



# List of the future non food crops as it was recorded in 4F CROPS project

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# Market potential based on present production data (Eurostat 2005)

	<i>Number of product categories</i>	<i>Percentage product categories registered</i>	<i>Total registered value* (billion €)</i>	<i>Present share Biobased ** (billion €)</i>	<i>Commodities</i>	<i>Crops</i>
Materials from biomass	323	78%	250.6	187.7	?	?
Substances from biomass	101	60%	47.9	23.2	?	?
Building blocks from biomass	356	33%	155.2	34.5	?	?
Totals	780	55%	453.7	245.3	?	?

\* excluding the confidential data

\*\* of the non-food, non-feed component, based on expert judgement

# NON FOOD CROPS

The term **non food crops** should apply to the use of agricultural crop for uses other than human (as [food](#)) or animal consumption (as [feed](#)). They include:

- **Energy crops:** crops grown for direct heat/power generation (e.g. coppiced willow) or a feedstock for liquid fuels (e.g. oilseed rape for biodiesel, cereal and beet crops for bioethanol).
- **Pharmaceutical-crops** (or pharma-crops): crops (plant, animal, microbial), largely in development at present, grown for the production of pharmaceuticals or their precursors, e.g. vaccines, antibodies or therapeutic proteins.
- **Other non-food crops:** crops grown for other purposes of which examples include: fibres (cotton, hemp, flax etc), lubricants and waxes (oilseed rape, mustard, linseed), printing inks (oil seed rape) essential oils and dyes, compostable plastics (starch-crops).

# NON FOOD CROPS

A non food product may be obtained from:

- **A food/feed crop** (i.e. silage maize used for biogas production; biodiesel from rapeseed, ethanol from sugar cane and sugar beet, etc.)
- **A variety** bred for a non food product derived **from a food crop** (flax bred for fiber other than oil)
- **A crop used for non food purposes** (cotton, hemp)
- **A new species grown for non food product** (*Arundo donax*, *Miscanthus*, *Brassica carinata*, etc.)

# NON FOOD CROPS

According to the agronomic and breeding development the crops (food/feed and non food) for non food products suited to European Union soil and climatic conditions have been classified as

**Old (conventional) crops**: when exists a sufficient number of varieties, agronomic management is well known and agricultural machinery has been developed

**New crops (species)**: when no or scarce breeding activity was carried out, agronomic management is still under research activity and agricultural machinery was not yet developed

# List of crops (food/feed and non food) for non food products suited to European Union soil and climatic conditions

## Oil crops

*Old crops:* rapeseed, linseed, hemp, cotton, sunflower, castor bean, safflower

*New Crops:* *Brassica carinata*, cardoon, *Crambe abyssinica*, *Brassica juncea*, *Sinapis alba*

## Starch and sugar crops

*Old crops:* wheat, barley, triticale, oats, rye, maize, potato, sugar beet, grain sorghum, Jerusalem artichoke

*New crops:* sweet sorghum

# List of crops (food/feed and non food) for non food products suited to European Union soil and climatic conditions

## Fiber and cellulose crops

*Old crops:* flax, cotton, hemp, kenaf

*New crops:* fiber sorghum, *Arundo donax*

## Lignocellulosic crops

*Old crops:* hemp, kenaf

*New Crops:* Poplar, Willow, Eucaliptus, *Arundo donax*, miscanthus, switchgrass, cardoon, fiber sorghum, reed canary grass, Castor bean, *Phragmites* spp., *Saccharum aegyptiacum*, *Sida hermaphrodita*

# Plant-derived pesticides

(Carruba and Torre, 2003)

Family (species number)	Utilized part	Family (species number)	Utilized part
<i>Anacardiaceae</i> (1)	E	<i>Liliaceae</i> (4)	B
<i>Annonaceae</i> (1)	L, F	<i>Malvaceae</i> (1)	E
<i>Apiaceae</i> (2)	E	<i>Meliaceae</i> (3)	E, S
<i>Apocinaceae</i> (3)	E, L	<i>Mirtaceae</i> (1)	R
<i>Araceae</i> (4)	E	<i>Papaveraceae</i> (1)	E
<i>Asteraceae</i> (12)	E, Fl, R	<i>Pedaliaceae</i> (1)	S
<i>Brassicaceae</i> (2)	S, E	<i>Polygonaceae</i> (1)	E
<i>Celastraceae</i> (3)	E, R	<i>Rubiaceae</i> (2)	R
<i>Chenopodiaceae</i> (1)	L	<i>Rutaceae</i> (2)	S
<i>Ericaceae</i> (1)	Fl	<i>Simarubaceae</i> (4)	E, W
<i>Labiatae</i> (8)	E	<i>Solanaceae</i> (3)	S, F, L, E
<i>Leguminosae</i> (7)	P, R, S		

E= extracts; L= leaves; F= fruits; R= roots; Fl=flowers; P=pods; S= seeds;  
B=bulbs; W=wood



# Plant-derived antifeedants that inhibits normal feeding behaviour of pests

Family (species number)	Active compounds	Family (species number)	Active compounds
<i>Amarillidaceae</i> (2)	A	<i>Labiatae</i> (20)	D
<i>Apiaceae</i> (5)	Se, S	<i>Leguminosae</i> (6)	F, I
<i>Aracesa</i> (1)	A	<i>Piperaceae</i> (2)	L
<i>Asteraceae</i> (17)	S, A, C	<i>Plumbaginaceae</i> (1)	N
<i>Cannaceae</i> (2)	n.a.	<i>Polygonaceae</i> (2)	S
<i>Chenopodiaceae</i> (2)	A, n.a.	<i>Rutaceae</i> (5)	n.a., C
<i>Convolvulaceae</i> (3)	A, n.a.	<i>Solanaceae</i> (3)	A, F
<i>Cruciferae</i> (1)	T	<i>Verbenaceae</i> (6)	D

A= alkaloids; Se= sesquiterpens; T= terpens; S= steroids; A=asarons;  
 C=coumarins; D= diterpens; T= triterpens; F= flavonoids; I= isoflavonoids;  
 L=lignans;

n.a.=not available information

# Brassicaceae

- *Brassica carinata*
- *Brassica rapa*
- *Sinapis alba*
- *Crambe abyssinica*
- *Brassica campestris*
- *Brassica juncea*
- *Brassica nigra*

*Habitus:* annual

*Growing season:* fall-spring

*Sowing time:* fall

*Thermal requirements:* 5-30° C

Oil with high erucic acid



# *Brassicaceae*

- ✓ Native of Mediterranean countries
- ✓ No need of vernalization
- ✓ the growing season end in April (Crambe) and June (Brassica): 150-190 days
- ✓ Earlier flowering than rapeseed
- ✓ No pod shatter
- ✓ Seed yield: between 2 and 3.5 t ha<sup>-1</sup>
- ✓ Seed oil content between 25% and 45%
- ✓ Erucic acid content between 30% and 45%



**Brassica juncea**



**Brassica napus**

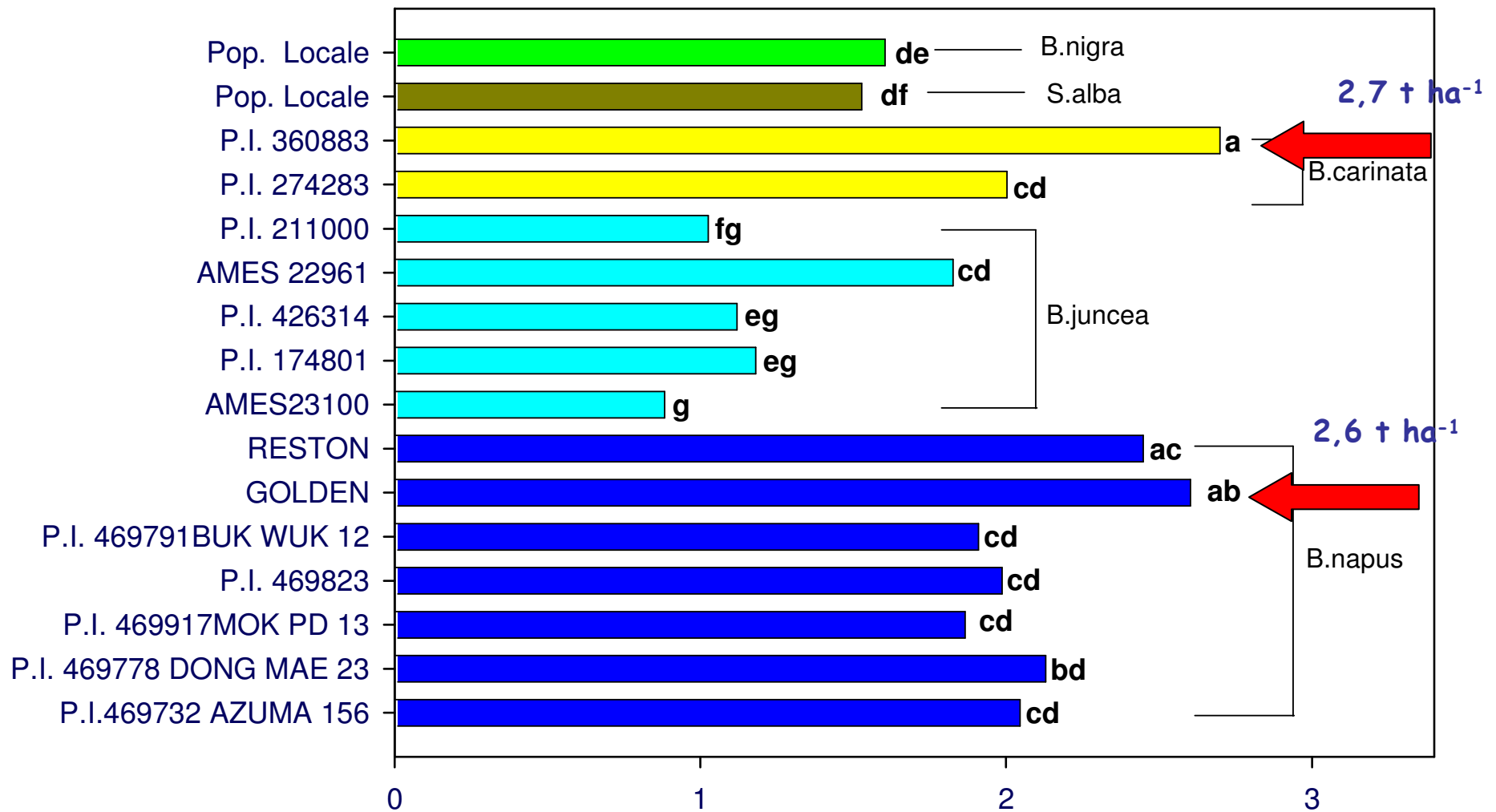


**Brassica nigra**

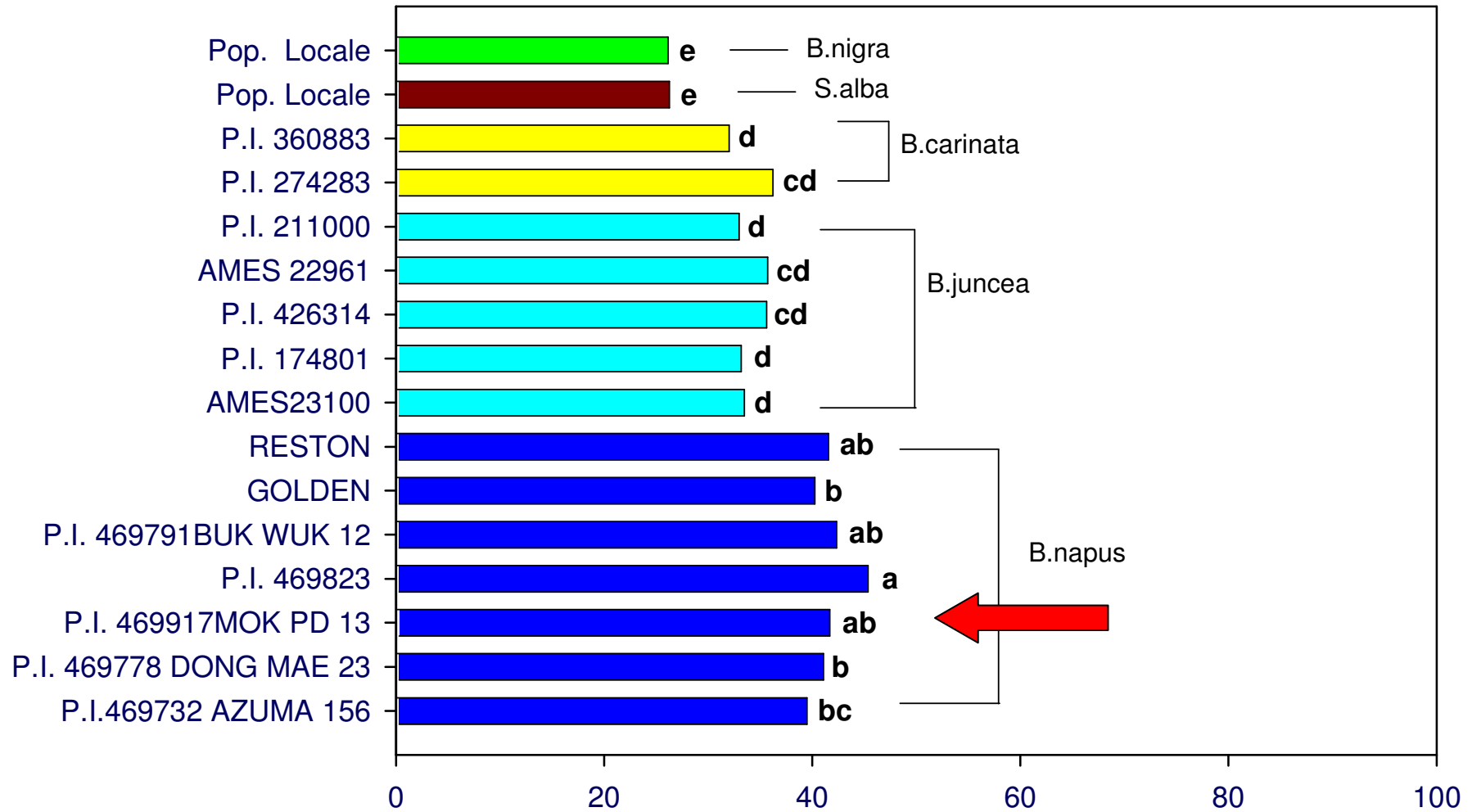


**Brassica carinata**

# Brassicaceae: Seed yield (t ha<sup>-1</sup>)



# Brassicaceae: Oil content (%)

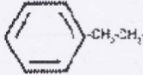
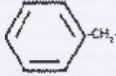
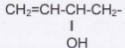


# Glucosinolates-containing plants in biofumigation

- Enzymatic hydrolysis of glucosinolates (GLs): the typical defensive system of the *Brassicaceae* families

- *Rapistrum rugosum*
- *Brassica juncea*
- *Brassica nigra*
- *Eruca sativa*

Table 1 – Chemical characteristics of some common glucosinolate side chains.

Glucosinolate (common name)	Glucosinolate (Structure of the chain)	Species of origin (ripe seeds)
NASTURTIN		<i>Barbarea verna</i> ISCI 100
TROPAEOLIN		<i>Lepidium sativum</i> ISCI 101
SINIGRIN	CH <sub>2</sub> =CH-CH <sub>2</sub> -	<i>Brassica juncea</i> ISCI 20
NAPIN	CH <sub>2</sub> =CH-CH <sub>2</sub> -CH <sub>2</sub> -	<i>Brassica rapa</i> cv. Silla
CHEIROLIN	CH <sub>3</sub> -SO <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	<i>Rapistrum rugosum</i> ISCI 4
ERUCIN	CH <sub>3</sub> -S-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	<i>Eruca sativa</i> cv. Nemat
IBERIN	CH <sub>3</sub> -SO-CH <sub>2</sub> -CH <sub>2</sub> -CH <sub>2</sub> -	<i>Iberis amara</i> cv. Eisberg
EPI-PROGOITRIN		<i>Crambe abyssinica</i> cv. Mario

- Amending soil with these biocidal compounds by contrasting nematocidal activity

# Flax (*Linum usitatissimum* L.)



- **Climate zone:** Pannonian, Continental, Atlantic, Lusitanian, Mediterranean N & S
- **Temperature requirement:** 8-22 °C
- **Growing season:** spring – summer (Central North Europe); autumn – winter – spring (South of Europe)
- **Constraints of cultivations:** None
- **Yield:** 6 – 11 t ha<sup>-1</sup> of straw; 0.69 – 1.69 t ha<sup>-1</sup> of seed
- **Fiber Characteristics:** mainly long fibers, able to absorb up to 12% of its own weight in water. The fibre are twice as strong as those of cotton and five times as strong as those of wool.
- **Uses:** The longer fibres are used for spinning into yarn and weaving, knitting and geo-textiles.

# Flax (*Linum usitatissimum* L.)

## Technical application of flax fibres (Smeder et al., 1996)

Building materials	Polymer compounds	Geotextiles	Pulp and paper	Cellulose	Absorbent materials	Others
Insulation material for bulk insulation	Thermoplastic composites	Ground protection during construction	Newsprint	Carboxymethyl-cellulose	Diapers	Friction lining
Reinforcement of concrete	Thermoset composites	Weed control	Printing and writing paper	Viscose fibres	Sanitary towels	Gaskets
Particle board	Rubber composites	Gardening	Sack paper	Microcrystalline cellulose	Industrial wipes	Nonwovens
Fibre board	Construction composites	Road construction	Folding boxboard		Napkins	Filters
Gypsum wallboard		Erosion control mats	Recycled paper			Drain-pipes
Vinyl floor carpet			Liner and toplineer			
Acoustical damping materials			Tissue and fluff pulp			
			Fluting and middle of board			



# Hemp (*Cannabis sativa* L.)

**Family: *Cannabaceae***



- **Habitus:** annual
- **Climate zone:** Pannonian, Continental, Atlantic, Mediterranean North
- **Temperature requirement:** 10-35 °C
- **Flowering** with short photoperiod
- **Growing season:** spring - summer
- **Constraints of cultivations:** Social and legal problems; irrigation (in South of Europe)
- **Yield:** 12-20 t ha<sup>-1</sup>
- **25,000 diverse uses:** high quality paper, rope, twine, cloth, non woven material, geotextiles, strengthen cement blocks, fibreglass etc.

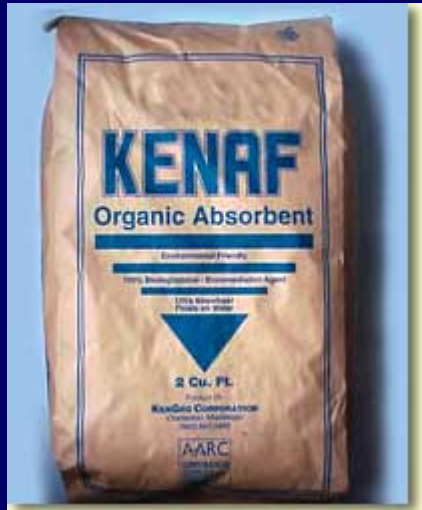
# Kenaf (*Ipiscus cannabinus* L.)

**Family: *Malvaceae***



- **Habitus:** annual
- **Climate zone:** Mediterranean North and South (with irrigation)
- **Temperature requirement:** 15-27 °C
- **Growing season:** spring - summer
- **Constraints of cultivations:** irrigation (500 -600 mm) in Med S
- **Yield:** 8-22 t ha<sup>-1</sup> above ground dry biomass
- **Products:** stem's outer bark with the long soft bast fibers useful for cordage and textiles. Bast fibers up 20 to 25% of the stem on a dry weight basis. Stalk yields from 8 to 12 t ha<sup>-1</sup>.
- **Uses:** cloths, rugs, rope, grass and erosion matt, kenaf-blend gred, core panels, composite with plastic polymers industry, fiber glass substitute, textile composite, animal bedding, particle board, industrial absorbent materials ecc.

# IL KENAF: prodotti ottenuti dal kenaf



Organic absorbent



Polymer compounds



Insulation material



bioplastic for Hi-tech



Cups

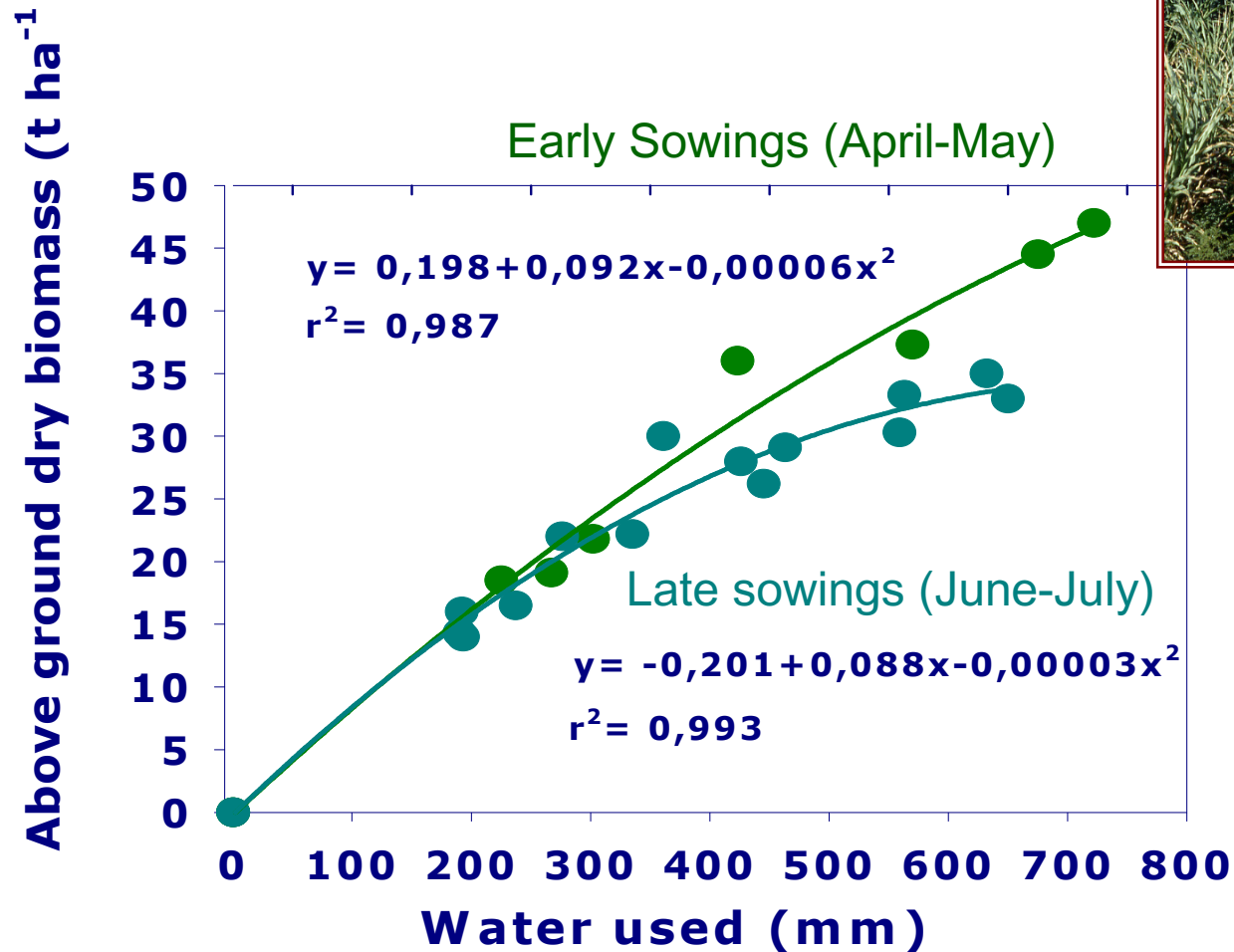
# Sweet and Fiber Sorghum (*Sorghum bicolor* L. Moench)

**Family: *Poaceae***

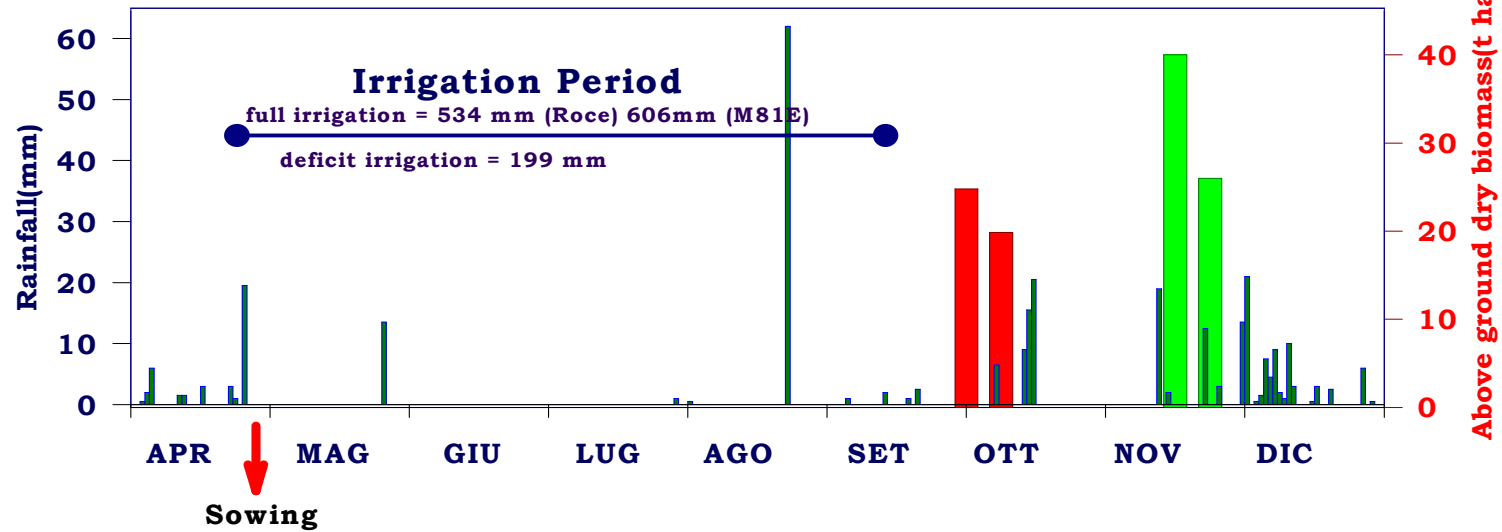
- **Habitus:** annual
- **Climate zone:** Continental, Lusitanian, Mediterranean North and South
- **Temperature requirement:** 12-40 °C
- **Growing season:** spring - summer
- **Constraints of cultivations:** irrigation in Mediterranean South (500 mm); few varieties
- **Yield:** 15-45 t ha<sup>-1</sup> (bioethanol 3000-6000 l ha<sup>-1</sup>)
- **Uses:** 1<sup>th</sup> and 2<sup>nd</sup> generation biofuel; particle board; pulp for paper



# Yield variation in relation to water used by sweet sorghum cv. Keller in field experiments in South of Italy (1991-1994)

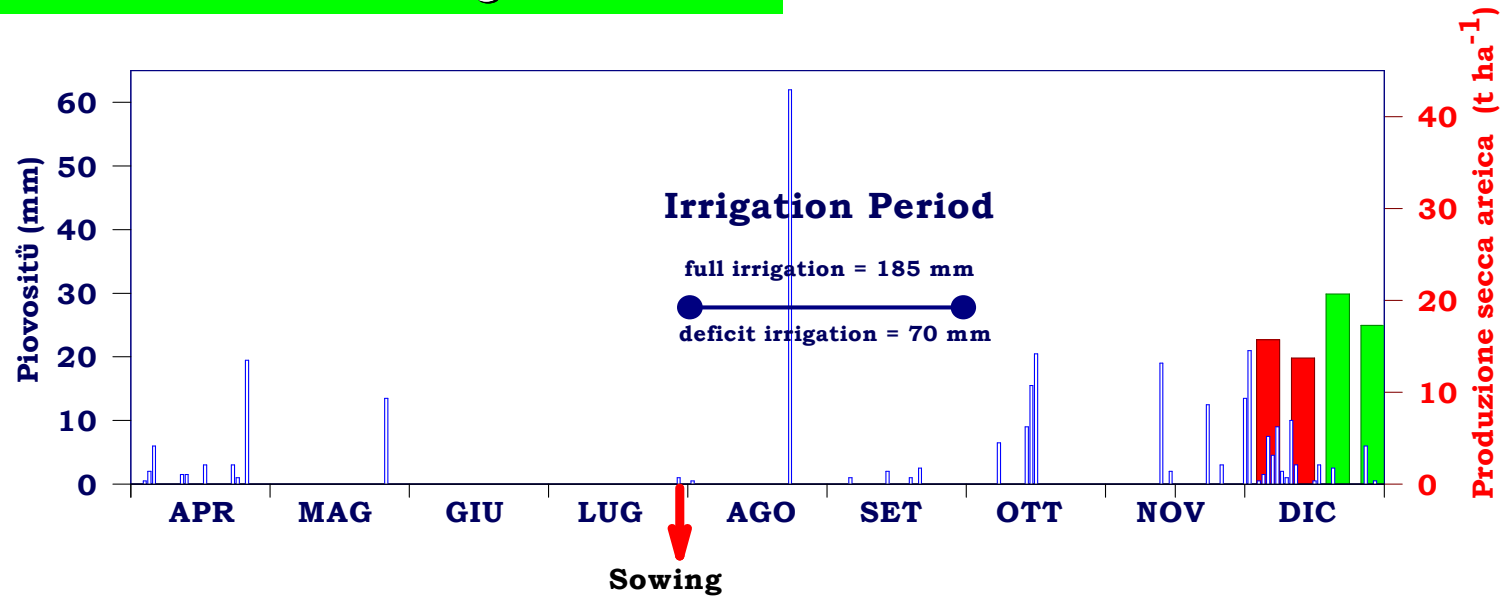


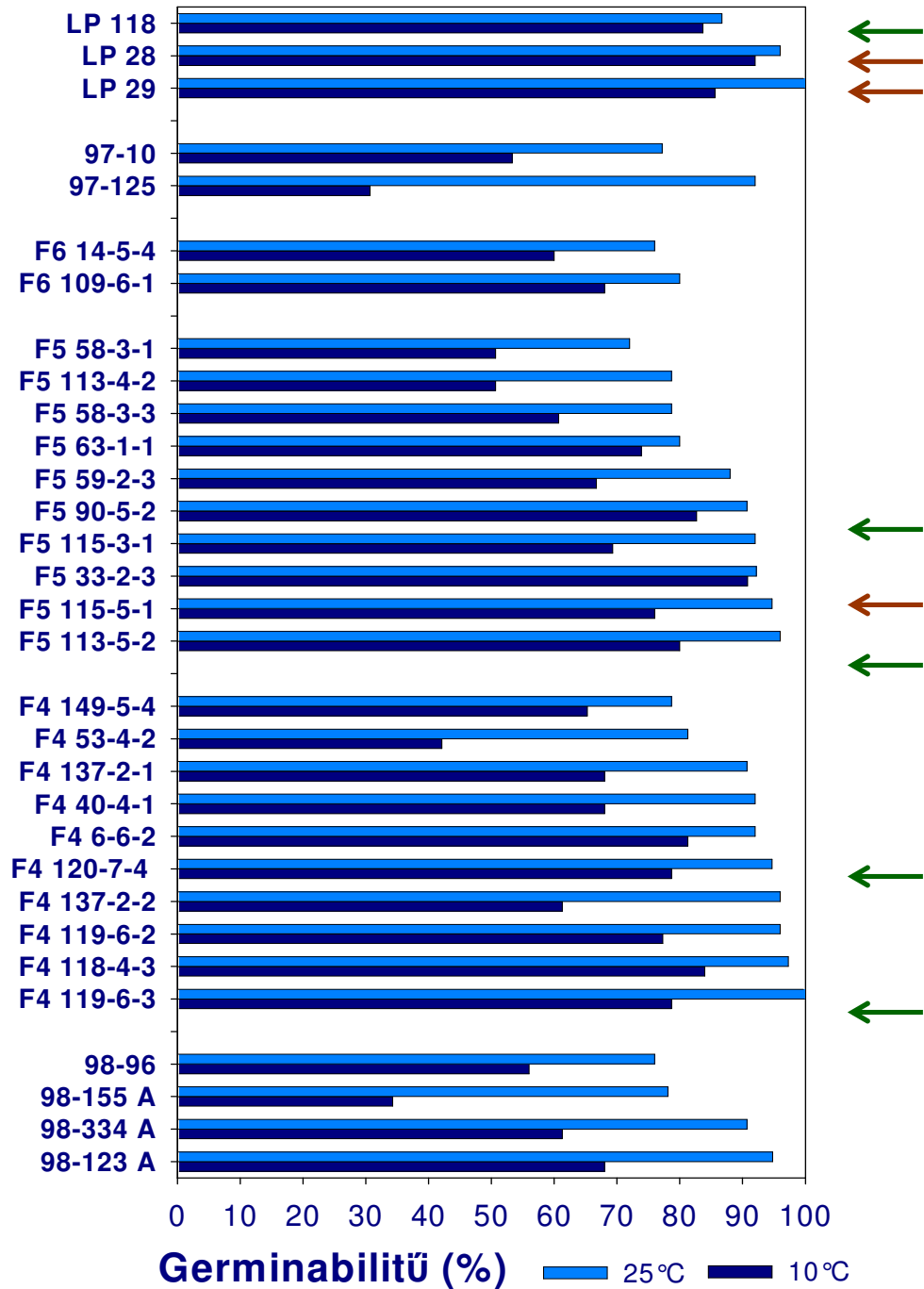
## Early Sowing



■ **Roce** ■ **M81E**

## Late sowing





## Sweet Sorghum

Selection of lines for germination at low temperature (10°C)



# Miscanthus spp.

**Family: *Poaceae***



- **Habitus:** perennial
- **Climate zone:** Continental, Pannonian, Atlantic, Mediterranean North and South
- **Temperature requirement:** 5-35 °C
- **Constraints of cultivations:** not resistant to cold in the year of transplanting; irrigation in Mediterranean South (500-900 mm); agamic propagation;
- **Yield:** 15-32 t ha<sup>-1</sup>
- **Uses:** biomass for heat and electricity; 2<sup>nd</sup> generation biofuel; sandwich materials with plastics or light metals;



*Miscanthus floridulus*



*Miscanthus x giganteus*



*Saccharum aegyptiacum*



*Miscanthus sinensis*

*Goliath*



*Clone 11*



# Produzione di biomassa secca aerea (kg m<sup>-2</sup>)



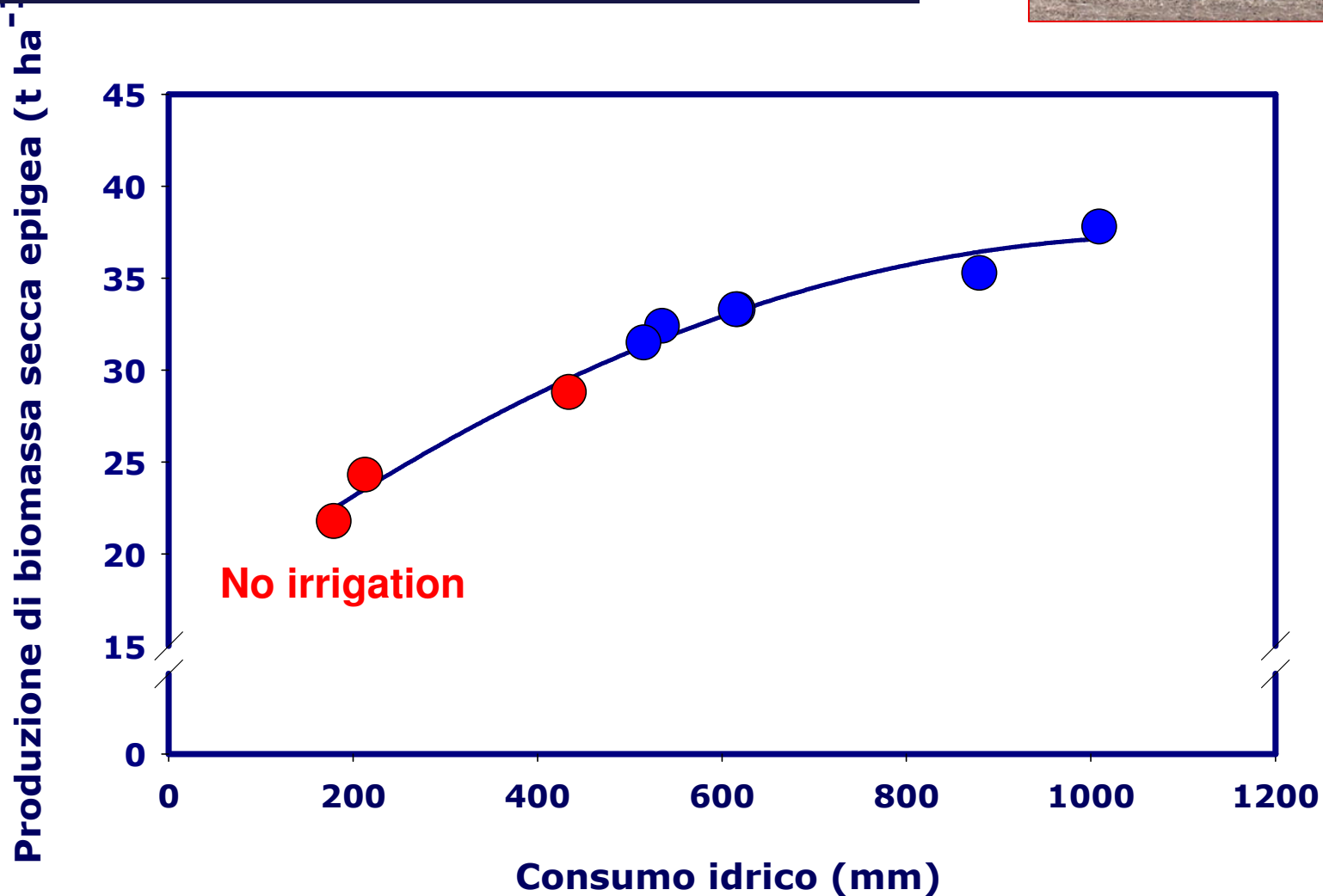
# Giant reed (*Arundo donax* L.)

## Family: *Poaceae*

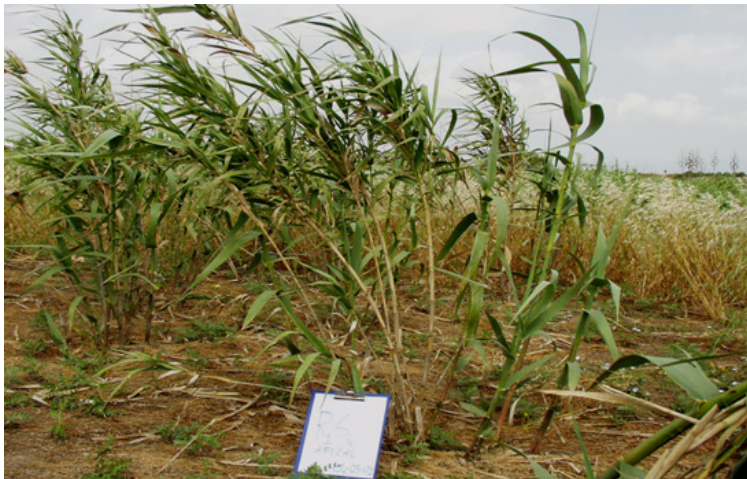
- **Habitus:** perennial
- **Climate zone:** Lusitanian, Continental, Mediterranean  
North and South
- **Temperature requirement:** 10-30 °C
- **Harvest time:** February
- **Constraints of cultivations:** irrigation in Mediterranean South (300 mm); agamic propagation;
- **Yield:** 15-42 t ha<sup>-1</sup>
- **Uses:** cellulose for paper, sandwich materials with plastics or light metals; biomass for heat and electricity; 2<sup>nd</sup> generation biofuel
- **Products:** In Italy, this crop was used to extract cellulose for pulp since 1930 already, when Snia-Viscosa established a trademark for the production process of cellulose pasta for the production of



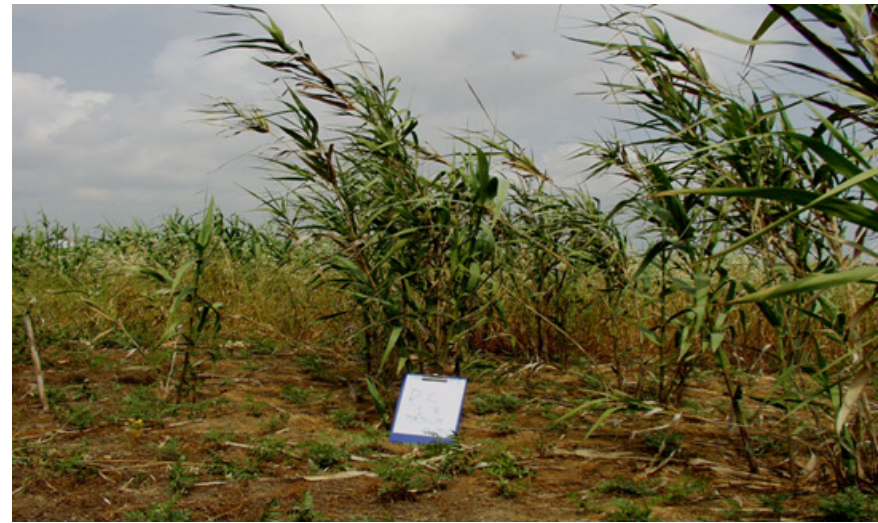
# Above ground dry biomass according to the water used in *Arundo donax* L



## Field propagation with stems or part of them



*Median portion*



*Apical portion*

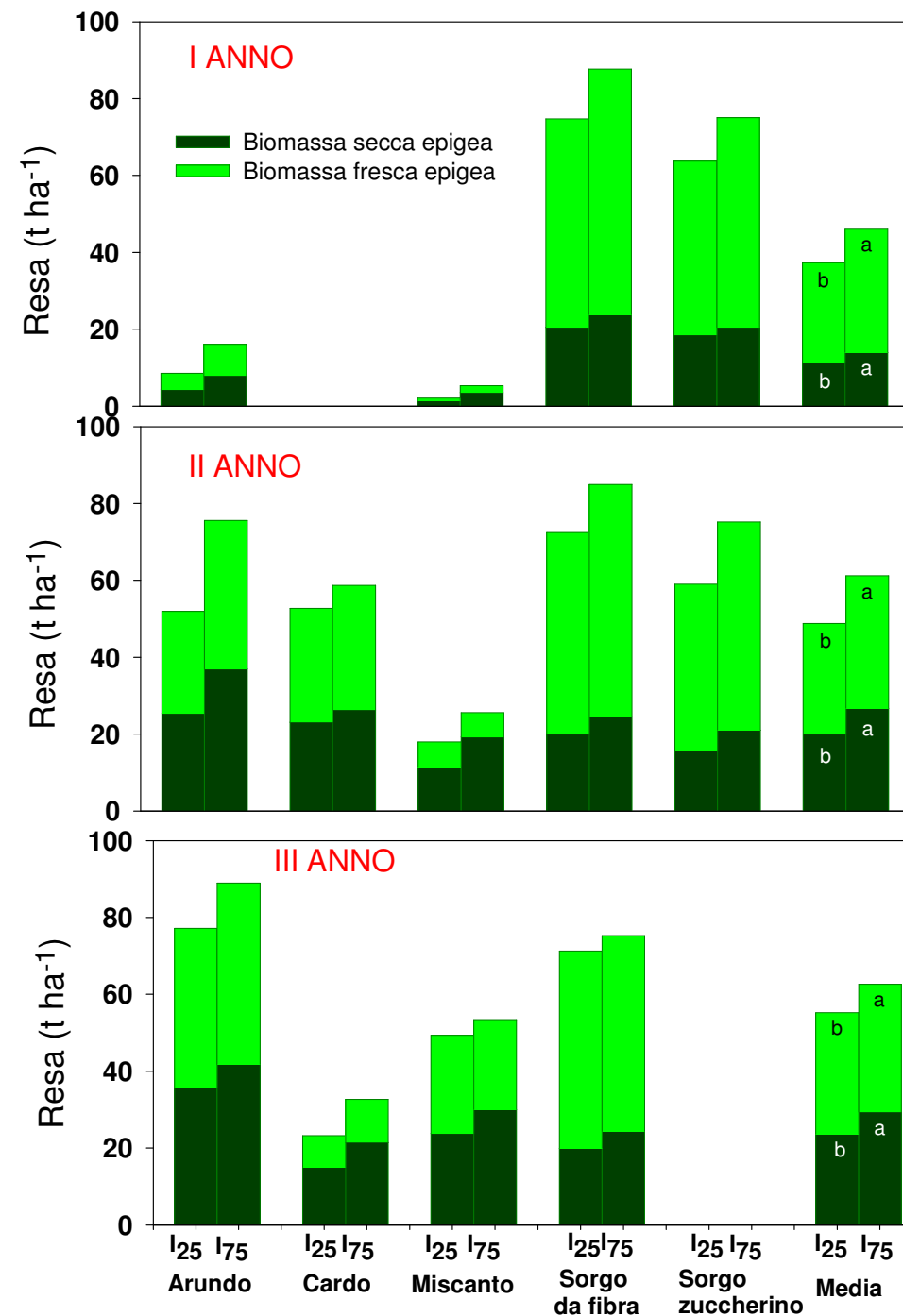
# Cardoon (*Cynara cardunculus* L.)

**Family: Asteraceae**



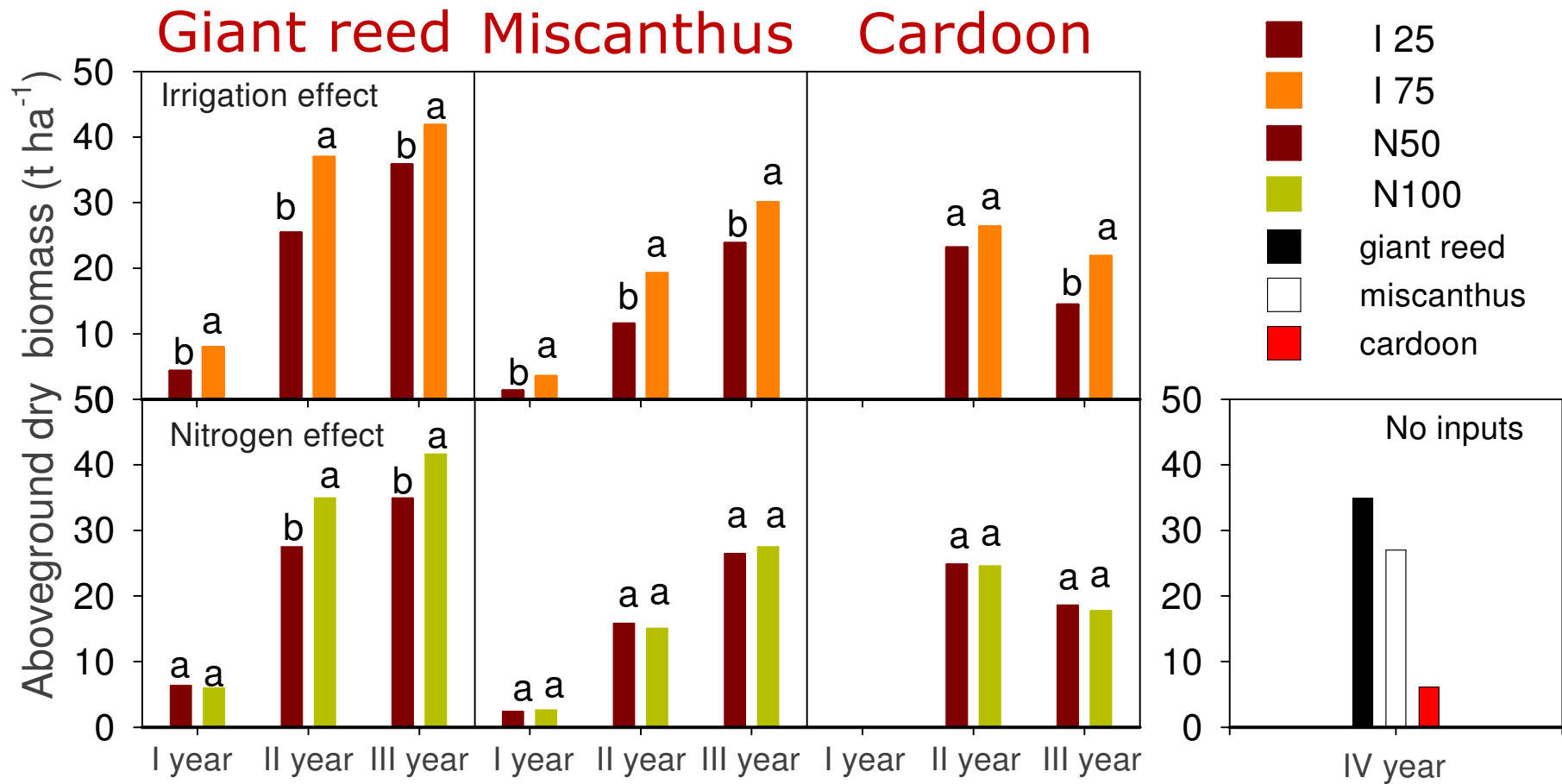
- **Habitus:** perennial
- **Climate zone:** Mediterranean North and South
- **Temperature requirement:** 5-30 °C
- **Growing season:** autumn – winter - spring
- **Constraints to cultivations:** None
- **Yield:** 8-22 t ha<sup>-1</sup>
- **Uses:**; 2<sup>nd</sup> generation biofuel; biomass for heat and electricity; biodiesel from oil in the seeds; roots rich in inulin

## Above ground dry biomass yield (t ha<sup>-1</sup>) in relation to irrigation





# Aboveground dry biomass





# Castor bean (*Ricinus communis* L.)

**Family: *Euphorbiaceae***



- **Habitus:** perennial
- **Climate zone:** Mediterranean North & South
- **Temperature requirement:** 5 - 35 °C
- **Constraints of cultivations:** genetic improvement, genotypes availability, harvesting
- **Yield:** 2-3 t ha<sup>-1</sup> of seed (50% seed oil); 15 -20 t ha<sup>-1</sup> of wood
- **Uses:** biodiesel, biomass for heat and electricity

# Topinambur (*Heliantus tuberosus* L.)

**Family: Asteraceae**



- **Habitus:** perennial
- **Climate zone:** Lusitanian, Mediterranean  
North and South
- **Temperature requirement:** 10-30 °C
- **Constraints of cultivations:** genotypes availability, invasive plant
- **Yield:** 10-15 t ha<sup>-1</sup> (5000 l ha<sup>-1</sup>)
- **Uses:** bioethanol

# Reed canary grass (*Phalaris arundinacea* L.)

**Family: *Poaceae***

- **Habitus:** perennial
- **Climate zone:** Pannonian, Continental, Atlantic,
- **Temperature requirement:** 5-23 °C
- **Constraints of cultivations:** invasive plant
- **Yield:** 12-15 t ha<sup>-1</sup>
- **Uses:** paper, biomass for heat; 2<sup>o</sup> generation Biofuel

