Barley-Flax

- Hemp-Barley-Pea

- Rapeseed-Pea-Wheat

- Rapeseed-Barley-Pea-Rapeseed

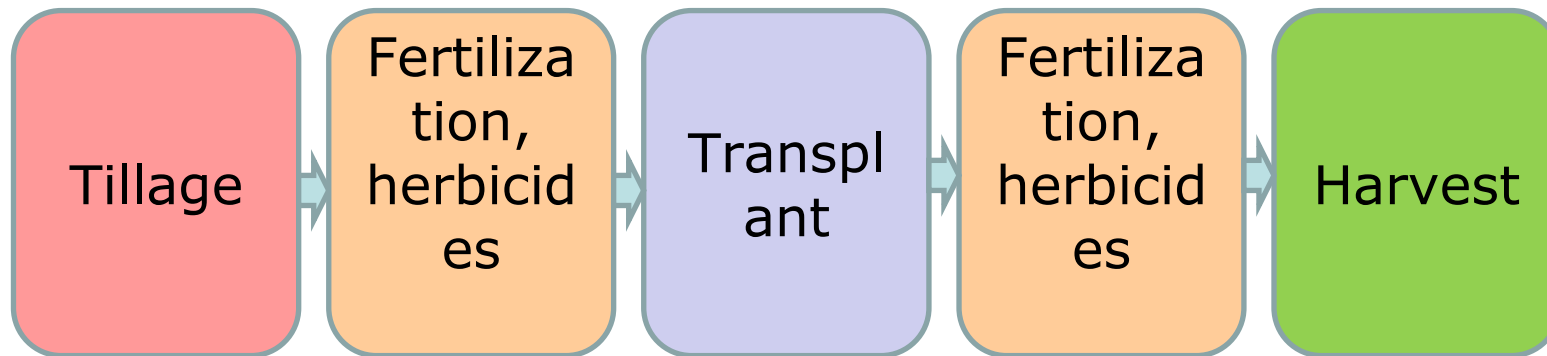
- Flax-Wheat-Pea

- Rapeseed-Flax-Red clover

# Atlantic North Cropping system

## Willow

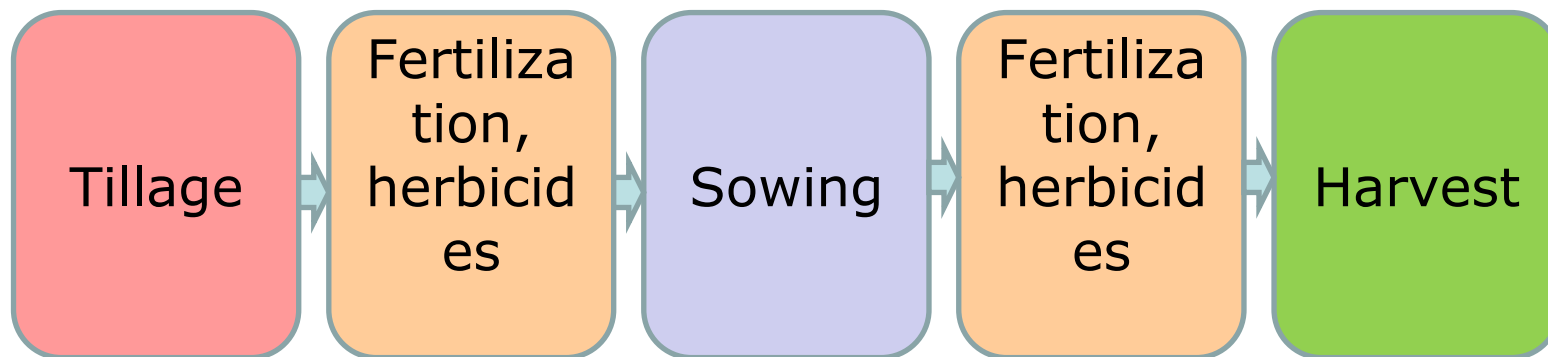
I			II-III						III-IV						V								
1 <sup>st</sup> year						2-3 <sup>rd</sup> year						5 <sup>th</sup> year											
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Atlantic North Cropping system

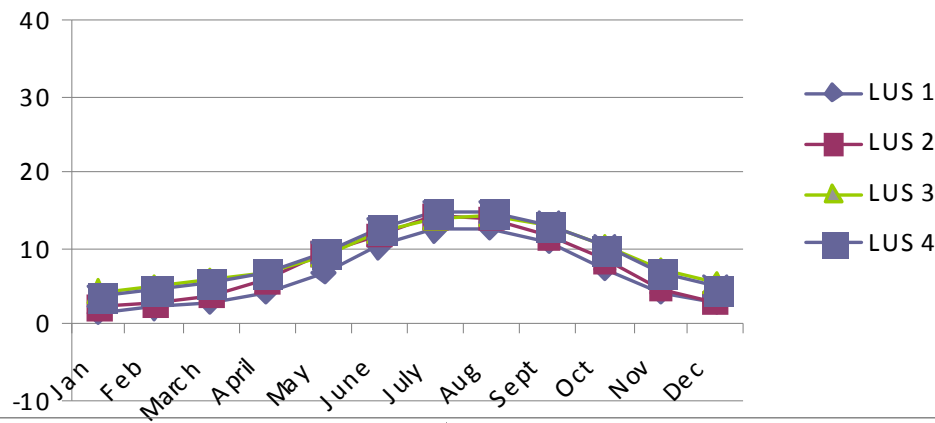
## Rapeseed-Flax-Red clover

I										II										III										
Rapeseed										Flax										Red clover										
F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A

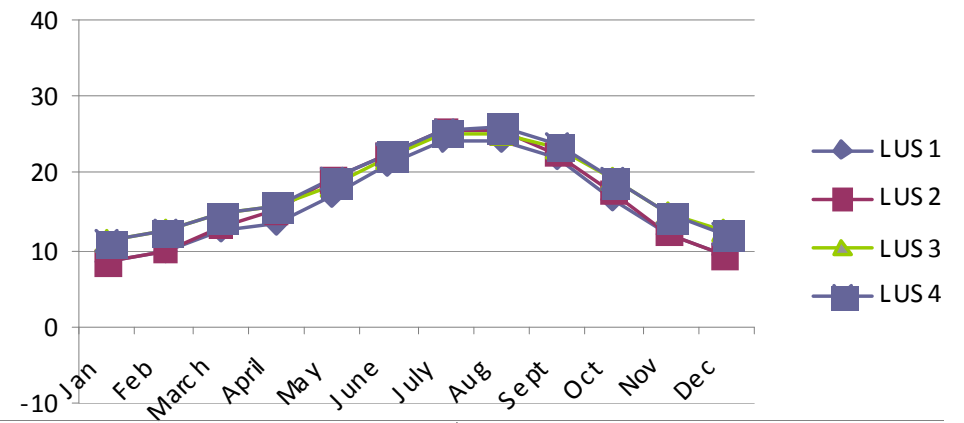


# Lusitanian Cropping system

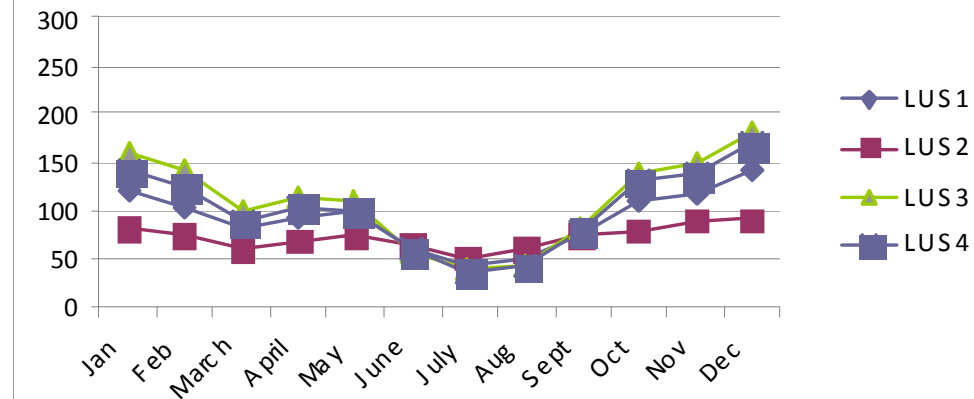
## Minimum Temperature (°C)



## T max(°C) Lusitanian



## Rainfalls (mm) Lusitanian



# Lusitanian Cropping system

- Poliennial:

- Willow

- Poplar

- Eucalyptus

- Miscanthus

- Annual crop rotation:

- Pea-Wheat-Rapeseed

- Rapeseed-Wheat-Hemp-Barley

- Wheat-Maize-Sunflower-Sorghum-Red clover

- Pea-Maize-Sunflower-Sorghum- Red clover

- Rapeseed-Wheat-Pea-Rapeseed

- Maize-Sugar beet-Sorghum

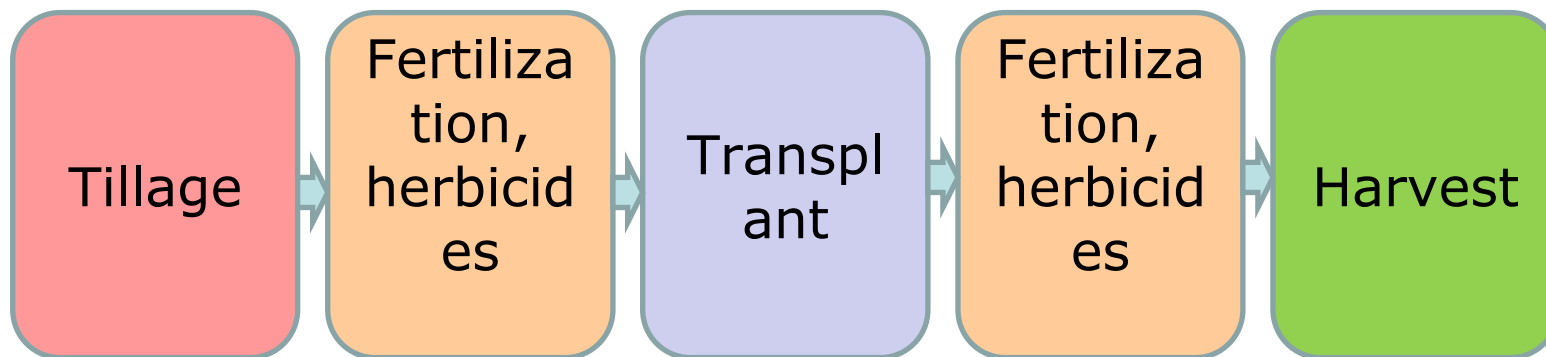
- Soybean-Ethiopian mustard-Sunflower

- Rapeseed-Flax-Red clover

# Lusitanian Cropping system

## Eucalyptus

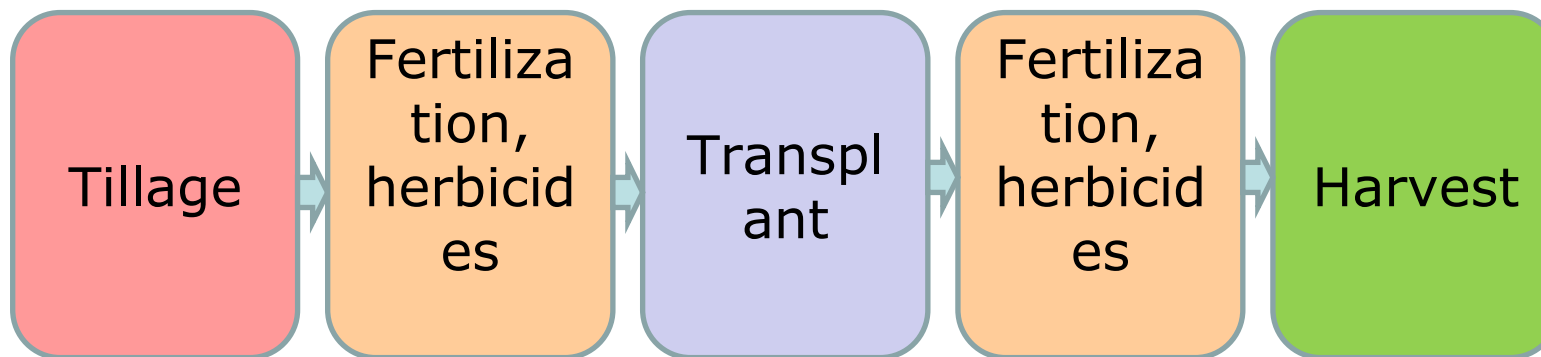
I	II-III												III-IV												V										
1 <sup>st</sup> year												2-3 <sup>rd</sup> year												5 <sup>th</sup> year											
S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A



# Lusitanian Cropping system

## Pea-Wheat-Rapeseed

I							II							III														
Pea							Cereal							Rapeseed														
F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J





# Nemoral: Poplar

Nemoral		Cropping system 1: Poplar			
Yr		Marginal land		Agricultural land	
		High input	Low input	High input	Low input
Poplar I	<u>Tillage</u> Plough and disk harrow:	40-50 cm	35 cm	40-50 cm	35 cm
	h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	3.8 883.32	2.9 883.32	2.9 883.32	2.3 883.32
Poplar I	<u>Sowing</u> Season:	Spring	Spring	Spring	Spring
	Amount (plant ha <sup>-1</sup> ): Planter h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	10000 2.9 380.73	8000 2.9 380.73	10000 2.2 380.73	8000 2.2 380.73
Poplar I	<u>Crop practices</u>	Planting	Planting	Planting	Planting
	Fertilization:	50-10-40-100	30-5-20-50	50-10-40-100	30-5-20-50
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	1.0	0.8	0.8	0.6
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	218.99	218.99	218.99	218.99
	Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.):	0.25	0.25	0.25	0.25
	Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0.5 218.99	0.5 218.99	0.3 218.99	0.3 218.99
Poplar II-III	<u>Harvest</u> Season:	Winter	Winter	Winter	Winter
	Combine harvester h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	1.9 825.55	1.8 825.55	1.5 825.55	1.2 825.55
	Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):	9	6	12	9
	Water content (%):	50	50	50	50
Poplar III	<u>Crop practices</u>	Top dressing	Top dressing	Top dressing	Top dressing
	Fertilization:	50-10-40-100	30-5-20-50	50-10-40-100	30-5-20-50
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	1.0	0.8	0.8	0.6
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	218.99	218.99	218.99	218.99
	Mechanical weed control h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	1.6 218.99	1.6 218.99	0.9 218.99	0.9 218.99
Poplar IV-V	<u>Harvest</u> Season:	Winter	Winter	Winter	Winter
	Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	1.9 825.55	1.8 825.55	1.5 825.55	1.2 825.55
	Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ):	9	6	12	9
	Water content (%):	50	50	50	50
Poplar V	<u>Crop practices</u>	Top dressing	Top dressing	Top dressing	Top dressing
	Fertilization:	50-10-40-100	30-5-20-50	50-10-40-100	30-5-20-50
	Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> :	1.0	0.8	0.8	0.6
	Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	218.99	218.99	218.99	218.99
	Mechanical weed control h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	1.6 218.99	1.6 218.99	0.9 218.99	0.9 218.99

# Nemoral: Pea – Cereal – Rapeseed

Nemoral		Cropping system 3: Pea – Cereal (barley) - Rapeseed				
Yr		Marginal land		Agricultural land		
		High input	Low input	High input	Low input	
Pea I	<u>Tillage</u>	Cultivator: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 1.2 323.50	0-15cm 0.8 323.50	0-25 cm 0.9 323.50	0-15 cm 0.7 323.50
	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73
Pea I	<u>Crop practices</u>					
	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 0-100-0-0 0.9 202.19 0.27 0.5 202.19	Sowing 0-70-0-0 0.7 202.19 0.27 0.5 202.19	Sowing 0-100-0-0 0.6 202.19 0.27 0.3 202.19	Sowing 0-70-0-0 0.5 202.19 0.27 0.3 202.19	
Pea I	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 4.6 18/24	Spring/Summer 0.7 825.55 3.1 18/24	Spring/Summer 0.6 825.55 5.9 18/24	Spring/Summer 0.5 825.55 4.3 18/24
	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 2.1 883.32	No tillage	0-25 cm 1.6 883.32	No tillage
Barley II	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 150 kg ha <sup>-1</sup> 0.4 380.73	Autumn 150 kg ha <sup>-1</sup> 0.5 380.73	Autumn 150 kg ha <sup>-1</sup> 0.2 380.73	Autumn 150 kg ha <sup>-1</sup> 0.3 380.73
	<u>Crop practices</u>					
Barley II	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 30-100-50-0 1.1 202.19 0.27 0.5 202.19	Sow.+Top dress. 10-50-30-0 1.0 202.19 0.27 0.5 202.19	Sow.+Top dress. 30-100-50-0 0.9 202.19 0.27 0.3 202.19	Sow.+Top dress. 10-50-30-0 0.7 202.19 0.27 0.3 202.19	
	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 7.2 17 3.5 13 3.7 20	Spring/Summer 0.7 825.55 4.4 17 2.1 13 2.3 20	Spring/Summer 0.6 825.55 8.0 17 3.9 13 4.1 20	Spring/Summer 0.5 825.55 5.4 17 2.6 13 2.8 20
Rapeseed III	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.9 883.32	0-10 cm 2.1 883.32	0-30 cm 2.3 883.32	0-10 cm 1.6 883.32
	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73
Rapeseed III	<u>Crop practices</u>					
	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress 170-80-70-0 1.1 202.19 2.0 0.5 202.19	Sow.+Top dress 80-40-40-0 1.0 202.19 2.0 0.5 202.19	Sow.+Top dress 170-80-70-0 0.9 202.19 2.0 0.3 202.19	Sow.+Top dress 80-40-40-0 0.7 202.19 2.0 0.3 202.19	
Rapeseed III	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 1.8 15	Spring/Summer 0.7 825.55 1.0 15	Spring/Summer 0.6 825.55 2.8 15	Spring/Summer 0.5 825.55 1.8 15

# Atlantic North: Rapeseed – Pea – Wheat

Atlantic North		Cropping system 7: Rapeseed-Pea-Wheat				
Yr		Marginal land		Agricultural land		
		High input	Low input	High input	Low input	
Rapeseed I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.9 883.32	0-10 cm 2.1 883.32	0-30 cm 2.3 883.32	0-10 cm 1.6 883.32
	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73
Rapeseed I	<u>Crop practices</u>					
	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress 170-80-70-0 1.1 202.19 2.0 0.5 202.19	Sow.+Top dress 80-40-40-0 1.0 202.19 2.0 0.5 202.19	Sow.+Top dress 170-80-70-0 0.9 202.19 2.0 0.3 202.19	Sow.+Top dress 80-40-40-0 0.7 202.19 2.0 0.3 202.19	
Rapeseed I	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 2.3 15	Spring/Summer 0.7 825.55 1.5 15	Spring/Summer 0.6 825.55 3.2 15	Spring/Summer 0.5 825.55 2.4 15
	<u>Tillage</u>	Cultivator: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 1.2 323.50	0-15cm 0.8 323.50	0-25 cm 0.9 323.50	0-15 cm 0.7 323.50
Pea II	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 200 kg ha <sup>-1</sup> 0.4 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73
	<u>Crop practices</u>					
Pea II	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 0-100-0-0 0.9 202.19 0.27 0.5 202.19	Sowing 0-70-0-0 0.7 202.19 0.27 0.5 202.19	Sowing 0-100-0-0 0.6 202.19 0.27 0.3 202.19	Sowing 0-70-0-0 0.5 202.19 0.27 0.3 202.19	
	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 8.9 18/24	Spring/Summer 0.7 825.55 7.2 18/24	Spring/Summer 0.6 825.55 10.5 18/24	Spring/Summer 0.5 825.55 8.9 18/24
Wheat III	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 2.1 883.32	No tillage	0-25 cm 1.6 883.32	No tillage
	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 230 kg ha <sup>-1</sup> 0.4 380.73	Autumn 250 kg ha <sup>-1</sup> 0.5 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.3 380.73
Wheat III	<u>Crop practices</u>					
	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 50-140-0-0 1.1 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 30-65-0 1.0 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 50-130-0-0 0.9 202.19 0.27 0 0.3 202.19	Sow.+Top dress. 30-65-0-0 0.7 202.19 0.27 0 0.3 202.19	
Wheat III	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 10.1 16.0 6.1 13 4.0 20	Spring/Summer 0.7 825.55 9.7 16.0 5.9 13 3.8 20	Spring/Summer 0.6 825.55 11.6 16.0 7.0 13 4.6 20	Spring/Summer 0.5 825.55 10.6 16.0 6.4 13 4.2 20

# Atlantic North: Rapeseed – Flax – Red clover

Yr	Atlantic North		Cropping system 10: Rapeseed-Flax-Red clover			
			Marginal land		Agricultural land	
			High input	Low input	High input	Low input
Rapeseed I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.9 883.32	0-10 cm 2.1 883.32	0-30 cm 2.3 883.32	0-10 cm 1.6 883.32
Rapeseed I	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73
Rapeseed I	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress 170-80-70-0 1.1 202.19 2.0 0.5 202.19	Sow.+Top dress 80-40-40-0 1.0 202.19 2.0 0.5 202.19	Sow.+Top dress 170-80-70-0 0.9 202.19 2.0 0.3 202.19	Sow.+Top dress 80-40-40-0 0.7 202.19 2.0 0.3 202.19
Rapeseed I	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 2.3 15	Spring/Summer 0.7 825.55 1.5 15	Spring/Summer 0.6 825.55 3.2 15	Spring/Summer 0.5 825.55 2.4 15
Flax II	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.5 883.32	0-10 cm 2.0 883.32	0-30 cm 1.9 883.32	0-10 cm 1.6 883.32
Flax II	<u>Sowing</u>	Season: Amount: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 100 kg ha <sup>-1</sup> 0.4 380.73	Spring 100 kg ha <sup>-1</sup> 0.4 380.73	Spring 100 kg ha <sup>-1</sup> 0.2 380.73	Spring 100 kg ha <sup>-1</sup> 0.2 380.73
Flax II	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 100-150-75-0 1.1 202.19 1.5 0.5 202.19	Sow.+Top dress 70-100-50-0 1.0 202.19 1.5 0.5 202.19	Sowing 100-150-75-0 0.9 202.19 1.5 0.3 202.19	Sow.+Top dress 70-100-50-0 0.7 202.19 1.5 0.3 202.19
Flax II	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Late summer/autumn 0.8 825.55 5.4 20	Late summer/autumn 0.7 825.55 4.1 20	Late summer/autumn 0.6 825.55 6.8 20	Late summer/autumn 0.5 825.55 5.7 20
Red clover III	<u>Tillage</u>	Disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.5 323.50	0-15 cm 2.0 323.50	0-30 cm 1.9 323.50	0-15 cm 1.6 323.50
Red clover III	<u>Sowing</u>	Season: Amount kg ha <sup>-1</sup> : h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 25 0.4 380.73	Spring 25 0.4 380.73	Spring 25 0.2 380.73	Spring 25 0.2 380.73
Red clover III	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 0-40-0-0 1.1 202.19	Sowing 0-20-0-0 1.1 202.19	Sowing 0-40-0-0 0.7 202.19	Sowing 0-20-0-0 0.7 202.19
Red clover III	<u>Harvest</u>	Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Late summer/autumn 0.7 825.55 3.1 70	Late summer/autumn 0.7 825.55 3.0 70	Late summer/autumn 0.5 825.55 3.5 70	Late summer/autumn 0.5 825.55 3.4 70

# Lusitanian: Eucalyptus

Lusitanian Cropping system 3: Eucalyptus						
Yr			Marginal land		Agricultural land	
			High input	Low input	High input	Low input
Eucalyptus I	<u>Tillage</u>	Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	40-50 cm 3.8 883.32	35 cm 2.9 883.32	40-50 cm 2.9 883.32	35 cm 2.3 883.32
Eucalyptus I	<u>Sowing</u>	Season: Amount (plant ha <sup>-1</sup> ): Planter h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 5000 2.3 380.73	Spring 5000 2.3 380.73	Spring 5000 1.9 380.73	Spring 5000 1.9 380.73
Eucalyptus I	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Planting 125-12-132-92 1.0 218.99 0.25 0.5 218.99	Planting 60-5-65-45 0.8 218.99 0.25 0.5 218.99	Planting 125-12-132-92 0.8 218.99 0.25 0.3 218.99	Planting 60-5-65-45 0.6 218.99 0.25 0.3 218.99
Eucalyptus II-III	<u>Harvest</u>	Season: Combine harvester h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Winter 1.9 825.55 10 50	Winter 1.8 825.55 6 50	Winter 1.5 825.55 14 50	Winter 1.2 825.55 10 50
Eucalyptus III	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Mechanical weed control h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 70-0-0-0 0.9 218.99 1.6 218.99		Top dressing 70-0-0-0 0.6 218.99 0.9 218.99	
Eucalyptus IV-V	<u>Harvest</u>	Season: Combine harvester h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Winter 1.9 825.55 12 50	Winter 1.8 825.55 8 50	Winter 1.5 825.55 17 50	Winter 1.2 825.55 12 50
Eucalyptus V	<u>Crop practices</u>	Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Mechanical weed control h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Top dressing 70-0-0-0 0.9 218.99 1.6 218.99		Top dressing 70-0-0-0 0.6 218.99 0.9 218.99	

# Lusitanian: Rapeseed-Cereal-Hemp- Cereal

Lusitanian		Cropping system 6: Rapeseed-Cereal (wheat)-Hemp-Cereal (barley)			
Yr		Marginal land		Agricultural land	
		High input	Low input	High input	Low input
Rapeseed I	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm 2.9 883.32	0-10 cm 2.1 883.32	0-30 cm 2.3 883.32	0-10 cm 1.6 883.32
Rapeseed I	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.4 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73	Autumn 5/7 kg ha <sup>-1</sup> 0.2 380.73
Rapeseed I	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress 170-80-70-0 1.1 202.19 2.0 0.5 202.19	Sow.+Top dress 80-40-40-0 1.0 202.19 2.0 0.5 202.19	Sow.+Top dress 170-80-70-0 0.9 202.19 2.0 0.3 202.19	Sow.+Top dress 80-40-40-0 0.7 202.19 2.0 0.3 202.19
Rapeseed I	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 1.9 15	Spring/Summer 0.7 825.55 0.9 15	Spring/Summer 0.6 825.55 2.7 15	Spring/Summer 0.5 825.55 2.0 15
Wheat II	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 2.1 883.32	No tillage	0-25 cm 1.6 883.32	No tillage
Wheat II	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 230 kg ha <sup>-1</sup> 0.4 380.73	Autumn 250 kg ha <sup>-1</sup> 0.5 380.73	Autumn 180 kg ha <sup>-1</sup> 0.2 380.73	Autumn 180 kg ha <sup>-1</sup> 0.3 380.73
Wheat II	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 100-140-0-0 1.1 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 50-65-0 1.0 202.19 0.27 0 0.5 202.19	Sow.+Top dress. 100-130-0-0 0.9 202.19 0.27 0 0.3 202.19	Sow.+Top dress. 50-65-0-0 0.7 202.19 0.27 0 0.3 202.19
Wheat II	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 5.5 16.0 3.3 13 2.2 20	Spring/Summer 0.7 825.55 2.2 16.0 1.3 13 0.9 20	Spring/Summer 0.6 825.55 9.4 16.0 5.7 13 3.7 20	Spring/Summer 0.5 825.55 5.8 16.0 3.5 13 2.3 20
Hemp III	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	35-40 cm 2.9 883.32	15-30 cm 2.5 883.32	35-40 cm 2.2 883.32	15-30 cm 1.8 883.32
Hemp III	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 40 kg ha <sup>-1</sup> 0.4 380.73	Spring 40 kg ha <sup>-1</sup> 0.4 380.73	Spring 40 kg ha <sup>-1</sup> 0.2 380.73	Spring 40 kg ha <sup>-1</sup> 0.2 380.73
Hemp III	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Mechanical weed control h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress 120-60-120-0 1.1 202.19 1.6 218.99	Sow.+Top dress 60-30-60-0 1.0 202.19 1.6 218.99	Sow.+Top dress 120-60-120-0 0.9 202.19 0.9 218.99	Sow.+Top dress 60-30-60-0 0.7 202.19 0.9 218.99
Hemp III	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Summer 0.8 825.55 19.0 20	Summer 0.7 825.55 15.0 20	Summer 0.6 825.55 22.5 20	Summer 0.5 825.55 20.0 20
Barley IV	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm 2.1 883.32	No tillage	0-25 cm 1.6 883.32	No tillage

Barley IV	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 150 kg ha <sup>-1</sup> 0.4 380.73	Autumn 150 kg ha <sup>-1</sup> 0.5 380.73	Autumn 150 kg ha <sup>-1</sup> 0.2 380.73	Autumn 150 kg ha <sup>-1</sup> 0.3 380.73
Barley IV	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 60-100-50-0 1.1 202.19 0.27 0.5 202.19	Sow.+Top dress. 30-50-30-0 1.0 202.19 0.27 0.5 202.19	Sow.+Top dress. 60-100-50-0 0.9 202.19 0.27 0.3 202.19	Sow.+Top dress. 30-50-30-0 0.7 202.19 0.27 0.3 202.19
Barley IV	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer 0.8 825.55 6.3 17 3.0 13 3.3 20	Spring/Summer 0.7 825.55 3.8 17 1.8 13 2.0 20	Spring/Summer 0.6 825.55 7.2 17 3.5 13 3.7 20	Spring/Summer 0.5 825.55 4.2 17 2.0 13 2.2 20

# Mediterranean South: Giant reed

Yr	Mediterranean South					
	Cropping system 1: Giant reed					
	Marginal land			Agricultural land		
		High input	Low input	High input	Low input	
Giant reed I	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-40 cm	0-20 cm	0-40 cm	0-20 cm	
		2.9 883.32	2.1 883.32	2.2 883.32	1.6 883.32	
Giant reed I	<u>Sowing (transplant)</u> Season: Amount: Planter h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 10000 rhiz. ha <sup>-1</sup>	Spring 10000 rhiz. ha <sup>-1</sup>	Spring 10000 rhiz. ha <sup>-1</sup>	Spring 10000 rhiz. ha <sup>-1</sup>	
		2.9 380.73	2.9 380.73	2.2 380.73	2.2 380.73	
Giant reed I	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Irrigation (m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ): Irrigation system: Irrigation pump type: Delivery high (m): Distance (m): Mj ha-l	Sowing 100-120-150-0 1.0 218.99 1.2 0.5 218.99 3000 Sprinkler Diesel 15 100 9903	Sowing 50-60-75-0 0.9 218.99 1.2 0.5 218.99 1000 Sprinkler Diesel 15 100 3300	Sowing 100-120-150-0 0.8 218.99 1.2 0.3 218.99 3000 Sprinkler Diesel 15 100 9903	Sowing 50-60-75-0 0.6 218.99 1.2 0.3 218.99 1000 Sprinkler Diesel 15 100 3300	
Giant reed I	<u>Harvest</u> Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Winter/Spring 1.2 825.55 6 50	Winter/Spring 1.2 825.55 5 50	Winter/Spring 1.0 825.55 9 50	Winter/Spring 1.0 825.55 6 50	
Giant reed II	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Irrigation (m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ): Irrigation system: Irrigation pump type: Delivery high (m): Distance (m): Mj ha-l	Top dressing 100-120-0-0 1.0 218.99 5000 Sprinkler Diesel 15 100 16506		Top dressing 100-120-0-0 0.8 218.99 5000 Sprinkler Diesel 15 100 16506		
Giant reed II	<u>Harvest</u> Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Winter/Spring 1.2 825.55 30 50	Winter/Spring 1.2 825.55 20 50	Winter/Spring 1.0 825.55 38 50	Winter/Spring 1.0 825.55 25 50	
Giant reed III	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Irrigation (m <sup>3</sup> ha <sup>-1</sup> yr <sup>-1</sup> ): Irrigation system: Irrigation pump type: Delivery high (m): Distance (m): Mj ha-l	Top dressing 100-120-0-0 1.0 218.99 5000 Sprinkler Diesel/electric 15 100 16506		Top dressing 100-120-0-0 0.8 218.99 5000 Sprinkler Diesel/electric 15 100 16506		
Giant reed III	<u>Harvest</u> Season: Maize chopper: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Winter/Spring 1.2 825.55 60 50	Winter/Spring 1.2 825.55 28 50	Winter/Spring 1.0 825.55 76 50	Winter/Spring 1.0 825.55 40 50	

# Mediterranean South: Flax-Wheat-Pea

Mediterranean North		Cropping system 5: Flax-Cereal (wheat)-Pea			
Yr		Marginal land		Agricultural land	
		High input	Low input	High input	Low input
Flax I	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-30 cm	0-10 cm	0-30 cm	0-10 cm
		2.5 883.32	2.0 883.32	1.9 883.32	1.6 883.32
Flax I	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Spring 100 kg ha <sup>-1</sup>	Spring 100 kg ha <sup>-1</sup>	Spring 100 kg ha <sup>-1</sup>	Spring 100 kg ha <sup>-1</sup>
		0.4 380.73	0.4 380.73	0.2 380.73	0.2 380.73
Flax I	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 100-150-75-0	Sow.+Top dress 70-100-50-0	Sowing 100-150-75-0	Sow.+Top dress 70-100-50-0
		1.1 202.19 1.5 0.5 202.19	1.0 202.19 1.5 0.5 202.19	0.9 202.19 1.5 0.3 202.19	0.7 202.19 1.5 0.3 202.19
Flax I	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Late summer/autumn	Late summer/autumn	Late summer/autumn	Late summer/autumn
		0.8 825.55 5.4 20	0.7 825.55 4.1 20	0.6 825.55 6.8 20	0.5 825.55 5.7 20
Wheat II	<u>Tillage</u> Plough and disk harrow: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm	No tillage	0-25 cm	No tillage
		2.1 883.32		1.6 883.32	
Wheat II	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 230 kg ha <sup>-1</sup>	Autumn 250 kg ha <sup>-1</sup>	Autumn 180 kg ha <sup>-1</sup>	Autumn 180 kg ha <sup>-1</sup>
		0.4 380.73	0.5 380.73	0.2 380.73	0.3 380.73
Wheat II	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sow.+Top dress. 100-140-0-0	Sow.+Top dress. 50-65-0	Sow.+Top dress. 100-130-0-0	Sow.+Top dress. 50-65-0-0
		1.1 202.19 0.27 0 0.5 202.19	1.0 202.19 0.27 0 0.5 202.19	0.9 202.19 0.27 0 0.3 202.19	0.7 202.19 0.27 0 0.3 202.19
Wheat II	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield marketable product (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%): Yield straw (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer	Spring/Summer	Spring/Summer	Spring/Summer
		0.8 825.5 3.8 16.0 2.3 13 1.5 20	0.7 825.55 3.2 16.0 1.9 13 1.3 20	0.6 825.55 4.6 16.0 2.8 13 1.8 20	0.5 825.55 3.5 16.0 2.1 13 1.4 20
Pea III	<u>Tillage</u> Cultivator: h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	0-25 cm	0-15cm	0-25 cm	0-15 cm
		1.2 323.50	0.8 323.50	0.9 323.50	0.7 323.50
Pea III	<u>Sowing</u> Season: Amount: Seed drill h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Autumn 200 kg ha <sup>-1</sup>	Autumn 200 kg ha <sup>-1</sup>	Autumn 180 kg ha <sup>-1</sup>	Autumn 180 kg ha <sup>-1</sup>
		0.4 380.73	0.4 380.73	0.2 380.73	0.2 380.73
Pea III	<u>Crop practices</u> Fertilization: Amount (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O-CaO) kg ha <sup>-1</sup> : Fertilizer distributor h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Herbicides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Pesticides (kg ha <sup>-1</sup> yr <sup>-1</sup> of a.p.): Crop sprayer h ha <sup>-1</sup> : MJ h <sup>-1</sup> :	Sowing 0-100-0-0	Sowing 0-70-0-0	Sowing 0-100-0-0	Sowing 0-70-0-0
		0.9 202.19 0.27 0.5 202.19	0.7 202.19 0.27 0.5 202.19	0.6 202.19 0.27 0.3 202.19	0.5 202.19 0.27 0.3 202.19
Pea III	<u>Harvest</u> Season: Combine harvester: h ha <sup>-1</sup> : MJ h <sup>-1</sup> : Yield (t ha <sup>-1</sup> yr <sup>-1</sup> ): Water content (%):	Spring/Summer	Spring/Summer	Spring/Summer	Spring/Summer
		0.8 825.55 7.6 18/24	0.7 825.55 7.1 18/24	0.6 825.55 8.3 18/24	0.5 825.55 7.6 18/24