JatroMed 2nd International Workshop on Bioenergy for Enhancing Sustainable Development in Mediterranean Countries

Results of field research on energy crops in a Mediterranean environment with particular reference to oil crops

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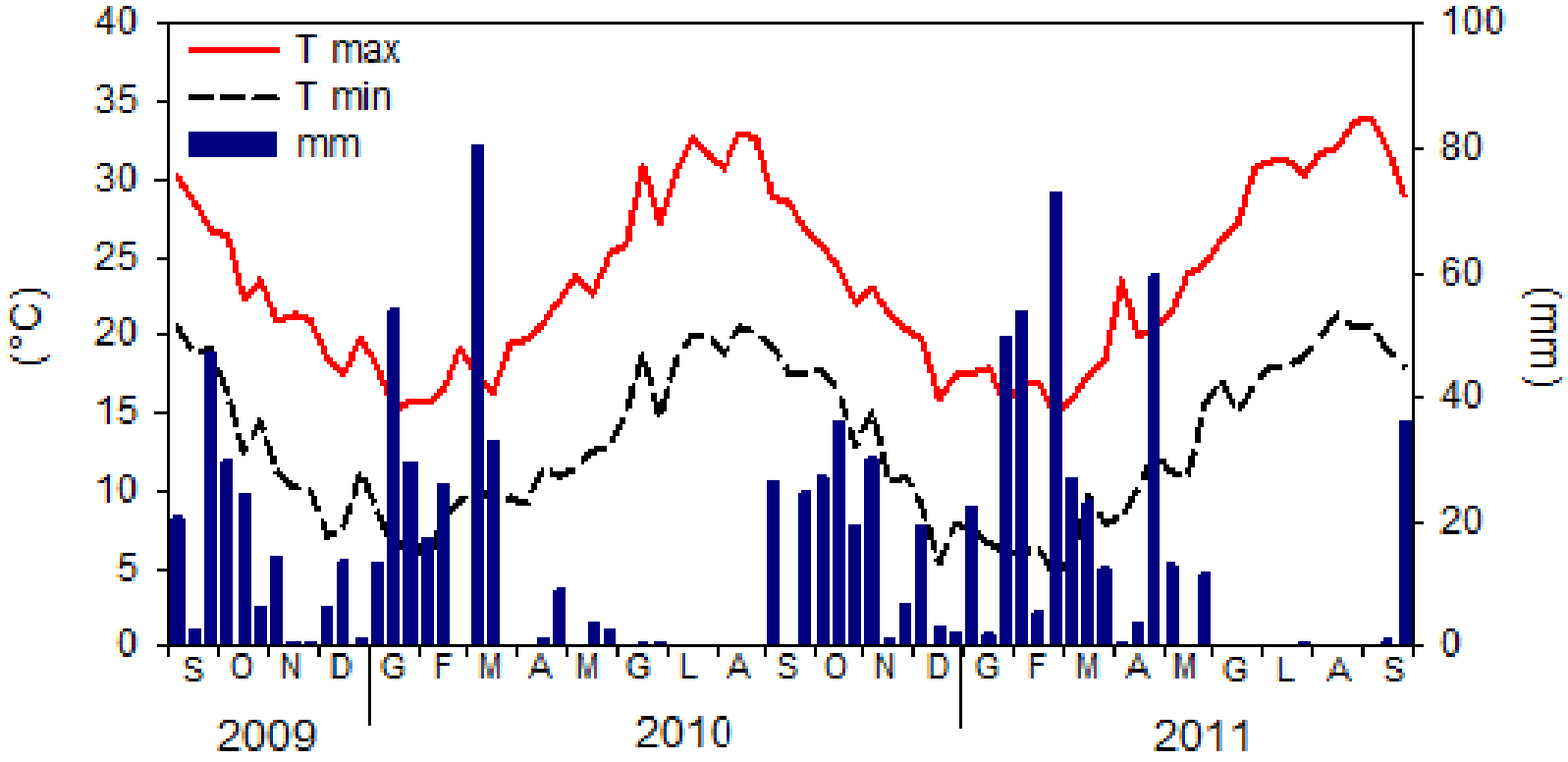
Algiers, 8th of May, 2014

FP7 Project: OPTIMA

- Title: Optimization of perennial grasses for biomass production in the Mediterranean environment
- Coordinator: prof . Salvatore Cosentino - University of Catania
- Collaborative projects
- Call:FP7 – KBBE-2011-5: Perennial grasses: optimising biomass production SICA
- Partners: 21, Europe, China, India, Argentina
- SME: 25% of budget
- Duration: 2011-2015

Weather in Sicily



Rainfall 2009-10 = 490 mm

Rainfall 2010-11 = 540 mm

Miscanthus floridulus

Miscanthus x giganteus

Saccharum aegyptiacum

Miscanthus sinensis

Cynara cardunculus

Sustainability of perennial lignocellulosic species

Many researches have shown the higher sustainability of perennial species as compared to annual species:

- Soil tillage limited to the year of crop establishment
- Long period with no tillage, reduces the risk of soil erosion
- Low demand for nutrient inputs due to nutrient recycle
- Low or no pesticide and herbicide demand
- Possible cultivation in marginal land

Techniques of propagation in giant reed (*Arundo donax* L.)

- Rhizomes

- Stems cuttings

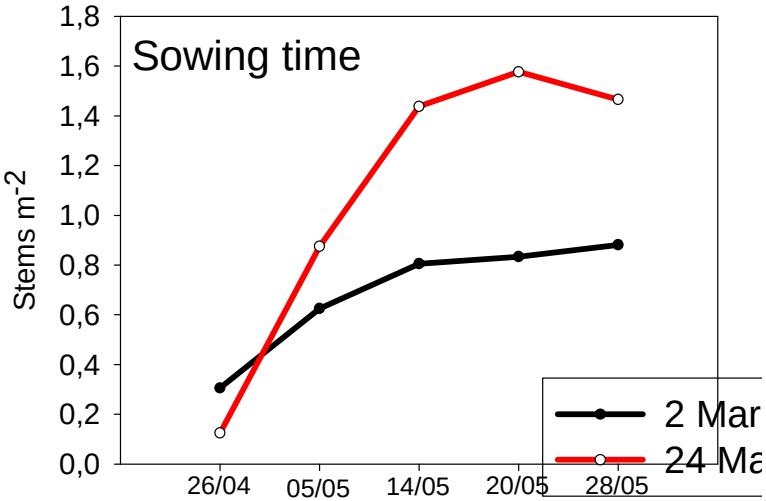
- 'In vitro' propagation

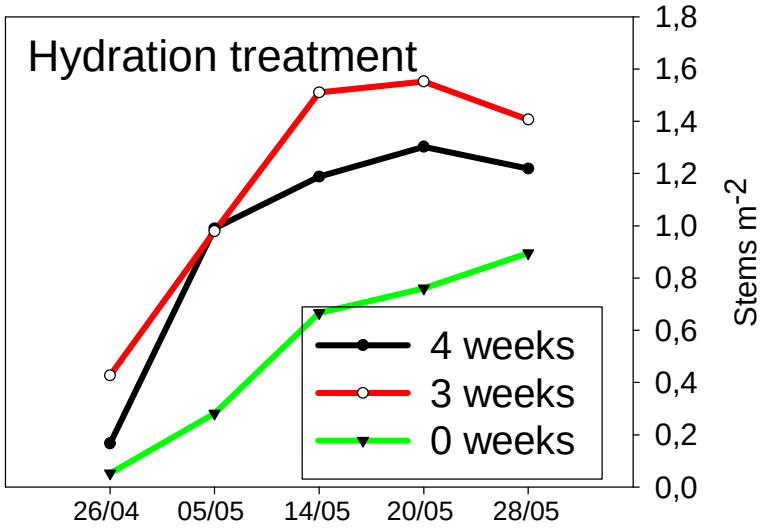
2007 - Sugar Cane propagation in Brazil

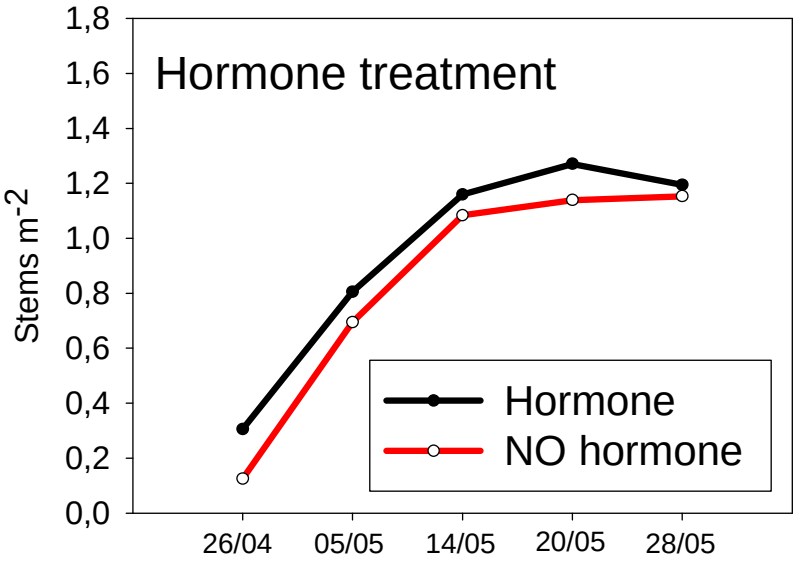

DEVELOPED WITH THE
SCIENTIFIC SUPPORT OF
CRA-ING
CRA
SPAPPERI

Mechanized transplanting in Winter- Spring

Paternò (CT)

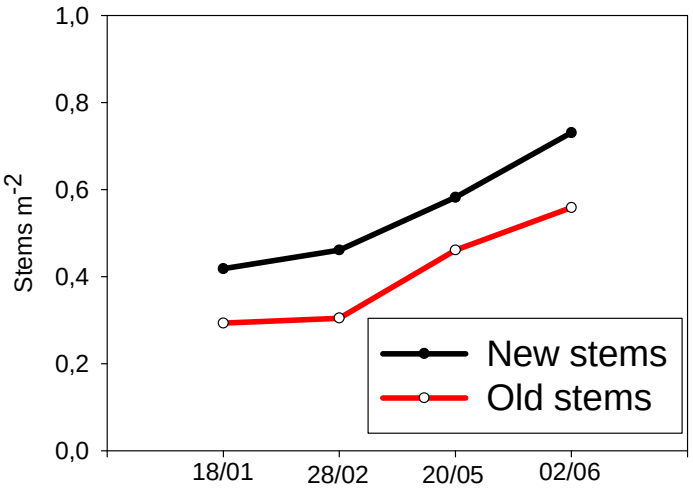


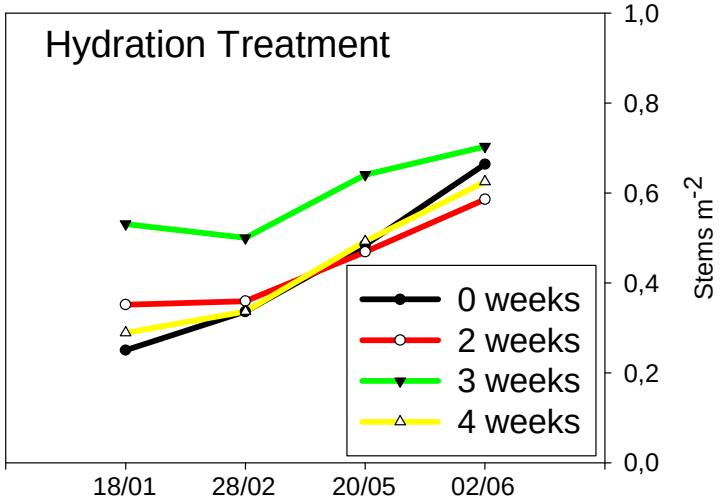


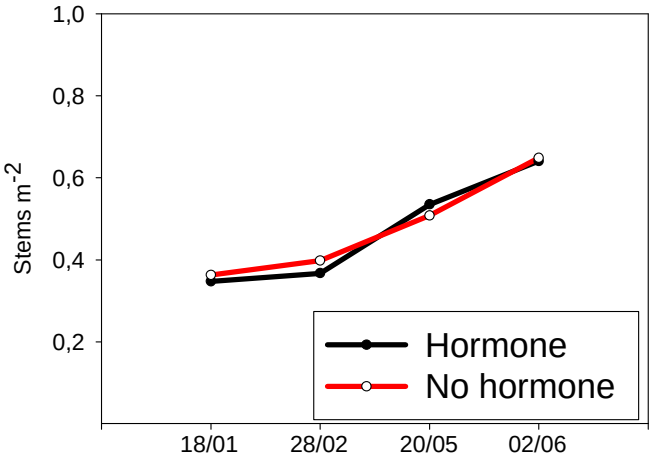


Mechanized transplanting in Autumn

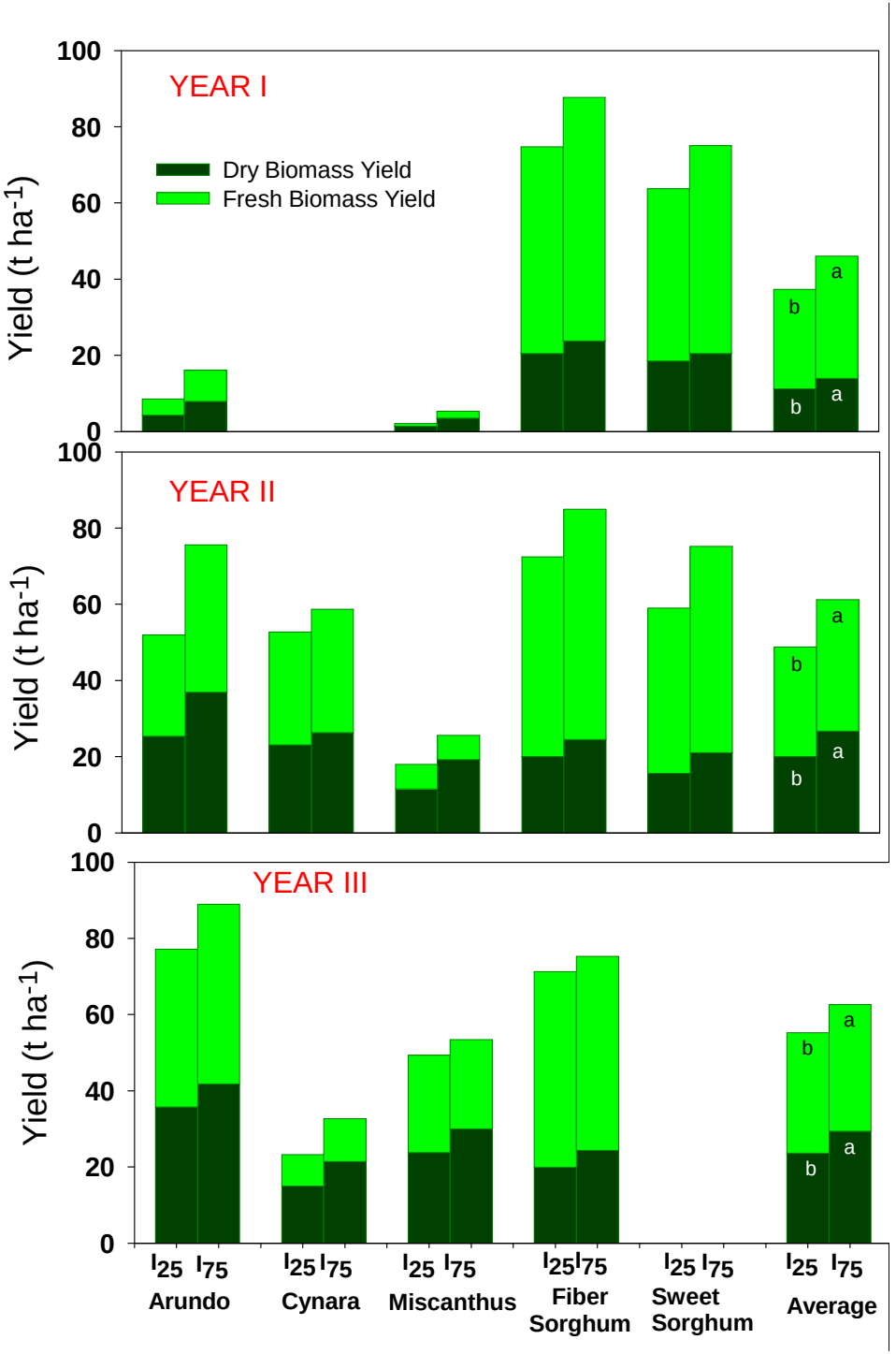
Catania





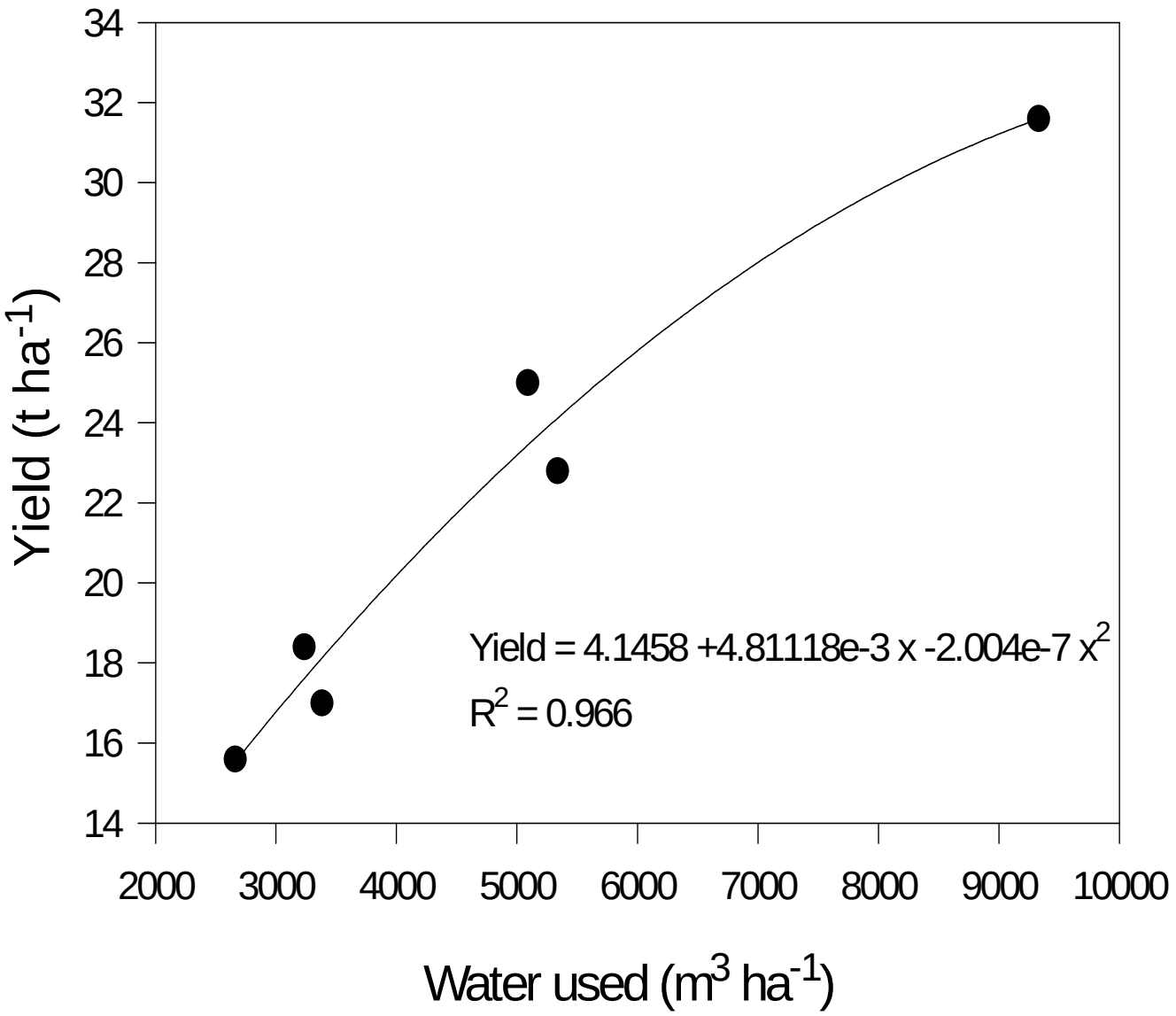


Biomass yield (t ha^{-1}) in relation to different soil water content

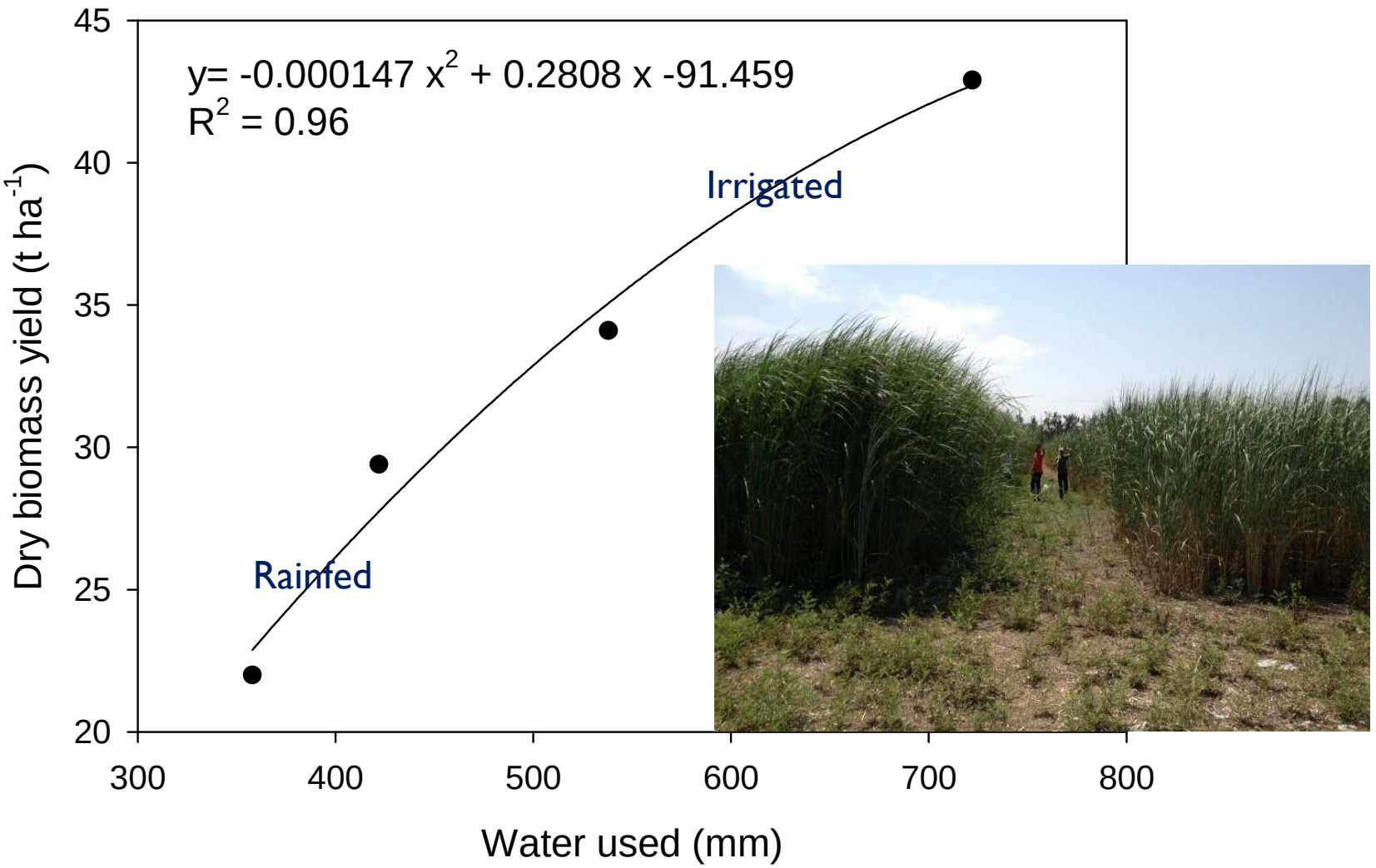


Arundo donax L. Dry biomass yield in relation to water used

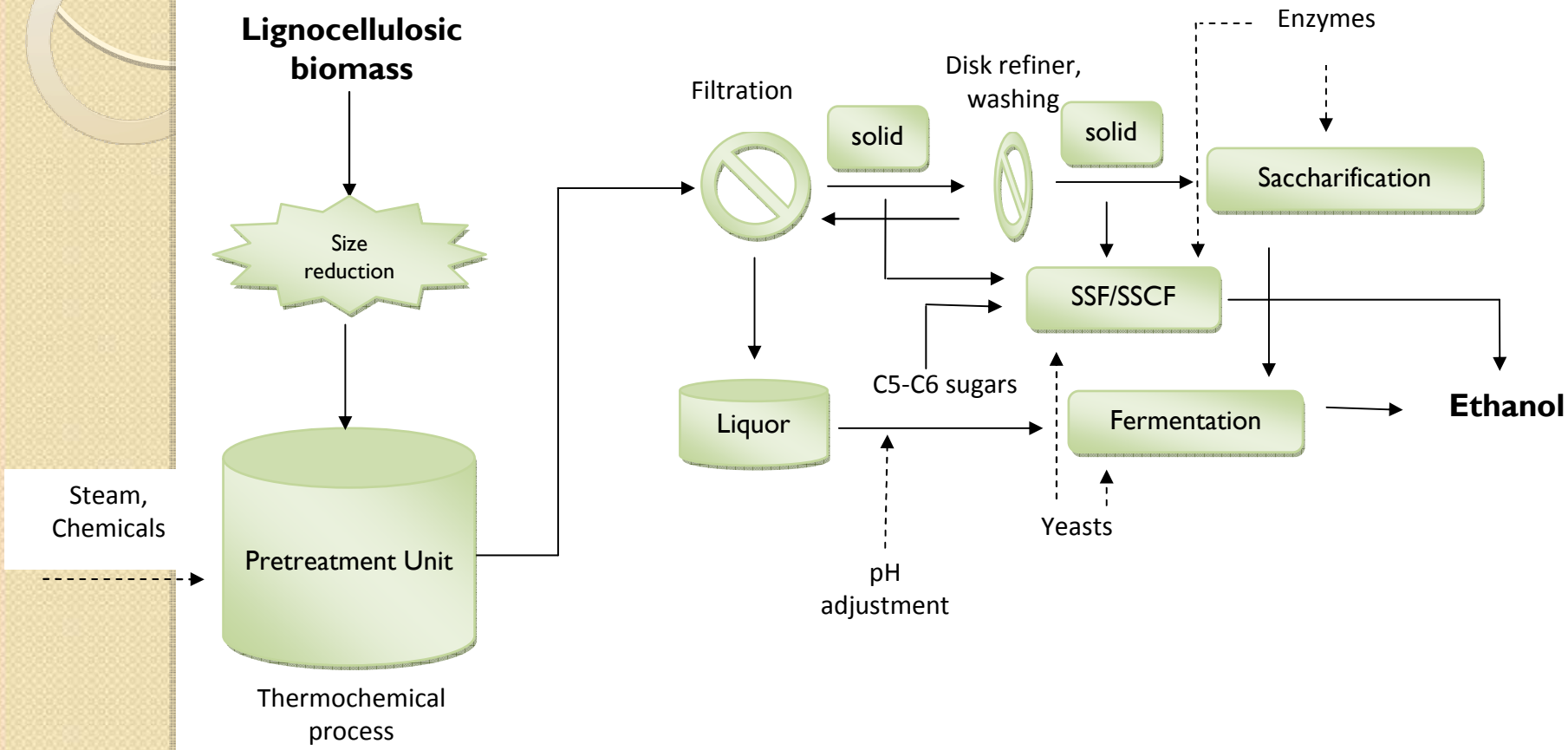
Miscanthus x Giganteus



Relation between dry biomass yield and water available during the growing season in *Saccharum aegyptiacum*

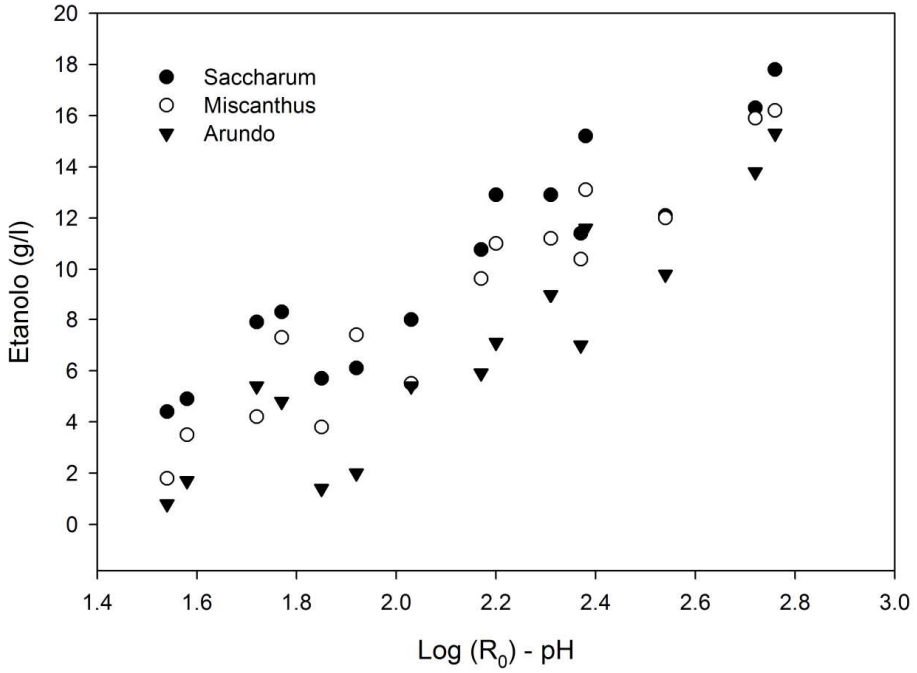


Second generation Bioethanol USDA FPL, Madison, WI, USA



Bioethanol Production Process
“USDA Forest Products Laboratory

Ethanol production versus combined severity factor [Log (R0) – pH] (only solid substrate)



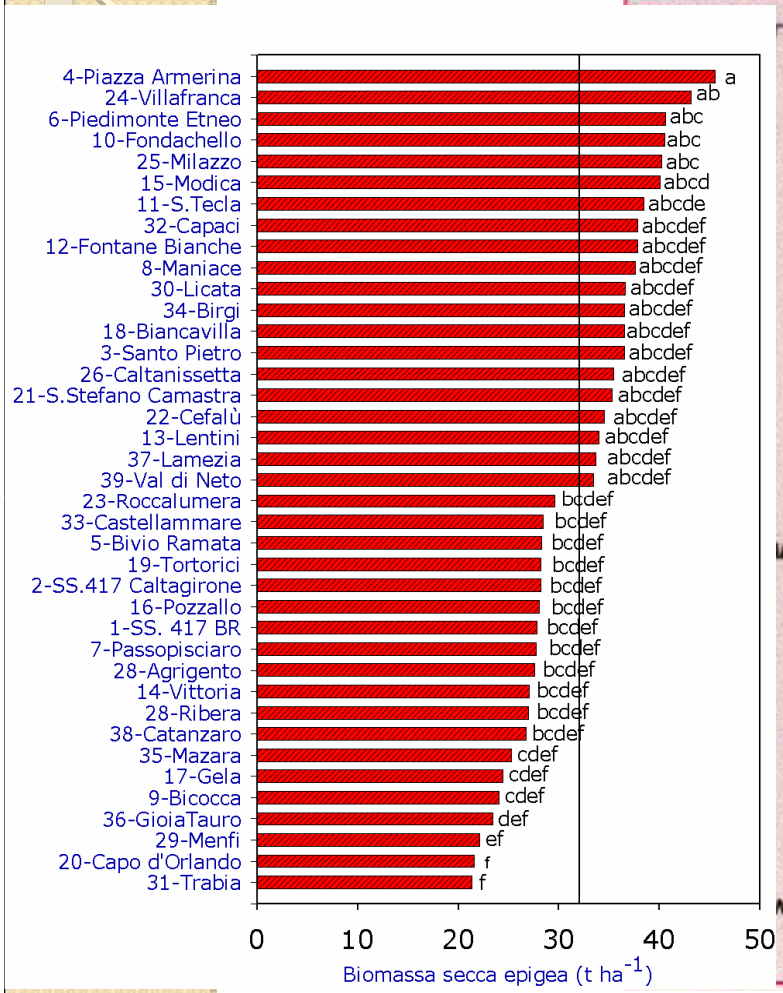
Severity Factor: Log (R0) = Log [t • exp (T - Tref)/14.75]

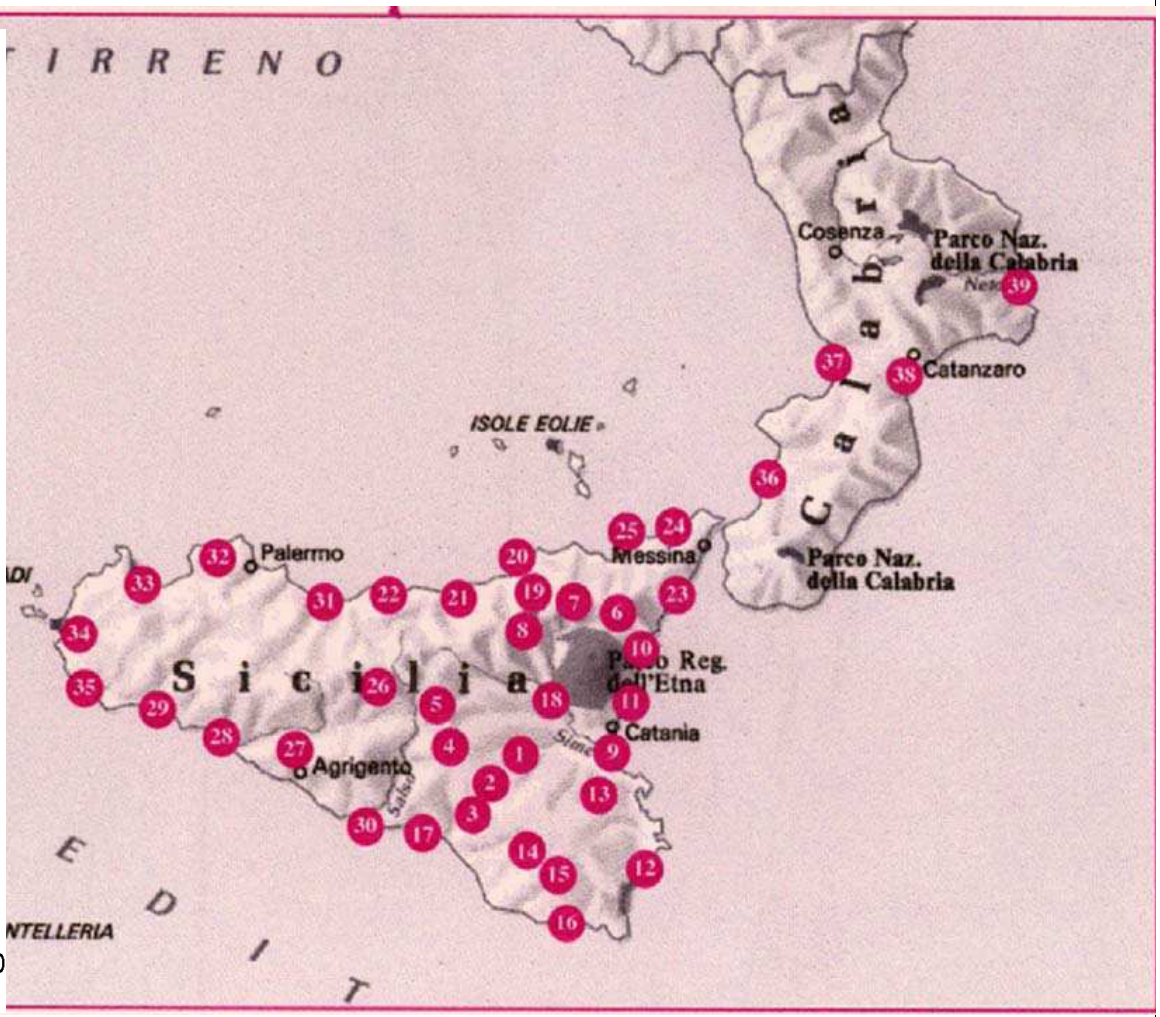
Combined Severity factor CS = Log (R0) – pH

Ethanol yields from 1 ton of d.m.

Feedstock	Theoretical/ obtained	C6 (l ton^{-1})	C5 (l ton^{-1})	Total (l ton^{-1})
Arundo	Theoretical	232	149	381
	Obtained	193	42	**235**
Miscanthus	Theoretical	273	146	419
	Obtained	205	47	**252**
Saccharum	Theoretical	247	159	406
	Obtained	225	53	**278**

Map of giant reed collection sites in Sicily and Calabria regions

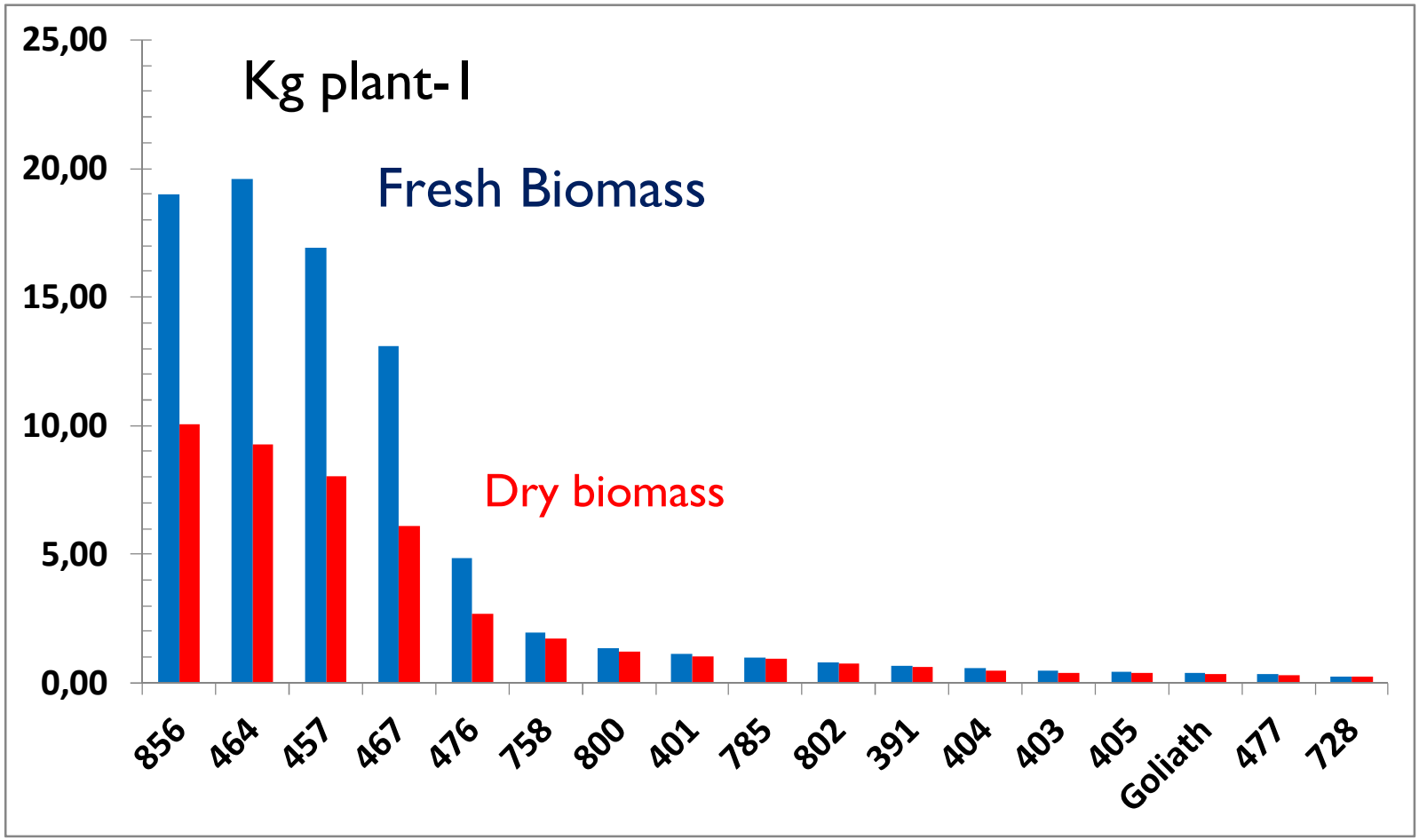




Cosentino et al., 2006

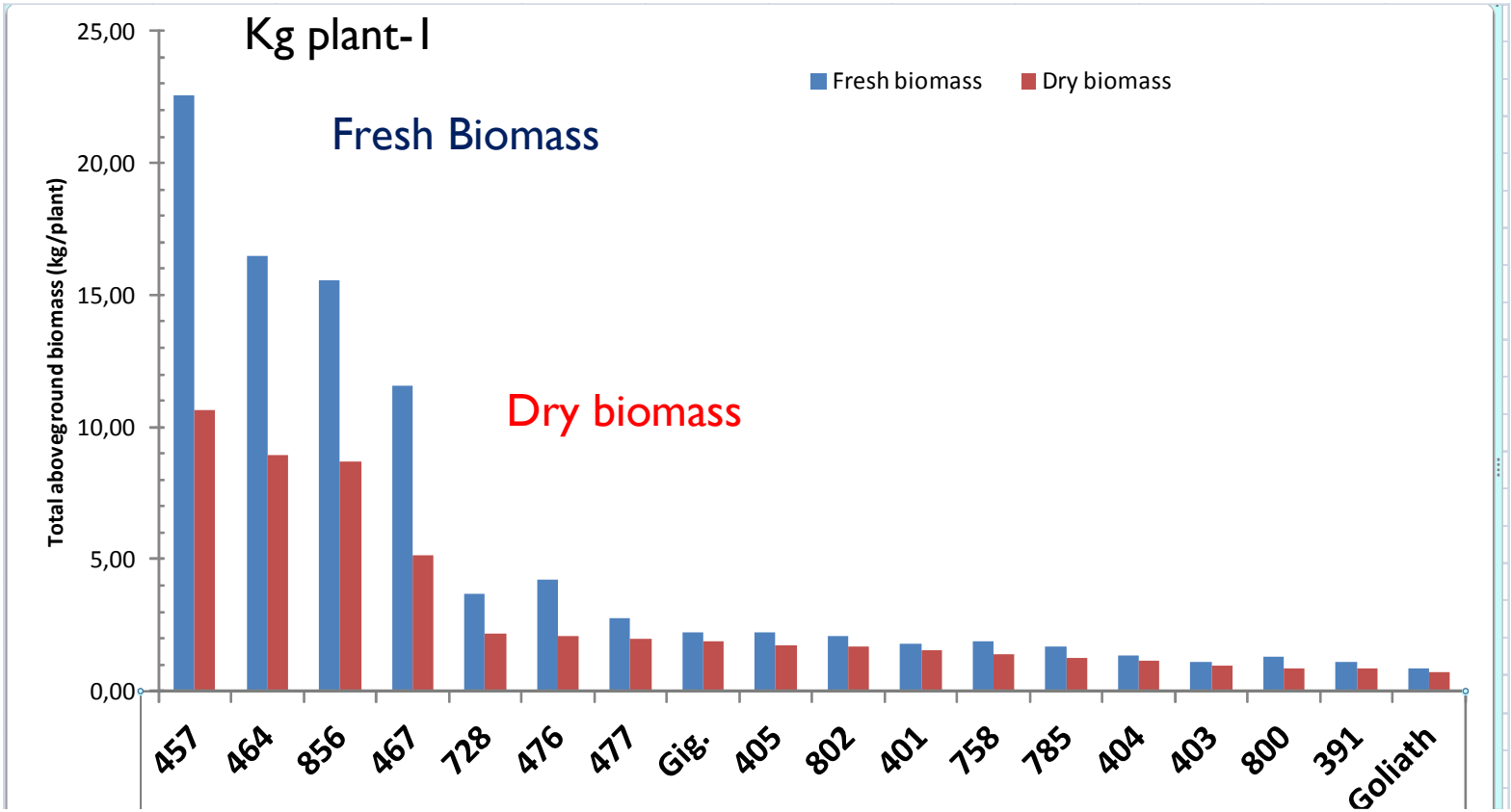
New Genotypes of Miscanthus – (IBERS, UK)

2010



New Genotypes of Miscanthus – IBERS, UK

2011



Yield score	9	8	8	8	6	6	5	5	5	5	5	5	5	4	4	4	4	3
Senesc. sc.	9	8	9	9	1	8	1	1	1	1	1	1	1	1	1	1	1	1

Miscanthus condensatus

856 464

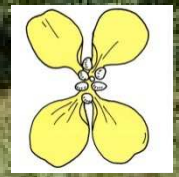
467 457

Studied Oil Crops for biodiesel production

- Rapeseed (*Brassica napus*)
- Ethiopian Mustard *(Brassica carinata)*
- *Brassica juncea*
- Linseed *(Linum usitatissimum)*
- Camelina *(Camelina sativa)*
- Safflower (*Cartamus tinctorius*)
- Castor bean *(Ricinus communis)*
- Cynara *(Cynara cardunculus)*
- Jatropha *(Jathropha curcas L.)*

Università degli Studi di Catania
Dipartimento di Scienze delle Produzioni Agrarie e Alimentari

Rapeseed (*Brassica napus* L. var. *oleifera* D.C.



Rapeseed production

- **Fruit:** siliqua with 20-40 seeds
- **Seme**:
  - ✓ Spherical
  - ✓ Red, brown, black

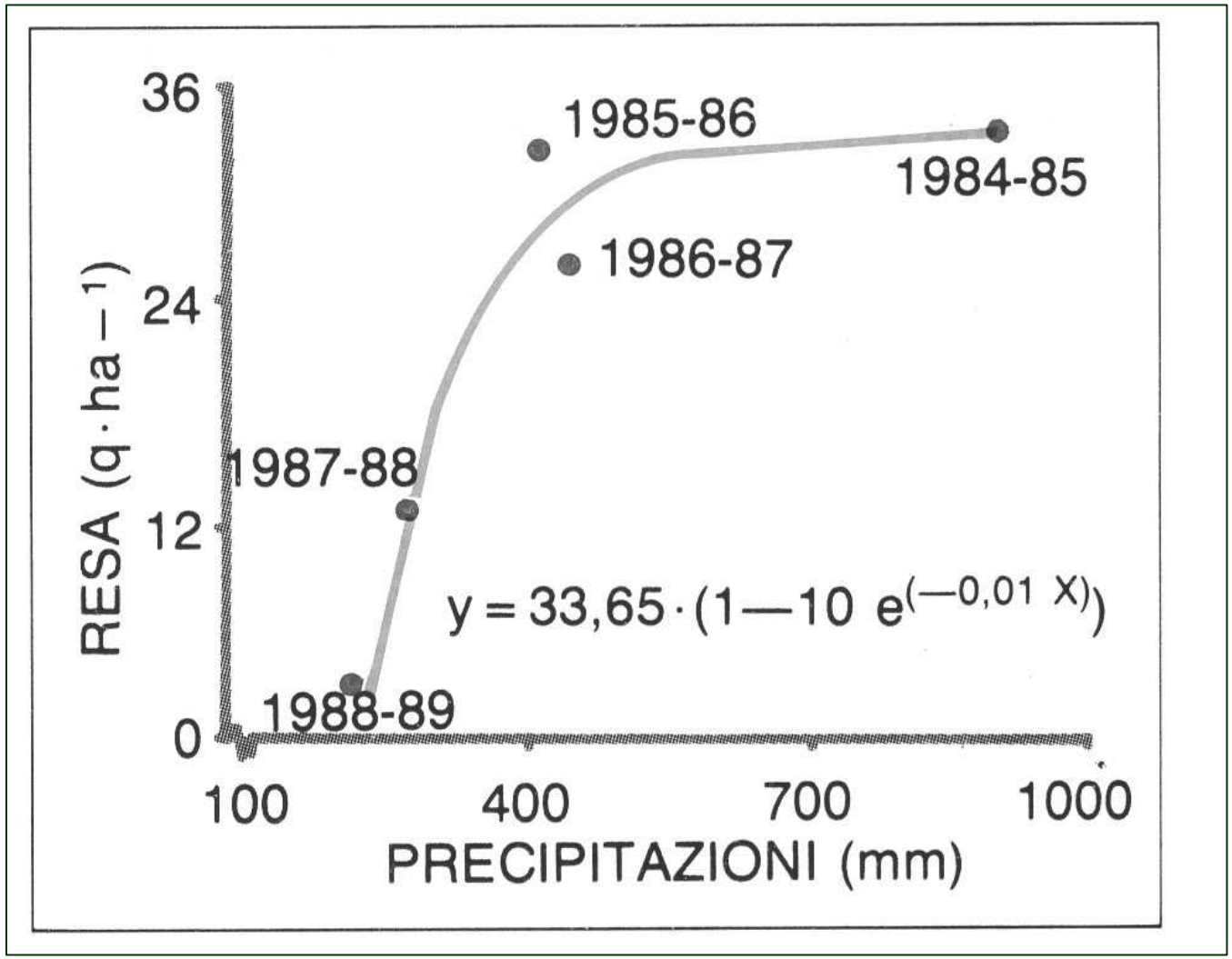
Costituenti del seme

- 38-44 % oil
- 21-24 % proteins
- 4-5% sugars
- 7-11% fibres

Yield in Sicily

- Seeds: 1-4 t ha^{-1}
- Oil: 0,5-1,5 t ha^{-1}
- Biomass residues: 5-10 t ha^{-1}
- Panel without oil: 0,5-1,8 t ha^{-1}

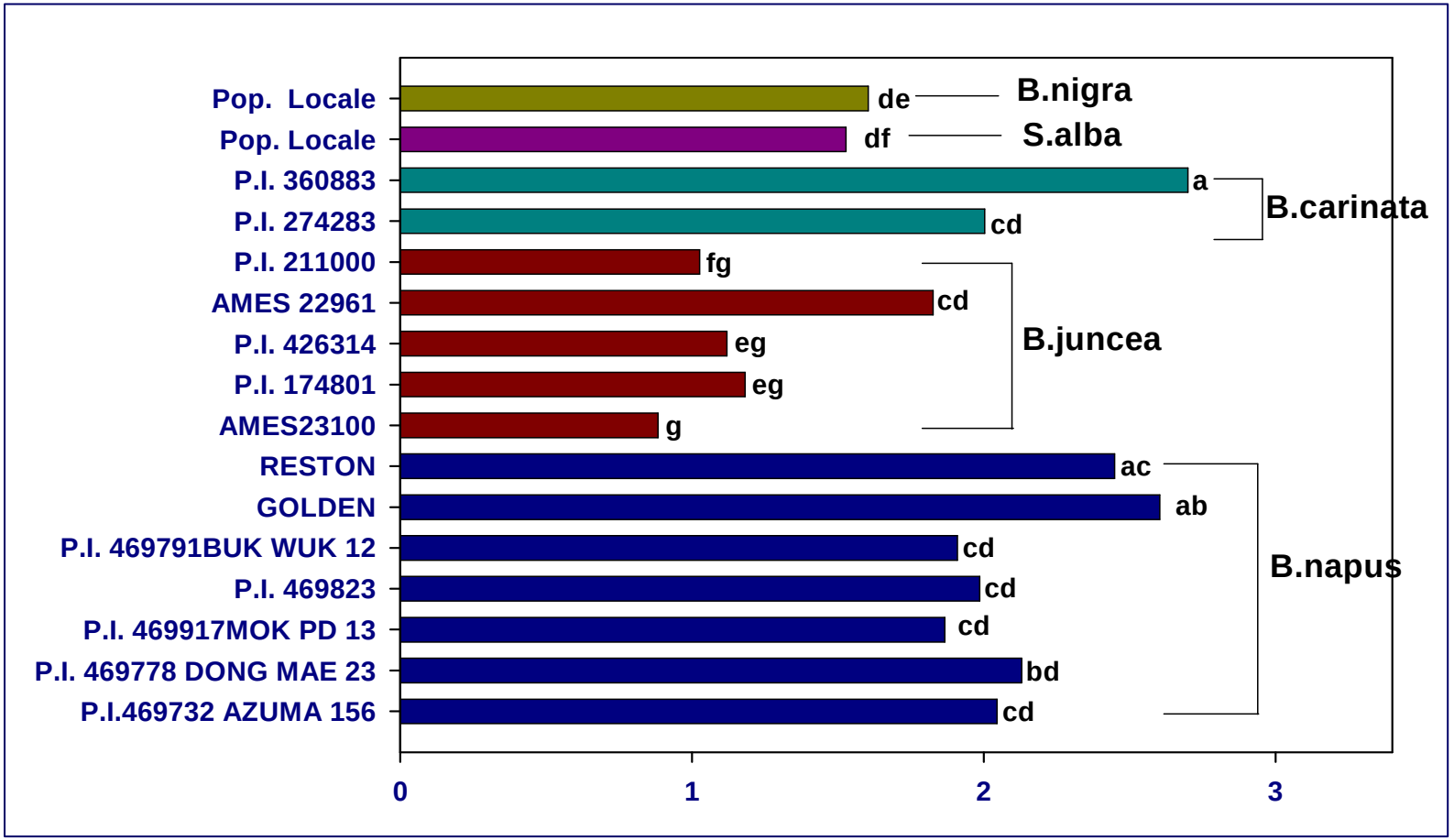
Relation between rainfall and seed yield in mediterranean environment
(Cosentino e Copani, 2003)



Brassicaceae: different species

- Geographical site: Barrafranca (EN)
- Sowing date: 21 november 2003
- Genotypes: 17 (8 *Brassica napus*, *5 Brassica juncea, 2 Brassica carinata, 1 S. alba, 1 B. nigra)*

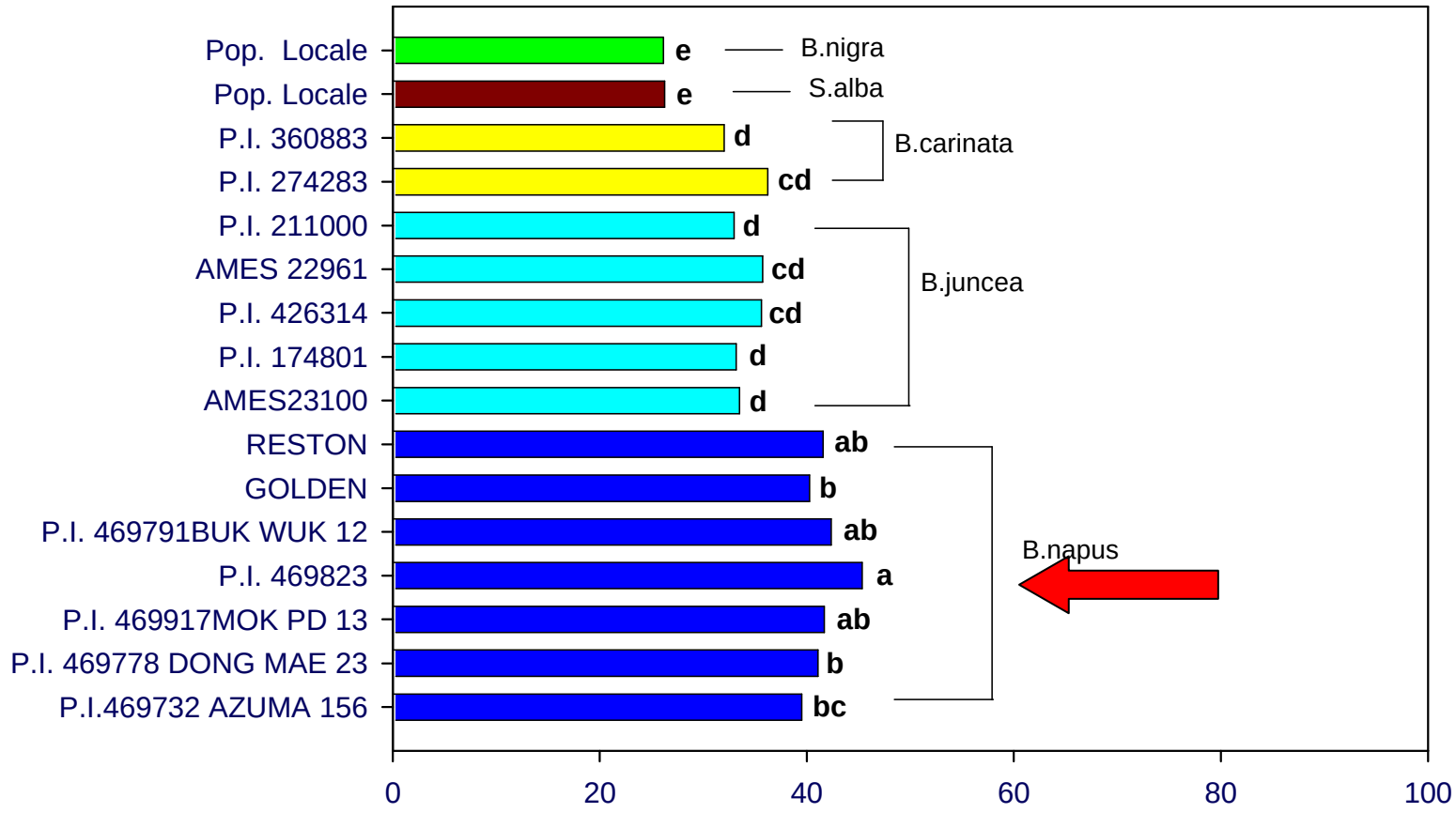
Seed Yield (t ha^{-1} d.m.)



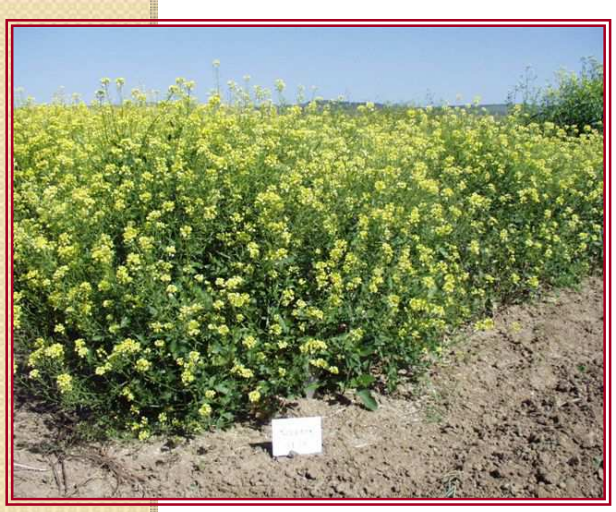
t ha-1 s.s.

Brassicaceae: different species

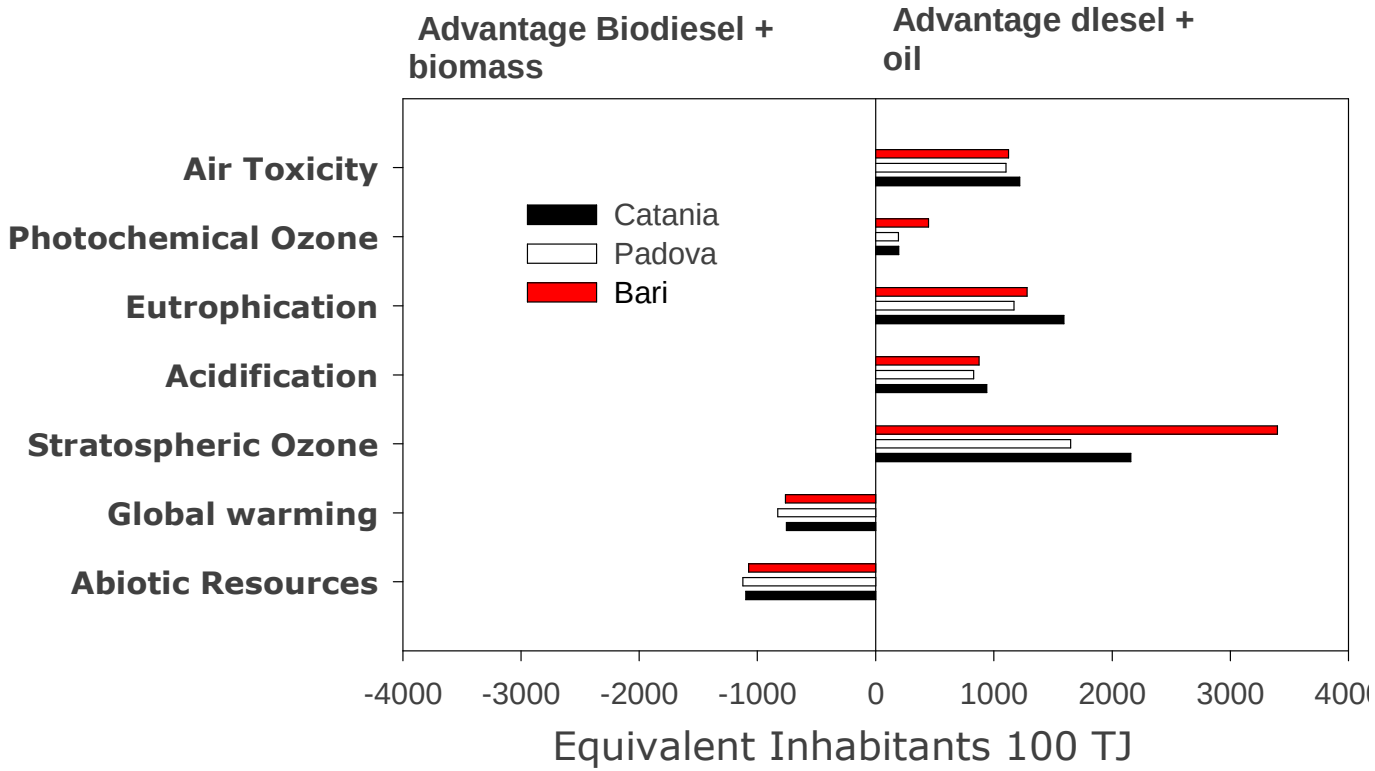
- Geographical site: Barrafranca (EN), Sicily
- Sowing Date: 21° november 2003



Seed Oil Concentration (%) t ha-1 s.s.



Life cycle Assessment Rapeseed



Comparison between Oil crops

Rapeseed
ibrido PR46W31

Linseed
cv. Sideral

Safflower
cv. Sabina

Camelina sativa
cv. Calena

Brassica carinata
cv. CT 180





Field experiment

Site Noto (SR, 15 m s.l.m.)

Sowing date: 14 December 2011

Seed harvest(2012):

Half June (camelina, linseed)

End June (rapeseed, B. carinata)

End July (safflower)

Laboratory analisys:

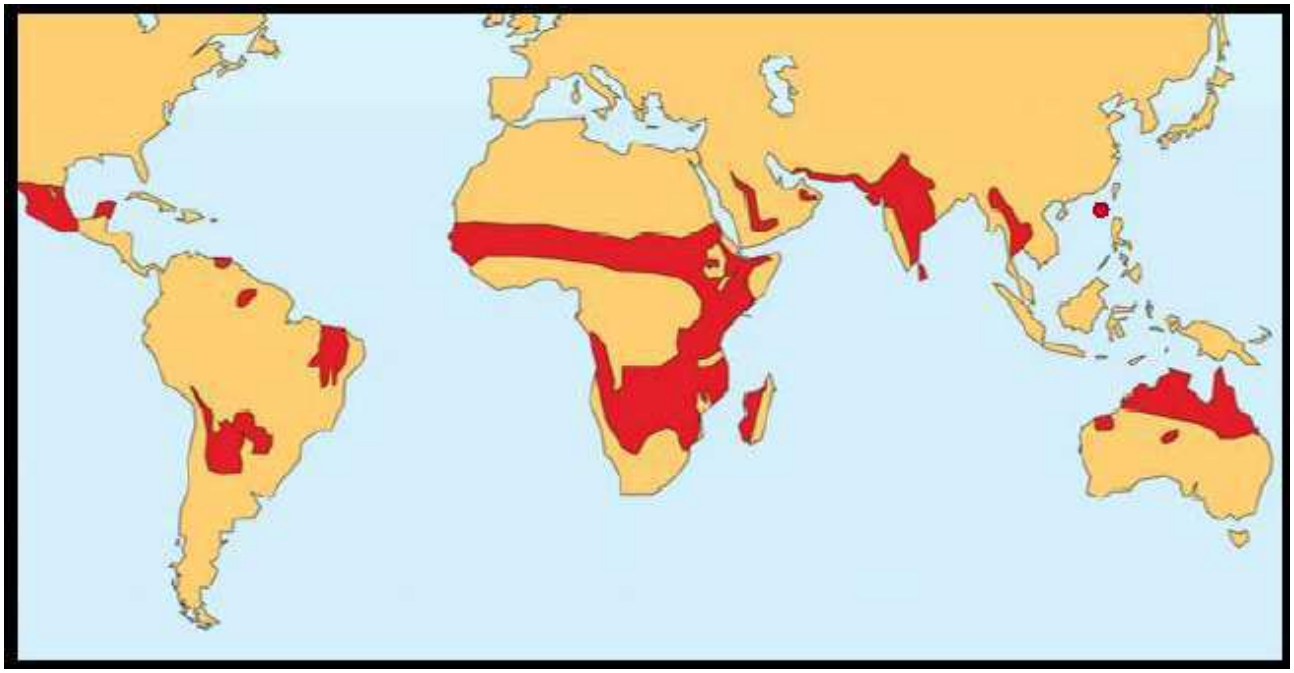
Oil estraction (Soxhlet)

Fatty acid composition of oil (gascromatography HRGC Mega 2, Carlo Erba Instruments)

Resa in seme, % di olio e resa in olio.

Specie	Resa seme t/ha	% Olio	Resa olio t/ha
Colza	3,65[a]	42,6	1,55[a]
Brassica carinata	3,02[b]	36,8	1,11[b]
Lino	2,78[b]	37,8	1,05[bc]
Camelina sativa	2,58[b]	36,4	0,94[c]
Cartamo	1,42[c]	31,9	0,45[d]

Jatropha curcas L.



Areas of *Jatropha curcas cultivation* (ICRISAT)

JATROPHA CURCAS FOR BIODIESEL: SUSTAINABLE CROP FOR SEMI ARID AND TROPICAL REGIONS

Proposal acronym
Jatropha-for-fuel

Type of funding scheme
Collaborative project

Work programme topics addressed
Call: FP7 - FP7-KBBE-2009-3
KBBE-2009-3-1-02: Jatropha curcas – breeding strategy – towards a sustainable crop for biomaterials and biofuels – SICA (India and/or African acp and/or Latin America)

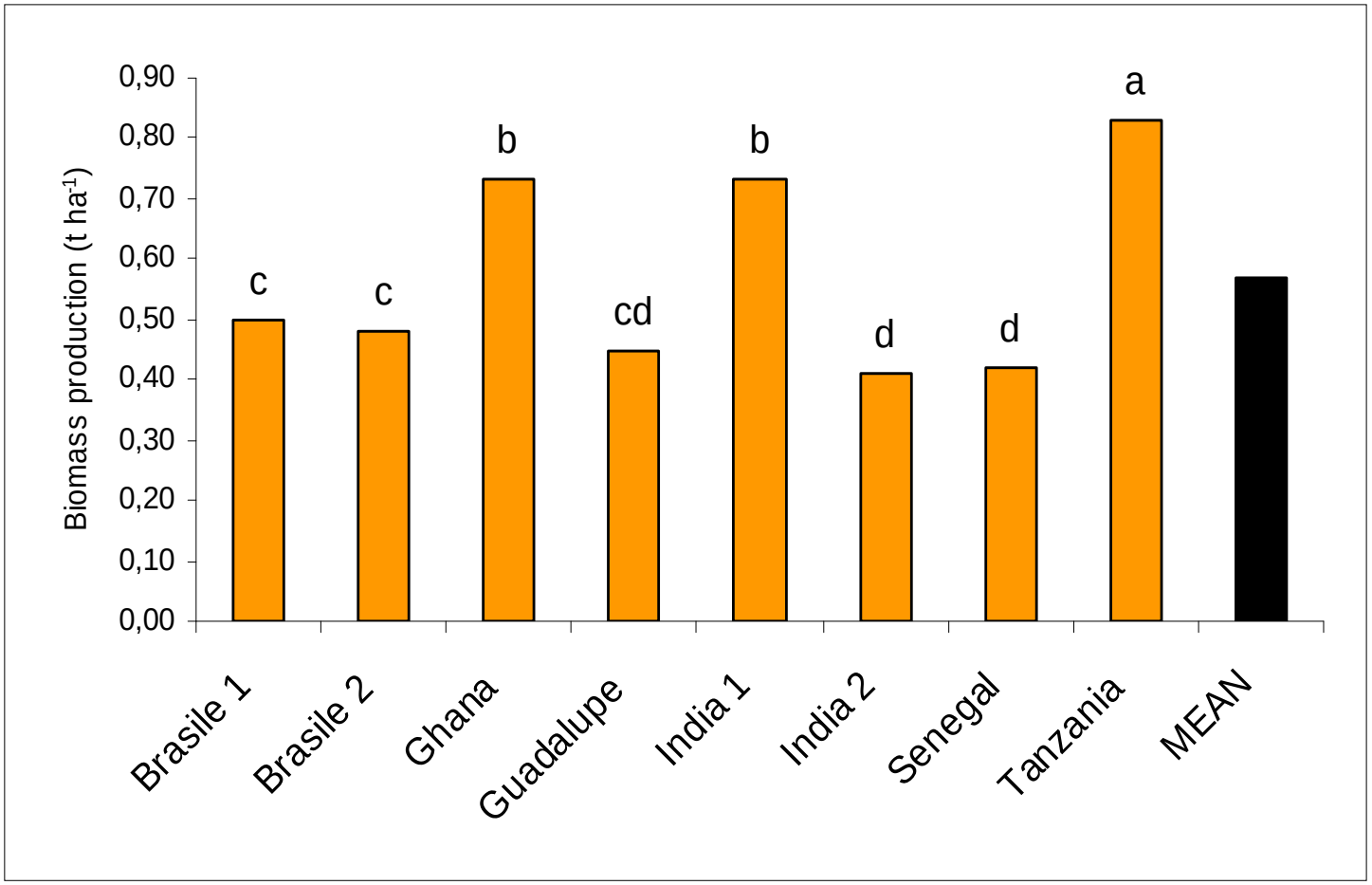
Name of the coordinating person
Prof. Salvatore Luciano Cosentino

Dipartimento di Scienze Agronomiche, Agrochimiche e delle Produzioni Animali
Università degli Studi di Catania
Via Valdisavoia, 5 95123 Catania, Italy

Participant n°	Participant organisation	Participant short name	Name Country
1	DACPA - Università di Catania	UNICT	Italy
2	Center of Renewable Energy Sources	CRES	Greece
3	Institut fuer Energie und Umweltforschung	IFEU	Germany
4	Forschungszentrum Juelich	FZJ	Germany
5	Wirtschaft und Infrastruktur GmbH & Co Planungs - KG	WIP	Germany
6	The Seed of Energy	ELAION	Mozambique
7	Acciona Biocombustibles S.A.	ACCIONA	Spain
8	Repsol YPF SA	Repsol	Spain
9	The Energy and Resources Institute	TERI	India
10	Universidad Nacional Autonoma de Mexico	UNAM	Mexico
11	Central Salt & Marine Chemicals Research Institute	CSMCRI	India
12	Consiglio per la Ricerca e Sperimentazione in Agricoltura	CRA	Italy
13	Diligent Tanzania Limited	DILIGENT	Tanzania
14	Parco Scientifico e Tecnologico della Sicilia	PSTS	Italy

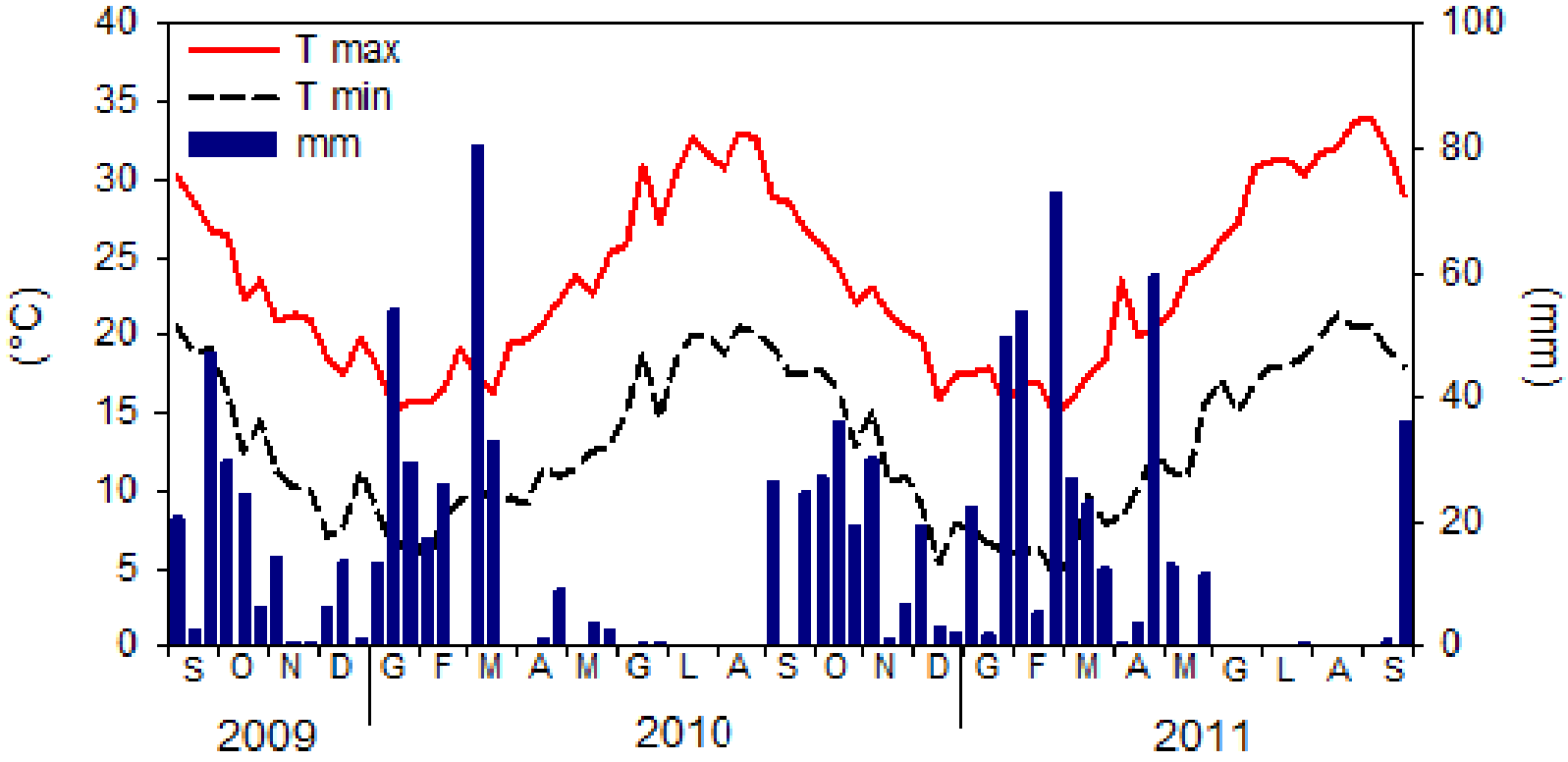
Jatropha curcas and at Ispica (RG) in 2008

Genotypes	Height (cm)	stem diameter (cm)			branches per plant (n°)	Branches lenght (cm)	leaves per plant (n°)	leaves per branch (n°)
		apical	median	basal				
India 2	75 d	3.5 c	5.0 d	6.0 c	6.0 a	40.0 c	169 e	28.2 e
Senegal	75 d	2.5 e	5.1 d	7.7 b	4.0 b	45.1 b	141 f	35.3 cd
Guadalupe	91 b	2.5 e	6.5 a	7.6 b	4.0 b	53.5 a	188 e	47.0 c
Brasile 2	74 d	3.1 d	5.1 d	6.4 c	6.0 a	39.1 c	151 f	21.2 e
Brasile 1	73 d	2.6 e	5.3 c	7.2 bc	6.0 a	40.7 c	219 d	36.5 cd
India 1	93 ab	2.9 de	6.1 b	7.6 b	5.0 ab	53.0 a	299 b	59.8 a
Ghana	82 c	3.9 b	6.1 b	8.1 a	7.0 a	45.2 b	363 a	51.9 b
Tanzania	95 a	4.4 a	5.3 c	7.9 a	7.0 a	45.2 b	229 c	32.7 d
Average	82.3	3.2	5.6	7.3	5.6	45.2	219.9	39.1



Biomass total yield in jatropha genotypes

Weather in Sicily



Rainfall 2009-10 = 490 mm

Rainfall 2010-11 = 540 mm

Transpiration rate (μmoli H_2O m^{-2} s^{-1})

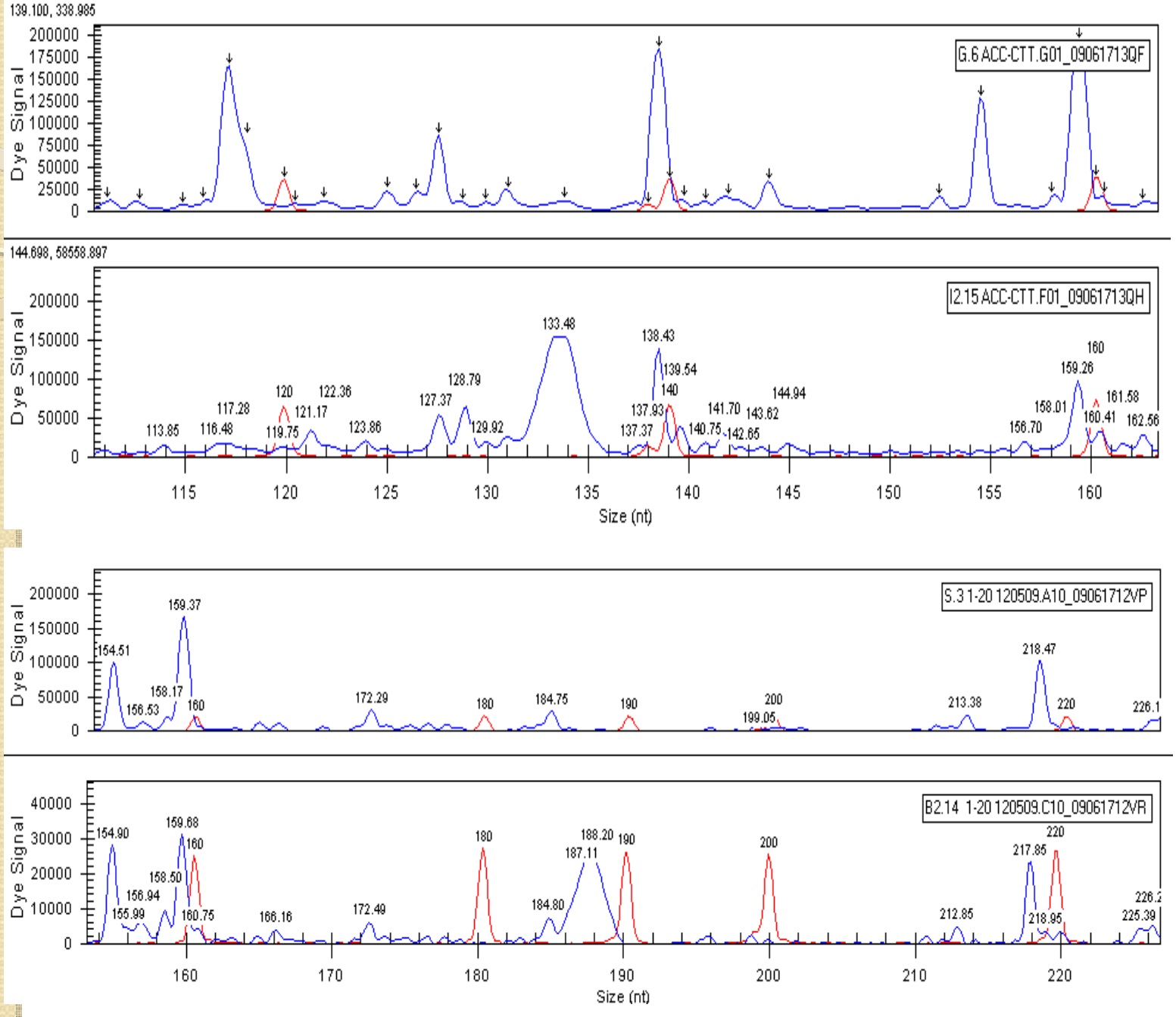
Genotypes	*17/11*	*25/11*	*6/12*	*19/12*	*28/12*
Brasile 1	0.89	1.14	0.88	0.31	0.31
Tanzania	0.63	1.00	0.56	0.14	0.15
India 1	0.47	1.22	0.66	0.23	0.03
India 2	1.28	1.17	0.82	0.36	0.15
Guadalupe	1.40	1.00	0.91	0.42	0.30
Brasile 2	1.40	0.80	0.91	0.42	0.37
Ghana	1.52	1.29	0.68	0.38	0.19
Senegal	1.47	1.17	1.03	0.34	0.14
Average	*1.13*	*1.10*	*0.80*	*0.32*	*0.20*
Std.dev	*0.41*	*0.16*	*0.16*	*0.10*	*0.11*

Net photosynthesis (μmoli m^{-2} s^{-1})

Genotypes	*17/11*	*25/11*	*6/12*	*19/12*	*28/12*
Brasile 1	9.13	7.33	7.43	5.09	0.90
Tanzania	7.99	3.86	6.96	3.31	0.43
India 1	4.41	3.27	7.19	1.80	0.50
India 2	11.37	2.88	6.97	7.04	0.09
Guadalupe	8.80	3.42	6.85	1.65	0.48
Brasile 2	10.71	5.64	6.91	5.30	0.50
Ghana	12.66	7.13	8.01	4.30	0.99
Senegal	11.66	3.42	5.24	1.87	0.03
Average	*9.59*	*4.62*	*6.94*	*3.79*	*0.49*
Std.dev	*2.63*	*1.81*	*0.79*	*1.97*	*0.34*

Effects of temperature and Priming (P) or Unprimimg (UP) on seed germination

Temperature	Brasile 2		Guadalupe		India I		Tanzania	
	UP	P	UP	P	UP	P	UP	P
10°C	-	-	-	-	-	-	22,5 b	30,1 a
15°C	-	-	18,5 a	22,5 a	8,3 b	20,1 a	59,3 b	87,2 a
20°C	23,2 b	36,8 a	42,8 a	42,6 a	53,1 b	62,4 a	98,4 a	100 a
25°C	48,7 a	51,8 a	79,5 b	87,7 a	76,1 b	87,9 a	61,4 b	98,7 a
30°C	83,5 a	85,5 a	68,7 a	63,9 a	75,0 a	73,9 a	51,2 b	98,3 a
35°C	67,8 b	81,5 a	-	-	-	-	-	-
Average	***55,8 b***	***63,9 a***	***52,4 a***	***54,2 a***	***53,1 a***	***61,1 b***	***58,6 b***	***82,9 a***



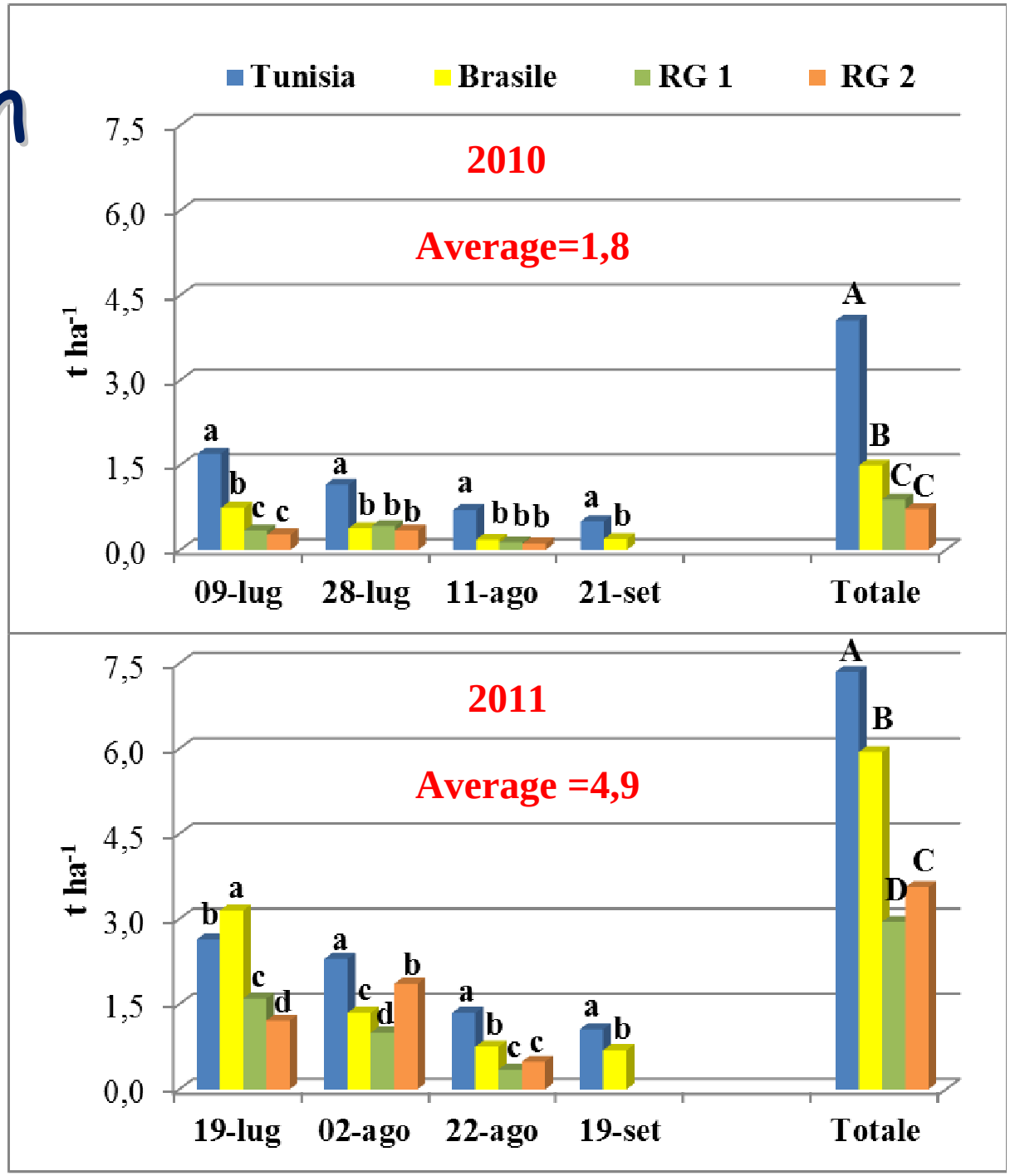
Analisi dei polimorfismi

Presence/absence of the found polimorphism

	135 nt	187 nt
J. Curcas Brazil 1	+	+
J. Curcas Brazil 2	-	-
J. Curcas Ghana	-	-
J. Curcas Guadalupe	-	-
J. Curcas India 1	-	-
J. Curcas India 2	+	+
J. Curcas Senegal	-	-
J. Curcas Tanzania	-	-

Jatropha curcas and Castor bean at Ispica (RG) in 2008

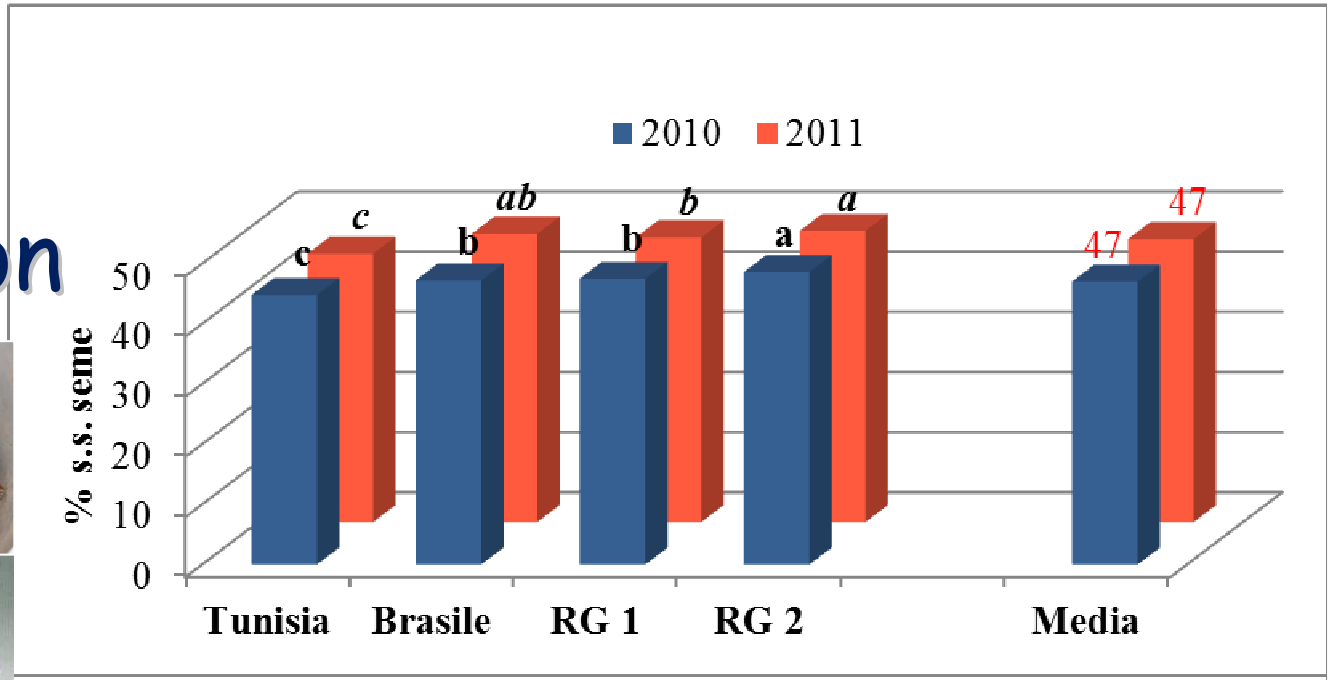
Castor Bean

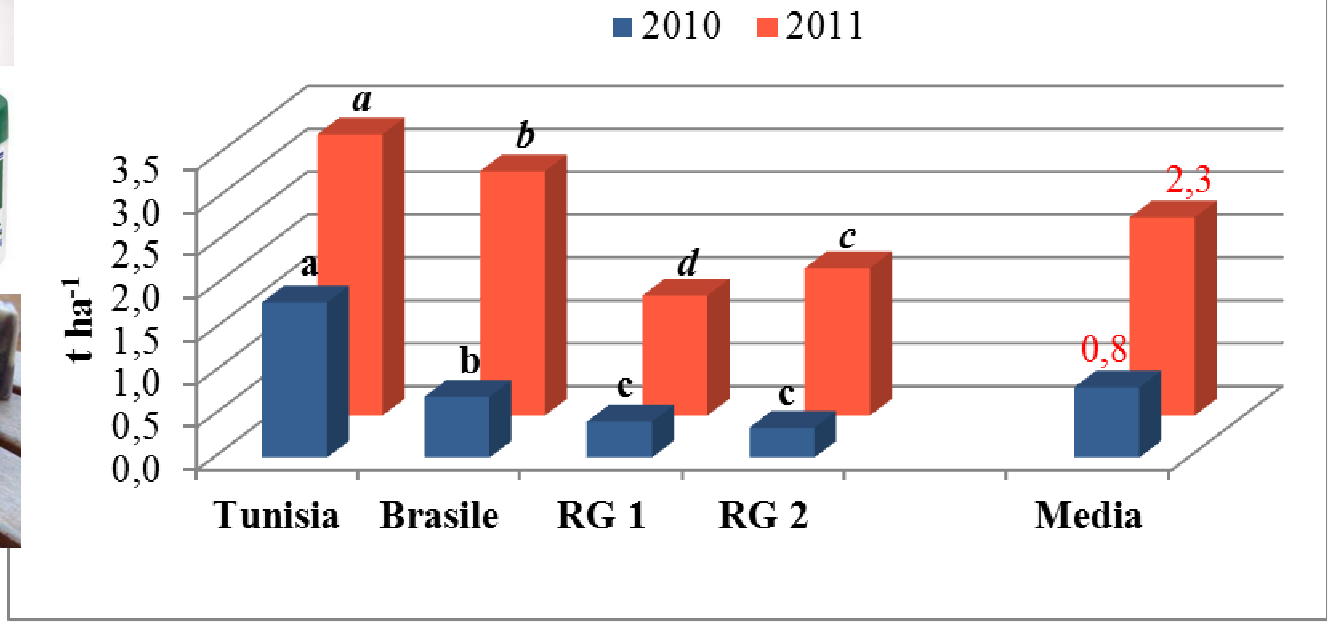

Tunisia
Brasile
RG 1
RG 2
2010
Average=1,8
t ha-1
7,5
6,0
4,5
3,0
1,5
0,0
09-lug
28-lug
11-ago
21-set
Totale
2011
Average =4,9
19-lug
02-ago
22-ago
19-set
Totale

Seed Oil Concentration







Oil Crops

Oil acidic composition and quality of Biodiesel according to the **UNI-EN 14214**

Evaluation of biodiesel

✓ Cetane Value

Readyness of the biodiesel to ignition

✓ Iodine number

Biodiesel stability (it depends on the unsatured fatty acids)

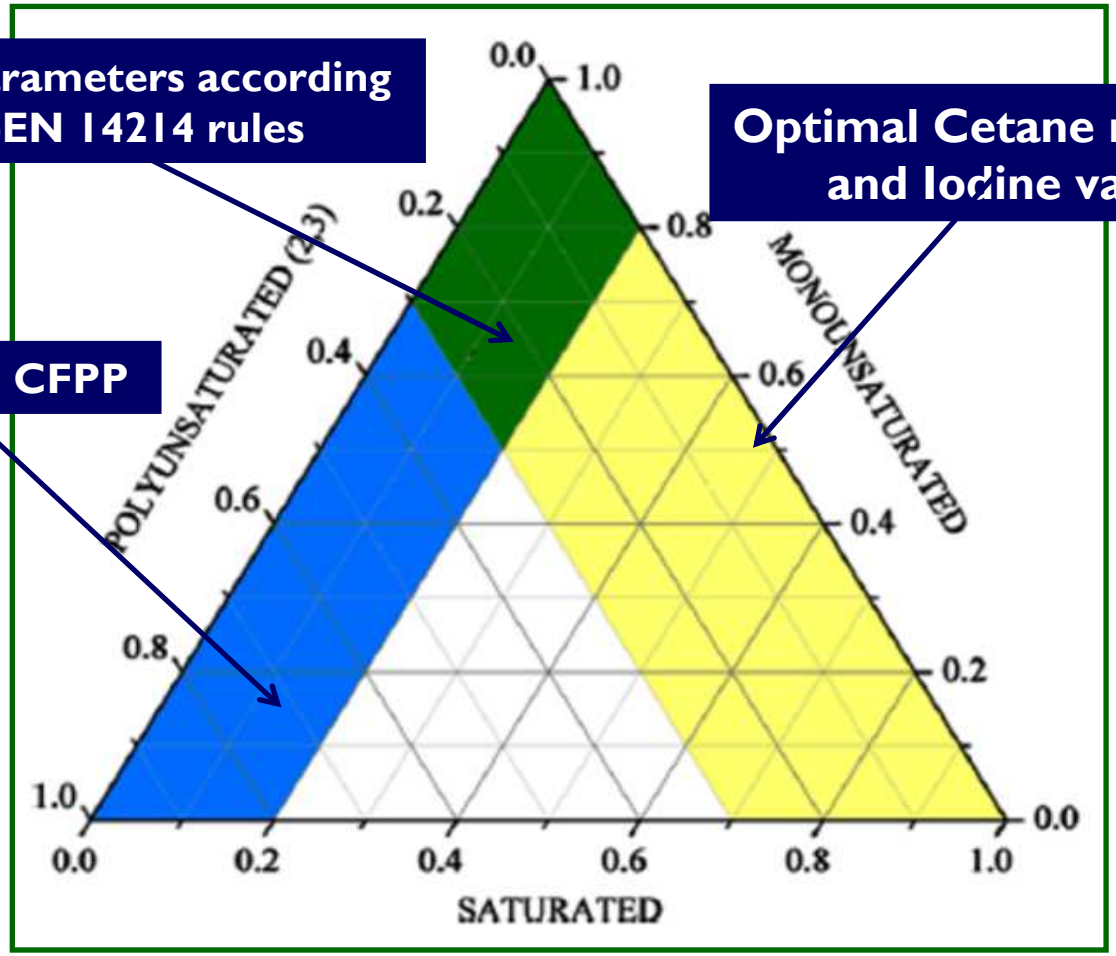
✓ Point of cold blocking of the filters (CFPP)

Behaviour of the oil at low temperatures (depends on the saturated fatty acids = viscosity)

Biodiesel parameters according to UNI-EN 14214 rules

Optimal Cetane number and Iodine value

Optimal CFPP



Ramos MJ, Fernández CM, Casas A, Rodríguez L, Pérez Á (2009) Influence of fatty acid composition of raw materials on biodiesel properties. Bioresour Technol 100:261–268

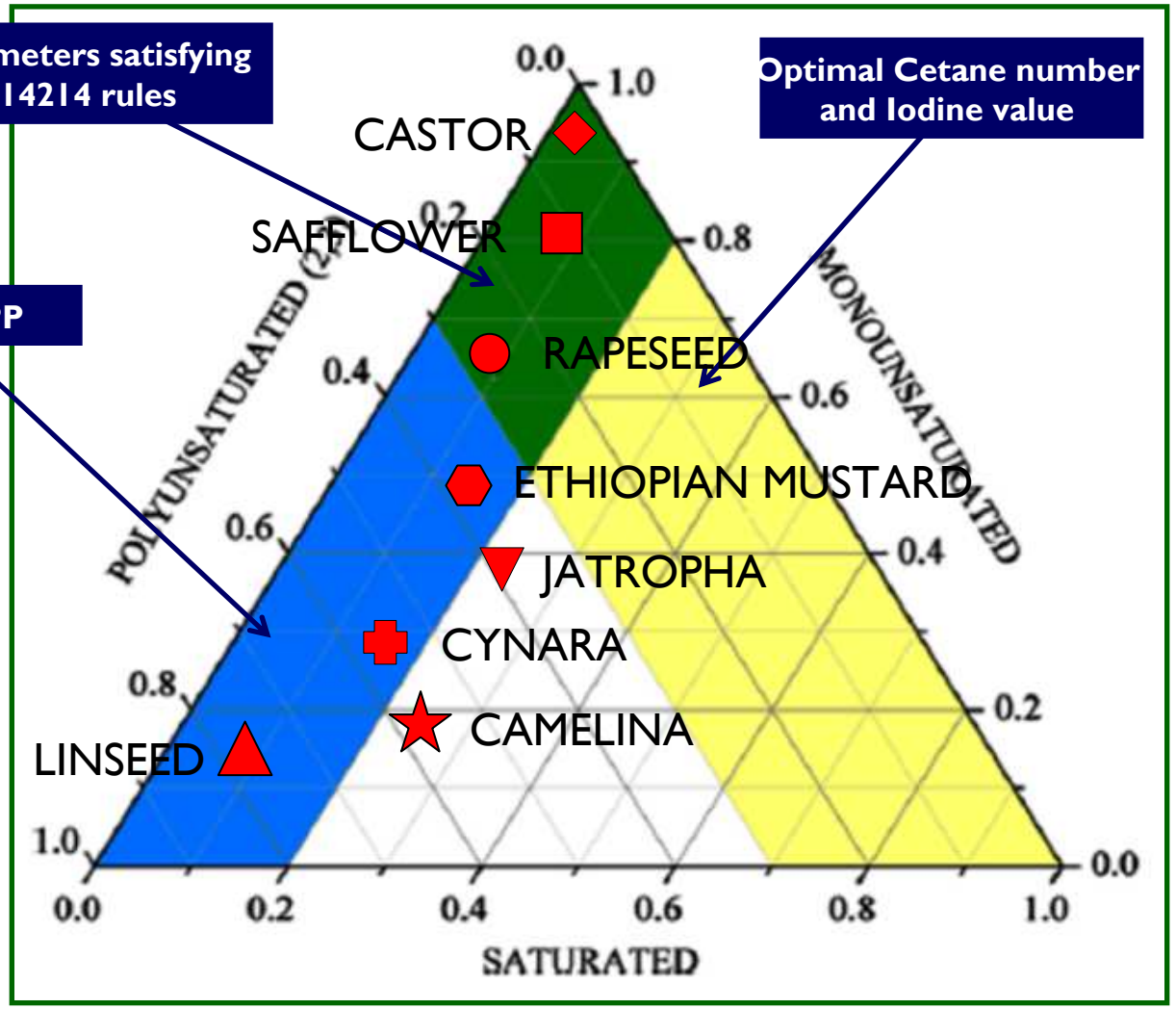
Contents of saturated (SFAs), monounsaturated (MUFAs), polyunsaturated (PUFAs) fat acids and their ratios

Species	SFAs	MUFAs	PUFAs	SFAs/ MUFAs	SFAs/ PUFAs	MUFAs/ PUFAs
Rapeseed	8.6	64.5	29.0	0.13	0.30	2.22
Brassica carinata	11.7	48.7	31.6	0.24	0.37	1.54
Flax	10.5	16.9	72.2	0.62	0.15	0.23
Camelina sativa	22.5	18.2	53.2	1.24	0.42	0.34
Safflower	8.4	79.4	11.5	0.11	0.73	6.90
Castor	2.0	92.0	6.0	0.02	0.33	15.33
Jatropha curcas	23.0	38.0	39.0	0.61	0.59	0.97
Cynara cardunculus	14.5	26.1	59.4	0.56	0.24	0.44

Biodiesel parameters satisfying UNI-EN 14214 rules

Optimal Cetane number and Iodine value

Optimal CFPP



- safflower
- rapeseed
- B. carinata
- Camelina
- flax
- castor
- Jatropha
- Cynara cardunculus

JatroMed 2nd International Workshop on Bioenergy for Enhancing Sustainable Development in Mediterranean Countries

Results of field research on energy crops in a Mediterranean environment with particular reference to oil crops

Thank you for your kind attention

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Algiers, 8th of May, 2014

Composizione acidica dell'olio delle specie allo studio.

Acido grasso	Struttura	Specie oleaginose				
		Colza	*Brassica carinata*	Lino	*Camelina sativa*	Cartamo
Palmitico	C16:0	5,00	3,31	6,13	5,97	6,02
Palmitoleico	C16:1	0,50	0,19	0,10	0,13	0,19
Margarico	C17:0	0,10	0,04	0,07	0,05	0,03
Stearico	C18:0	1,50	1,04	4,06	2,48	1,94
Oleico	C18:1	59,0	10,88	16,69	15,32	79,16
Linoleico	C18:2	20,0	17,81	15,23	18,79	11,38
Linolenico	C18:3	9,00	13,78	56,99	34,40	0,11
Eicosenoico	C20:0	1,50	6,83	0,12	13,79	0,23
Lignocerico	C24:0	0,40	0,43	0,08	0,18	0,10
Miristico	C14:0	0,10	0,06	0,06	0,06	0,10
Erucico	C22:1	5,00	37,61	0,12	2,70	-