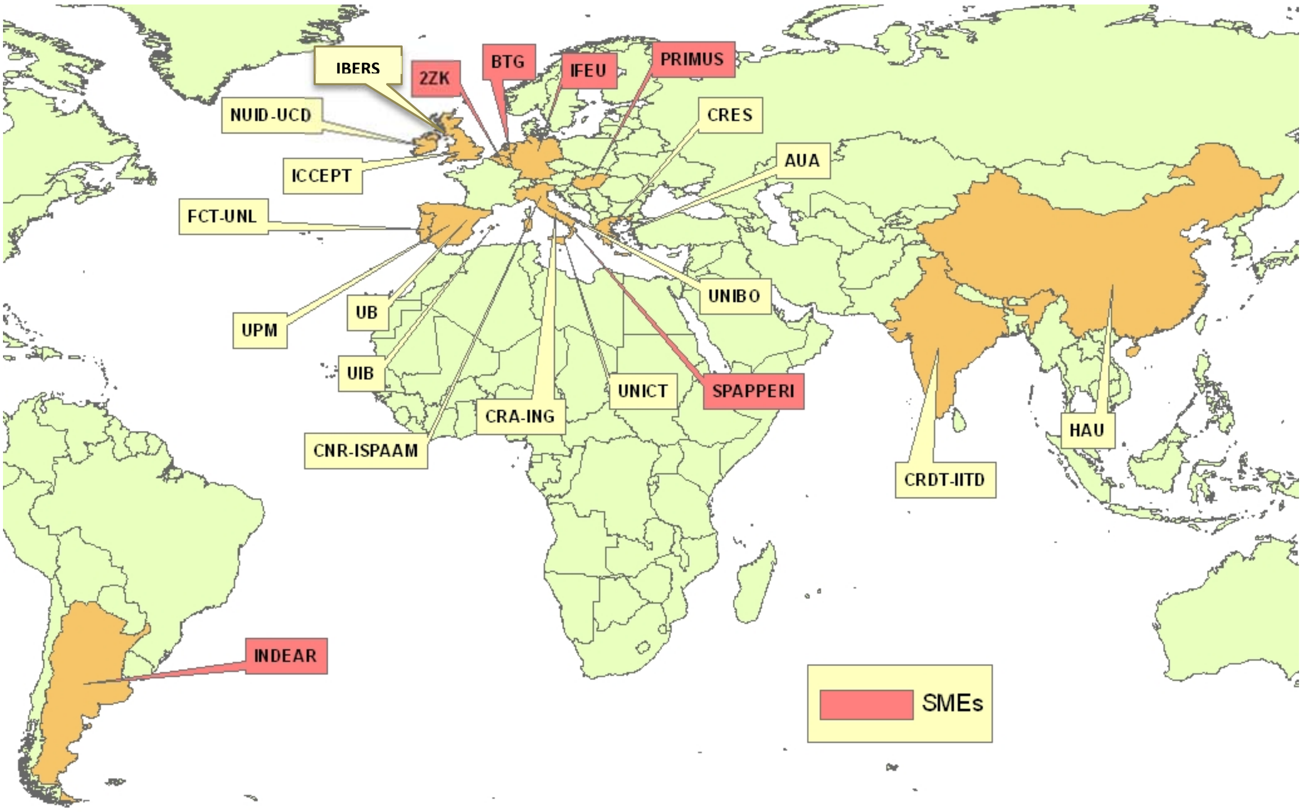
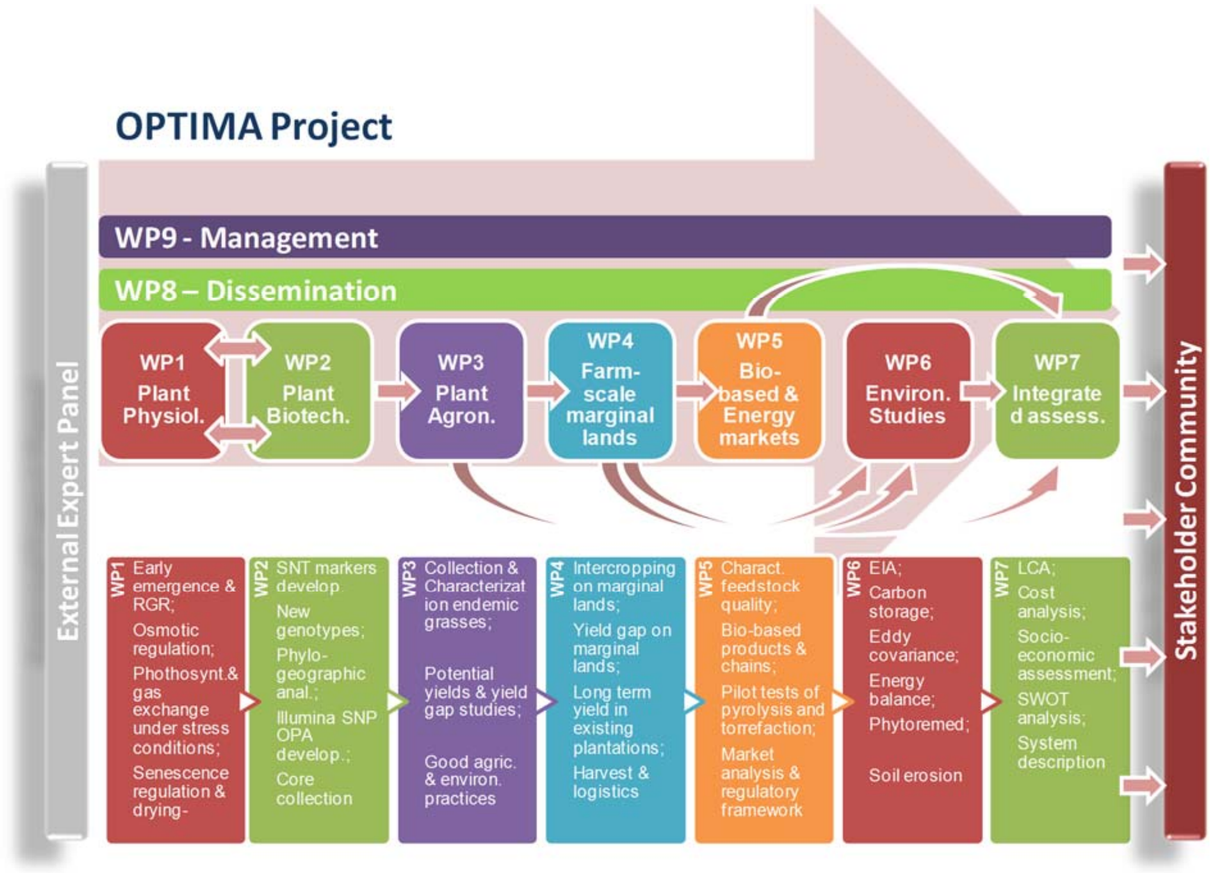
OPTIMA – Attachment to Final report

OPTIMA Logo



OPTIMA consortium



OPTIMA diagram WP flow

WP1 – Plant and leaf physiology

Task 1.1 Physiology of switchgrass and miscanthus (*UCD, INDEAR, IBERS, PRIMUS*)

Aberystwyth University – AU IBERS (n. 11)

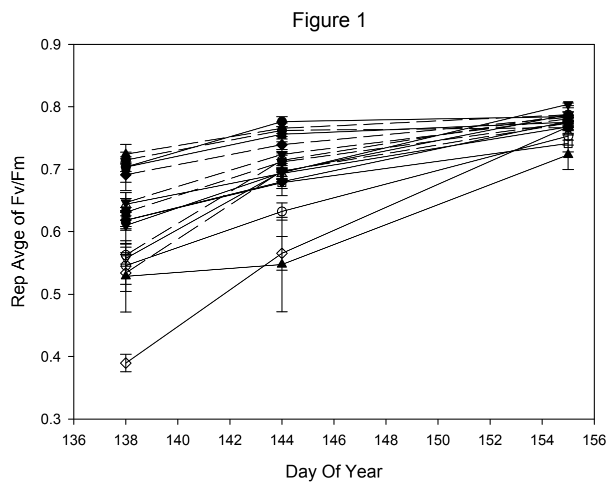


Figure 1 – IBERS. Progression of early season stress in selected genotypes demonstrating a range of tolerance and sensitivity.

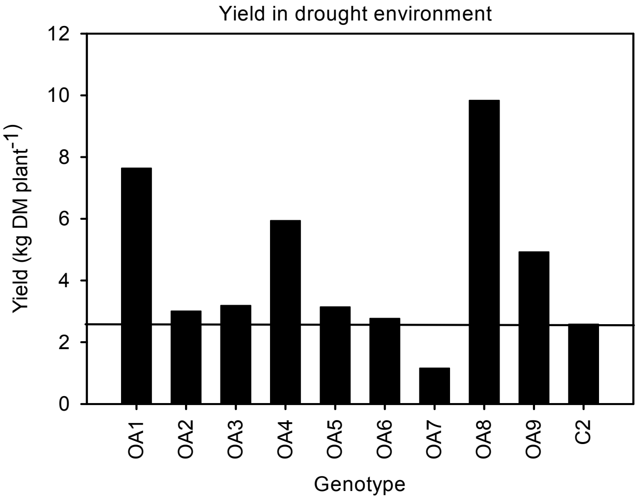


Figure 2 - IBERS. Variation in selected genotypes for biomass accumulation under field water stressed conditions used to identify genotypes exhibiting tolerance and sensitivity to drought stress.

Instituto of Agrobiotechnology Rosario – INDEAR (n. 17)

Table 1 – INDEAR. Survival percentage of *P. virgatum* seedlings after two weeks of treatment with gradually salinized nutrient solution in hydroponics.

Cultivar	NaCl (mM)	Survival (%)
EI	150	85,71
EII	150	85,71
TB	150	85,71
BW	150	42,86
S	150	42,86
PF	150	14,29

Figure 1 – INDEAR. *P. virgatum* seedlings under salt evaluation under gradually salinized nutrient solution in hydroponics conditions.

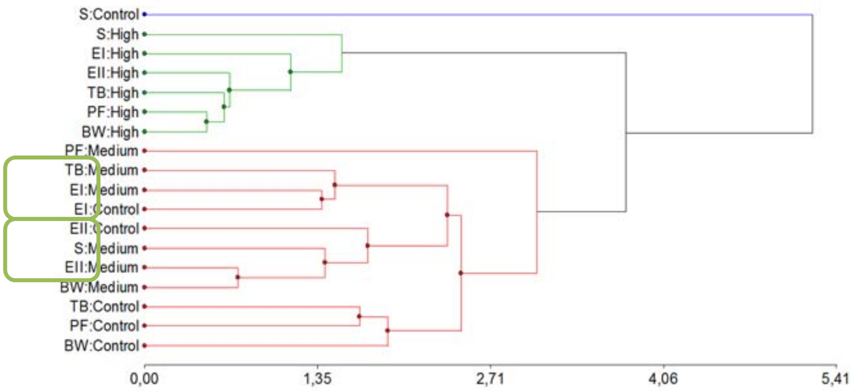


Figure 2 – INDEAR. Cultivar and treatment clustering after multivariate analysis.

Table 2 – INDEAR. *P* values for significance levels, after ANOVA for various physiological parameters.

Source	Photo- syntesis	Stomatalconductance	Transpirationrate	Quantum yield	SPAD
Cultivar	0,2405	0,2421	0,0075	0,8169	0,1599
Treatment	0,0917	0,0002	<0,0001	0,0243	0,9401
Cultivar x Treatment	0,2878	0,4025	0,1838	0,08066	0,4867

Figure 3 – INDEAR. Stages for *in vitro* direct regeneration of *P. virgatum* plants of different switchgrass cultivars (EI, EII, S, BW, A). 1, Mature caryopses as explants for plant direct regeneration; 2, young shoots; 3-4, shoot proliferation under *in vitro* conditions; 5, hardening of propagated plants in the greenhouse of INDEAR for water stress experiments.

Table 4 – INDEAR. Callus Induction Frequency (CIF) on MS media supplemented with different concentration of Sodium Chloride. The values having the same letter following are not significantly different at 0.01 probability level by Least Significant Difference Test (LSD).

Genotype	**Salt concentration (NaCl mM)**				
	0	50	100	150	300
EI	90,62 $_{a}$	75,96 $_{d}$	39,66 $_{f}$	15,77 $_{ij}$	2,3 $_{l}$
EII	86,44 $_{b}$	68,44 $_{e}$	37,25 $_{g}$	12,13 $_{j}$	0
S	90,31 $_{a}$	75,30 $_{d}$	32,63 $_{g}$	14,17 $_{j}$	0
BW	94,70 $_{a}$	31,34 $_{f}$	11,79 $_{h}$	3,9 $_{k}$	0
Mean	90,51	62,76	30,33	11,49	0,575

Table 5 – INDEAR. Chlorophyll content (mg/g fresh weight) calculated by a spectrophotometer in leaf sections of four different switchgrass materials after incubation with different concentrations of NaCl. EI and EII, Experimental I and II; A, Alamo; BW, Blackwell. The Table shows the rate data generated after two independent experiments. Each experiment included 20 leaf sections and 3 replicates (n=3). Different capital letters indicate significant differences (p<0.05) between switchgrass cultivars; different Non-capital letters indicate significant differences (p<0.05) between NaCl concentrations for the same *Panicum* cv.

	BW	A	EII	EI
0 mM	1,2 aA	1,4 aA	1,1 aA	1,25 aA
50 mM	0,8 bB	1,37 aA	1 aA	1,1 AA
150 mM	0,5 cC	1 bA	0,86 aB	0,9 aA
300 mM	0,29 dD	0,57 cC	0,54 bC	0,59 bC

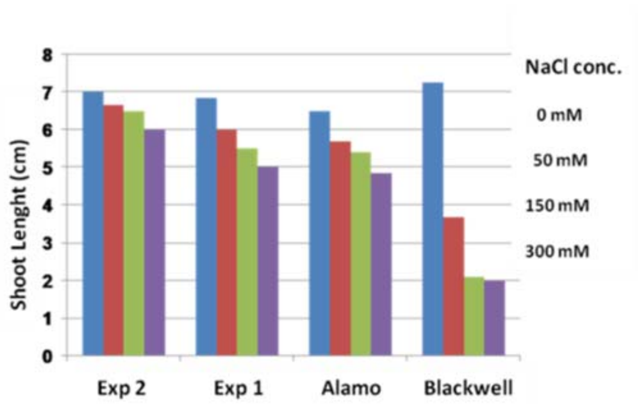


Figure 4 - INDEAR. Stem/shoot lenght (cm) after culture on media containing different concentrations of NaCl (0 mM in blue; 50 mM in red; 150 mM in green; 300 mM in purple). While non-significant differences were observed among Experimental 1 (Exp1 or EI), Experimental 2 (Exp 2 or EII) and Alamo (A), Blackwell (BW) cvs showed an arrested growth in the presence of NaCl. The Figure shows the effect of different concentrations of NaCl on stem elongation (cm) after culture for 9 weeks.

Table 6 – INDEAR. *In vitro* shoot growth under osmotic stress with PEG. SD, significant difference. Different letters indicate significant differences between treatments and between cultivars(*P <0,05*).

Switchgrass Cv	PEG %	Heigh (cm)	Leaves (#)
EI	0	12.9 a	9.6 ab
	10	11.4 ab	8.3 abcd
	15	11.1 ab	9.2 ab
	20	11.6 ab	9.2 ab
EII	0	10.2 ab	9.3 ab
	10	11.3 ab	8.4 abcd
	15	12.1 ab	8.8 abc
	20	11.0 ab	10.7 ab
S	0	6.2 de	4.0 1bcd
	10	6.3 de	2.2 f
	15	6.8 cde	4.2 def
	20	5.7 e	4.6 cdef
A	0	6.7 cde	6.6 bcde
	10	9.1 bcd	11.3 a
	15	9.5 bc	8.4 abcd
	20	9.4 bc	8.8 abc
SD 0.05		3.0	4.2

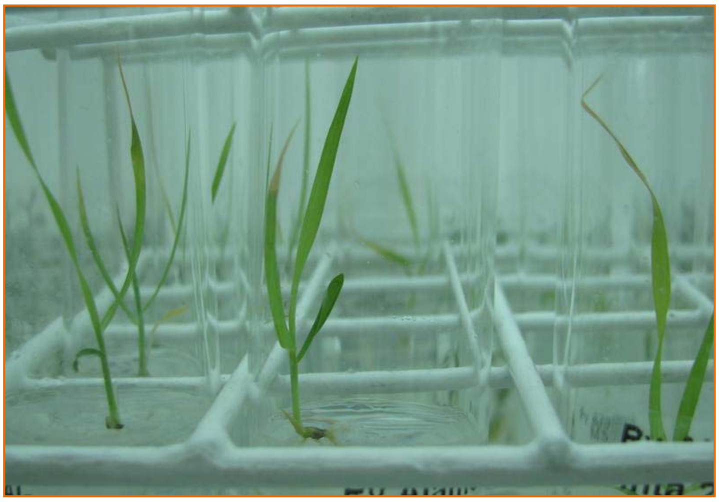


Figure 5 – INDEAR. *In vitro* plant growth and development under osmotic stress with PEG.

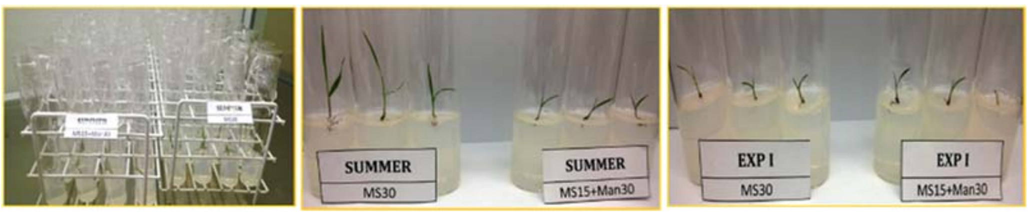


Figure 6 – INDEAR. *In vitro* osmotic stress experiment with mannitol: representative photographs of plant material under evaluation.

Table 7 – INDEAR. *In vitro* osmotic stress experiment with mannitol: Stem/shoot length and number of leaves were measured after 3 weeks. No significant differences were observed between the assayed treatments for both switchgrass cvs.

	Summer		EI	
	Shoots (number)	Shoot lenght (avg. in cm)	Shoots (Number)	Shoot lenght (avg. in cm)
Control Treatment	20	3.37	13	1.5
Mannitol Treatment	9	1.50	8	0.94

Table 8 – INDEAR. Survival percentage of *P. virgatum* clonally propagated plants after 60 days of treatment with suspended watering and after flooding treatment. Values are the rate of 10 replicates. Data followed by the same letter do not present significant differences (P<0,05).

Cultivar	Survival (%) No watering	Survival (%) Flooding
EI	65,51a	13,5a
EII	72,33b	22,2b
BW	25,26c	10,5a
S	72,26b	12,6a
A	45,65d	32,5d

Figure 7 – INDEAR. *Panicum* plants in the greenhouse at the beginning of a controlled experiment for the evaluation of plant survival % after 60 days of suspended watering.

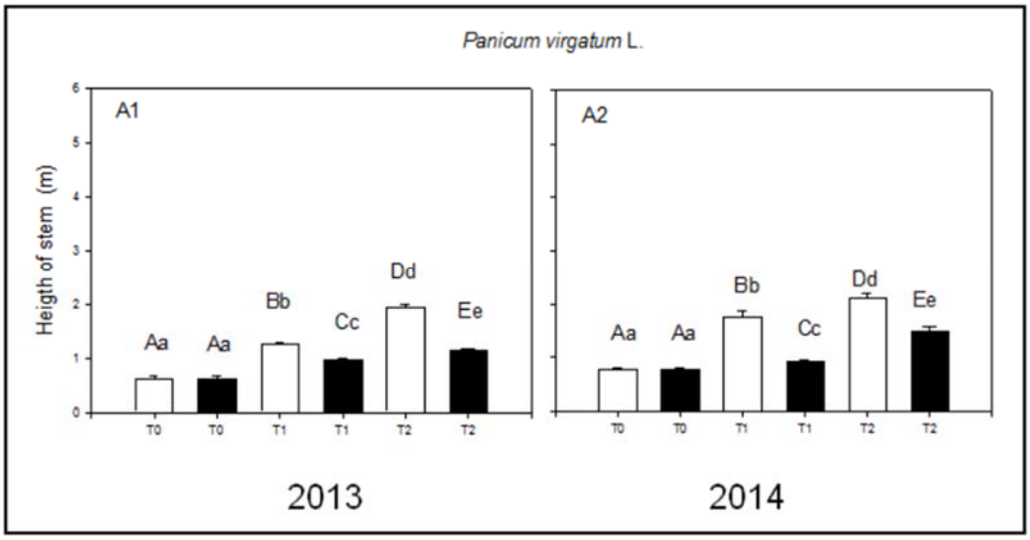


Figure 8 – INDEAR/UB. Plant Stem lenght (m) under normal water rainfall regime and with irrigation. Data were taken at different moments in the year: T0, spring time; T1, early summer and T2, summer end. White bars: irrigation treatment; black bars: no irrigation. A1, Plant lenght (m*) in P. virgatum* L. plant in 2013; A2, data for 2014. Bars and values are the rate ± SE of 4 replicates (*n=4*). In the same year, capital letters indicate significant differences (*P< 0,05*) between the data registration time for the same treatment. Non-capital letters indicate differences (*P <0,05*) between treatments in the same year and data registration time.

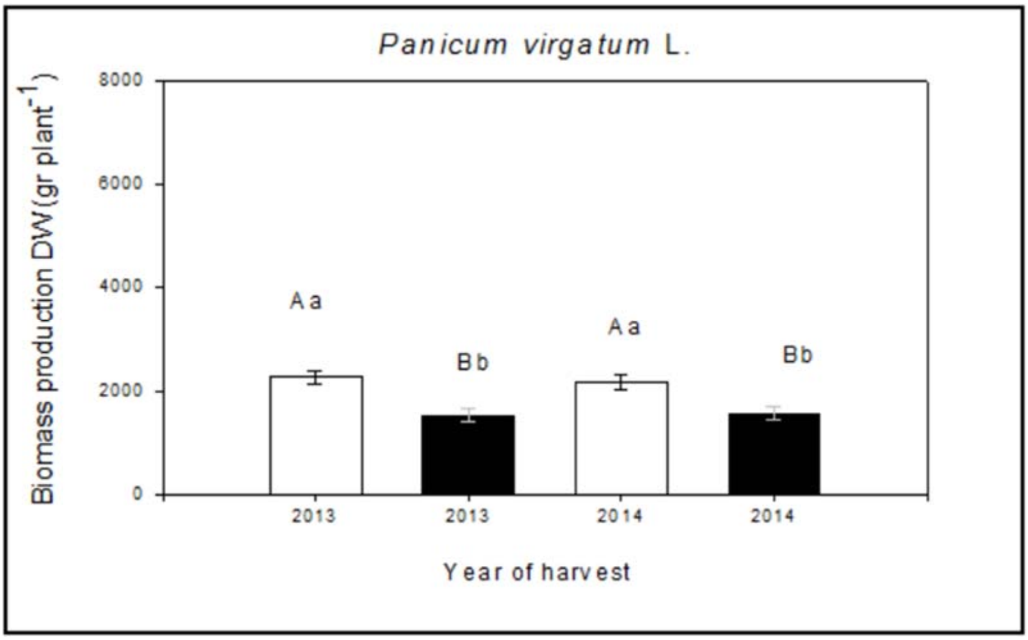


Figure 9– INDEAR/UB. Biomass production: dry Weight (g) of aerial part of the plants grown under normal waterfall regime and with irrigation, during 2013 and 2014. A, DW (Peso Seco, PS) in g for *P. virgatum* L. White bars: irrigation; black bars: no irrigation. Bars and values are the rate ± SE of 4 replicates (*n=4*). Capital letters indicate significant differences (*P< 0,05*) between years for the same treatment and non-capital letters indicate differences (*P <0,05*) between treatments within the same year.

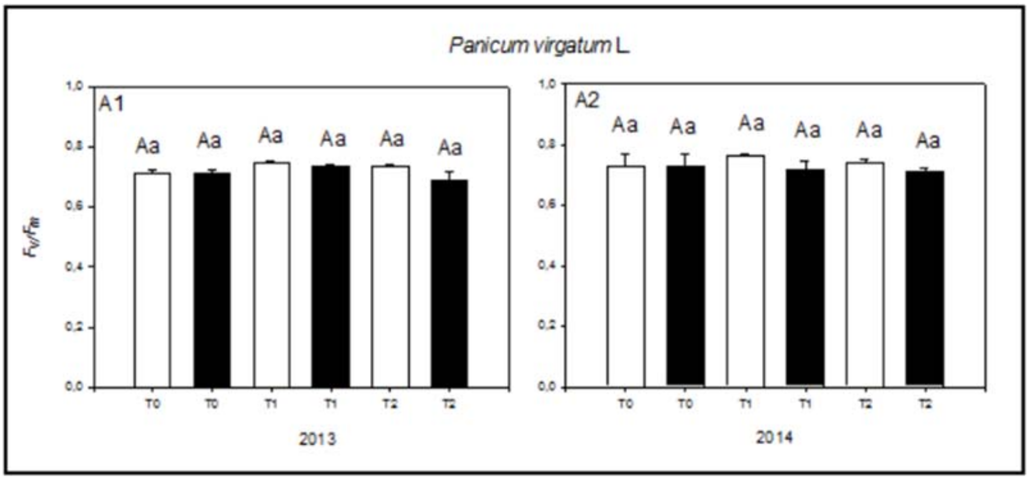


Figure 10– INDEAR/UB. Maximum Quantum Yield of Photosystem II (F_v/F_m) in *Panicum virgatum* L. plants grown under normal waterfall regime and watering conditions at different moments (T0: spring; T1: early summer and T2: summer end). White bars: irrigation treatment; black bars: no irrigation. Bars and values are the rate ± SE of 3 replicates (*n=3*). In the same year, capital letters indicate significant differences (*P<0,05*) between the data registration time for the same treatment. Non-capital letters indicate differences (*P <0,05*) between treatments in the same data registration time.

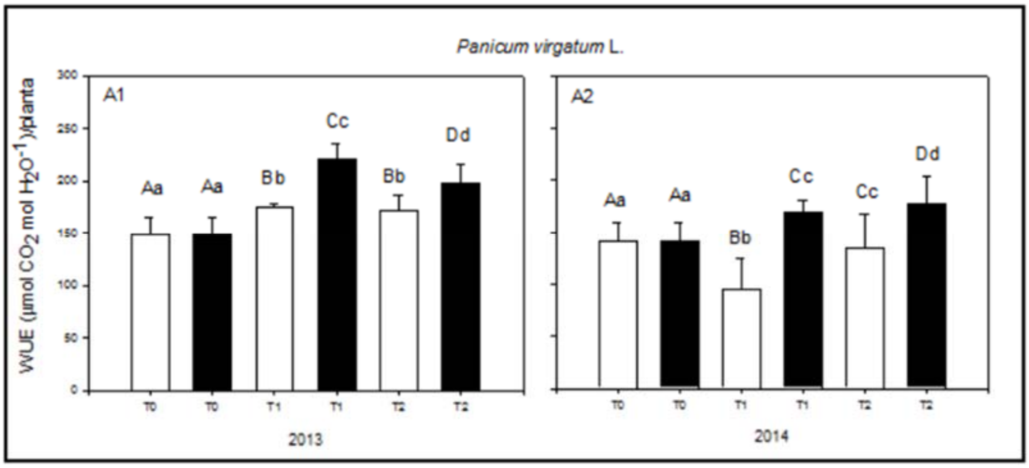


Figure 11– INDEAR/UB. Water Use Efficiency, WUE (µmol CO_2 mol H_2O^{-1}) in *Panicum virgatum* L. plants grown under normal waterfall regime and watering conditions at different moments (T0: spring; T1: early summer and T2: summer end). White bars: Irrigation treatment; black bars: no irrigation. Bars and values are the rate ± SE of 4 replicates (*n=4*). In the same year, capital letters indicate significant differences (*P<0,05*) between the data registration time for the same treatment. Non-capital letters indicate differences (*P <0,05*) between treatments in the same data registration time.

Table 9 – INDEAR/UB. Photosynthetic parameters: Net CO_2 Accumulation Rate at light saturation (A_{sat}), Maximum Net Photosynthetic Rate (A_{max}), stomatal conductance (g_s), measured in *Panicum virgatum* L. plants grown under normal waterfall regime and with irrigation. Data were taken at three moments in the year: (T0: spring; T1: early summer and T2: summer end). Values are the media ± SE of three replicates (*n=3*). Different capital letters indicate significative differences (*P <0,05*) between years for the same parameter, time and treatment. Non-capital letters show significative differences (*P <0,05*) between times for the same parameter and year.

			Panicum virgatum L.			
Parameters	**Time**	**Treatment**	**2013**		**2014**	
A_{sat} ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)	T0	Irrigation	19,33	±1,45Aa	17,00	±1,00Aa
	T0	Rainfall	19,33	±1,45Aa	17,00	±1,00Aa
	T1	Irrigation	21,00	±1,50Aa	19,83	±3,35Aa
	T1	Rainfall	4,50	±0,50Bb	5,07	±1,39Bb
	T2	Irrigation	15,50	±2,18Cc	16,17	±1,17Cc
	T2	Rainfall	3,17	±0,93Bb	5,33	±0,17Bb
A_{max} ($\mu mol\ CO_2\ m^{-2}\ s^{-1}$)	T0	Irrigation	26,03	±3,24Aa	29,15	±2,15Bb
	T0	Rainfall	26,03	±3,24Aa	29,15	±2,15Bb
	T1	Irrigation	26,60	±0,30Aa	25,57	±2,44Aa
	T1	Rainfall	6,80	±0,34Cc	7,42	±2,14Cc
	T2	Irrigation	19,90	±2,50Dd	26,23	±2,02Aa
	T2	Rainfall	6,40	±1,02Cc	7,92	±1,79Cc
g_s ($mol\ H_2O\ m^{-2}s^{-1}$)	T0	Irrigation	0,130	±0,010Aa	0,120	±0,010Aa
	T0	Rainfall	0,130	±0,010Aa	0,120	±0,010Aa
	T1	Irrigation	0,120	±0,004Aa	0,210	±0,005Bb
	T1	Rainfall	0,014	±0,010Cc	0,030	±0,010Cc
	T2	Irrigation	0,090	±0,003Dd	0,120	±0,003Aa
	T2	Rainfall	0,016	±0,004Cc	0,030	±0,010Cc

University of Dublin, UCD School of Biology and Environmental Science – NUID UCD (n. 12)

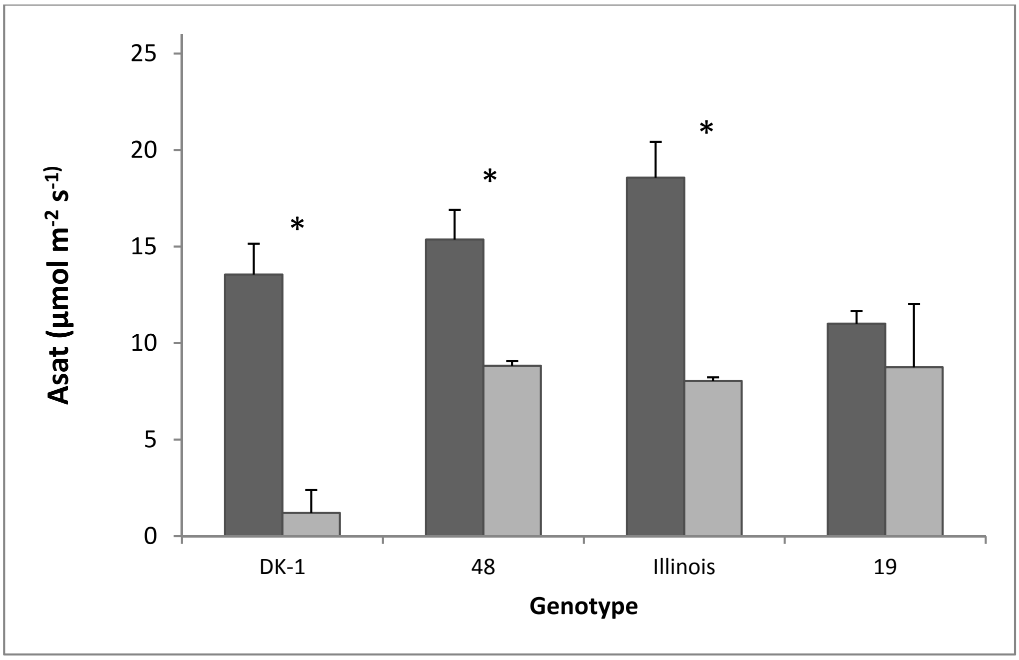


Figure 1 – UCD. Leaf-level CO_2 assimilation rate (Asat) measured at 400 µmol mol^{-1} CO_2, 2000 µmol photon m^2 s^{-1} and 25 ±2 °C (n=3) in control (black bars) and plants exposed to a ten day low temperature exposure (grey bars). Values represent mean ±SE. Within each genotype, values that are significantly different are identified with * ($p \leq 0.05$).

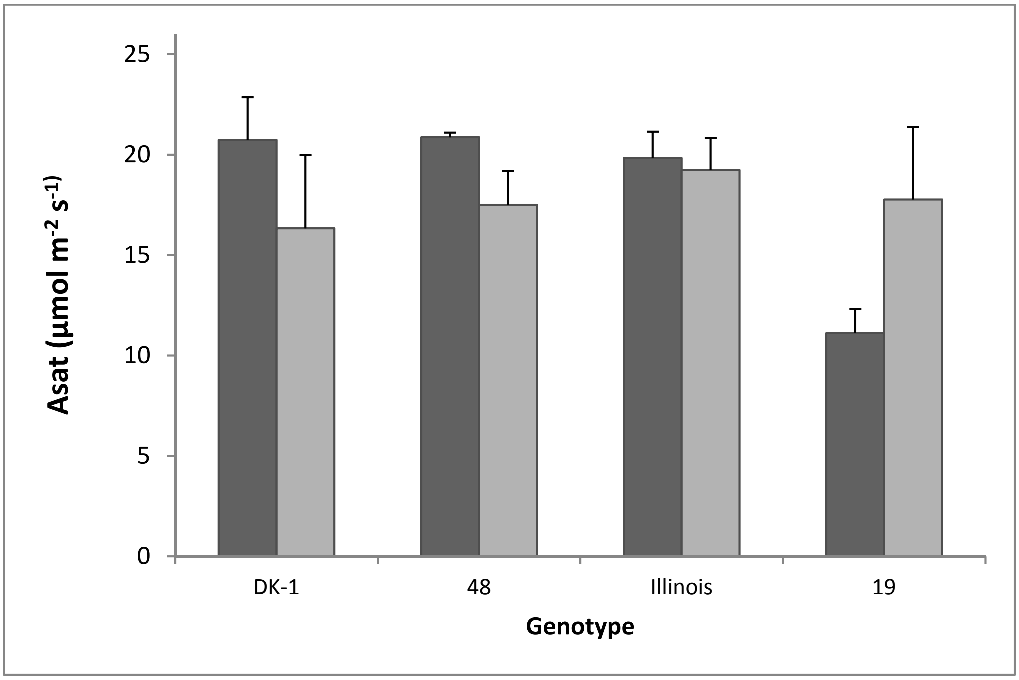


Figure 2 - UCD. Leaf-level CO_2 assimilation rate (Asat) measured at 400 µmol mol^{-1} CO_2, 2000 µmol photon m^2 s^{-1} and 25 ±2 °C (n=3) in control (black bars) and plants exposed to a ten day low temperature treatment (grey bars) on day 15 (recovery). Values represent mean ±SE. Within each genotype, values that are significantly different are identified with * ($p \leq 0.05$).

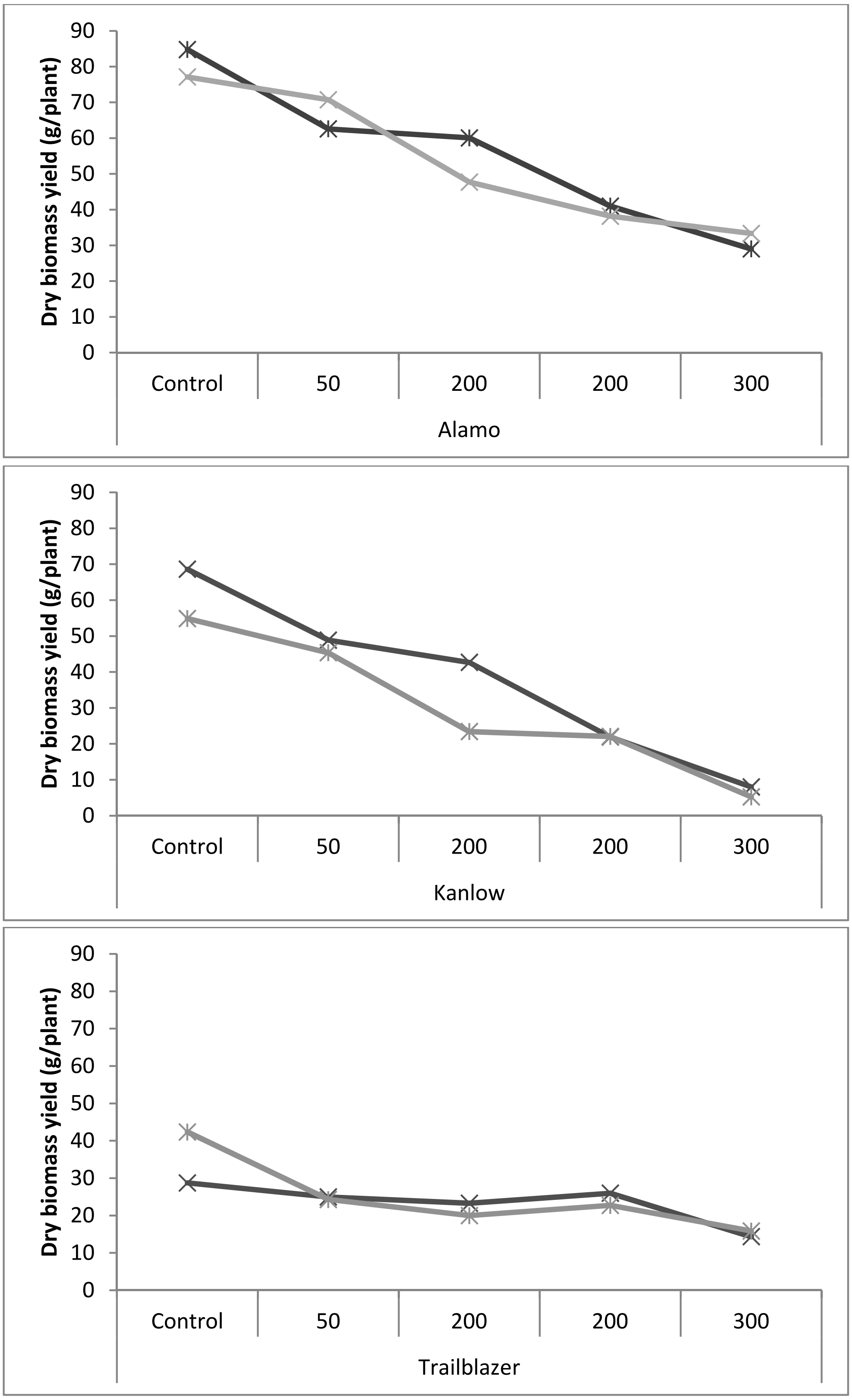


Figure 3 - UCD. Dry biomass yield (g/plant) in *Panicum virgatum* var. Alamo, Kanlow and Traiblazer (n=3) after 7 (black) and 9 (grey) months of growth under different salinities (mM).

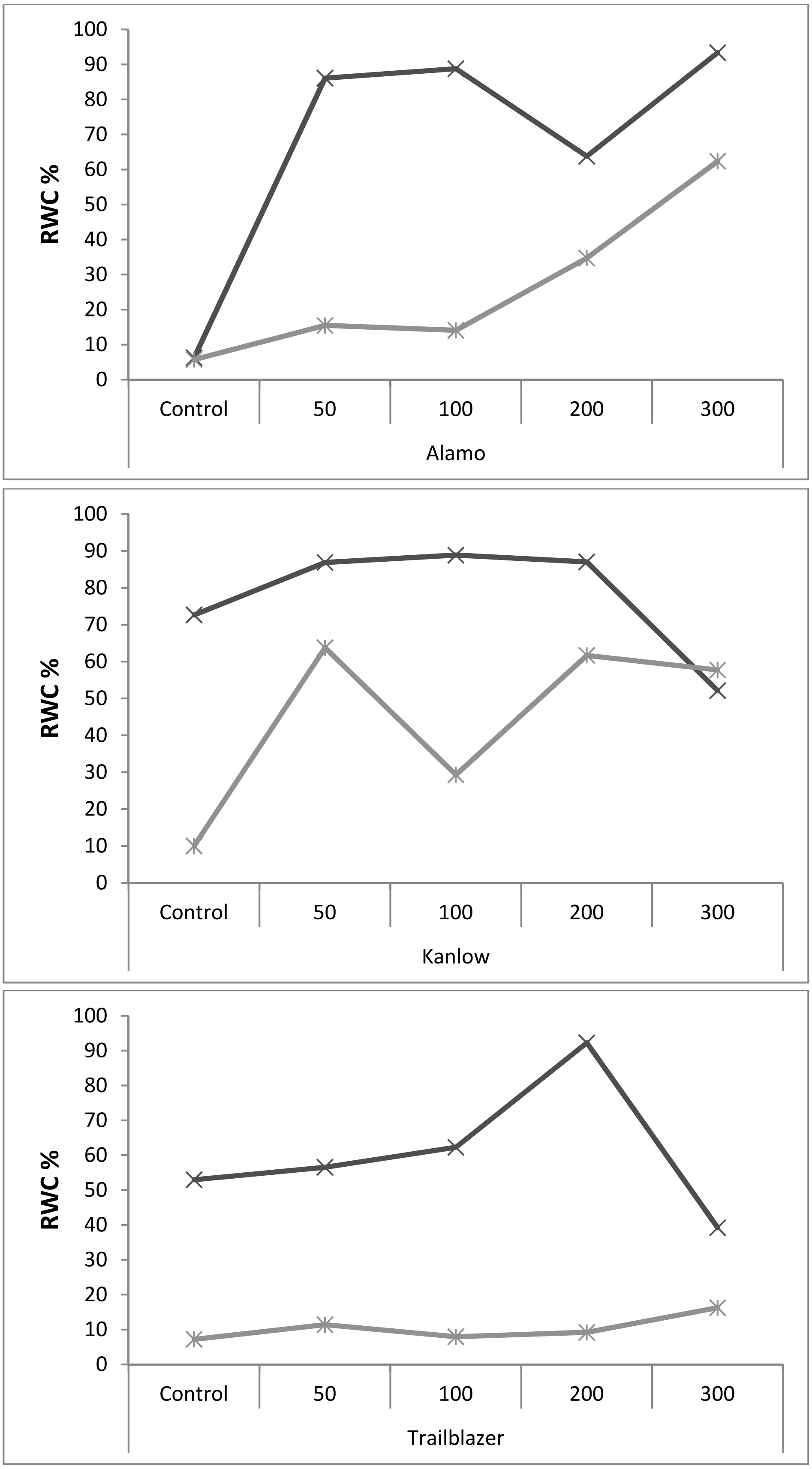


Figure 4 - UCD. Relative water content (RWC - %) in *Panicum virgatum* var. Alamo, Kanlow and Traiblazer (n=3) after 7 (black) and 9 (grey) months of growth under different salinities (mM).

Task 1.2 Physiology of giant reed (*UIB, UB*)

Universitat de Les Illes Balears – UIB (n. 9)

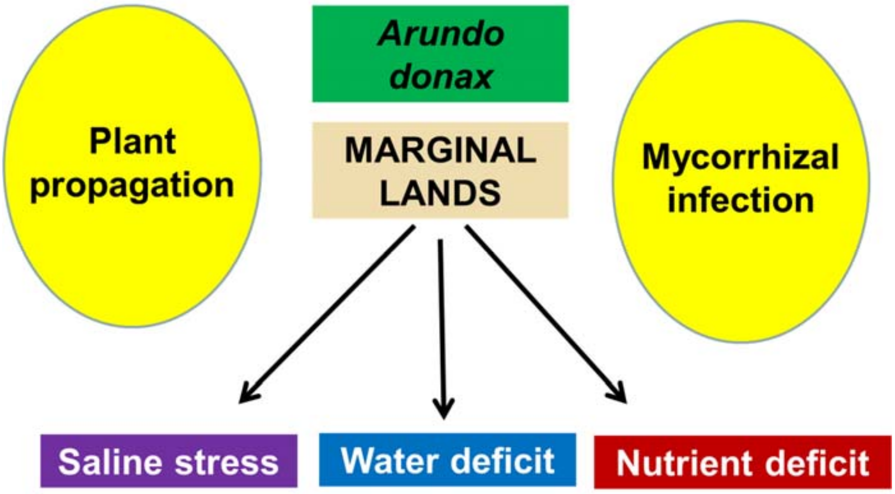


Figure 1 - UIB. Activities of Task 1.2 in which Partner 9 has been involved during 2013-14.

Table 1 - UIB. Biomass partitioning (grams, g) of inoculated (AM) and non-inoculated (C) *Arundo donax* plants under well-watered (WW), mild drought (MS) and severe drought (SS) conditions. Values are means of 6 replicates ± standard error. Different letters indicate significant differences at $p<0.05$

	LEAVES	STEM	ROOT	RIZOME	SHOOT	S/R	TB	LA (cm^2)
C-WW	61,48 ±2,30A	89,76 ±2,13A	110,74 ±11,04A	156,89 ±5,68A	151,24 ±4,01A	0,569 ±0,02AB	418,9 ±14,4A	754,1 ±52,0A
C-MS	44,62 ±2,41B	63,48 ±2,76B	80,39 ±5,52B	110,09 ±7,48B	108,10 ±4,27B	0,584 ±0,06A	298,6 ±10,6B	521,1 ±48,3AB
C-SS	38,08 ±0,52CD	51,21 ±2,35C	79,50 ±3,69B	107,85 ±5,18B	89,29 ±2,50C	0,479 ±0,016B	276,6 ±9,0BC	428,2 ±23,0AB
AM-WW	64,00 ±2,60A	93,10 ±5,97A	108,67 ±4,65A	160,73 ±3,03A	157,09 ±8,27A	0,584 ±0,03A	426,5 ±11,9A	743,4 ±46,1AB
AM-MS	42,92 ±1,77B	55,33 ±4,93BC	82,50 ±4,08B	108,13 ±4,61B	98,25 ±6,56BC	0,515 ±0,03AB	288,9 ±11,0B	510,02 ±69,99B
AM-SS	36,52 ±2,15D	50,97 ±4,76C	70,44 ±2,86B	98,21 ±3,11B	87,49 ±6,87C	0,522 ±0,05AB	256,1 ±7,3C	414,9 ±31,4AB

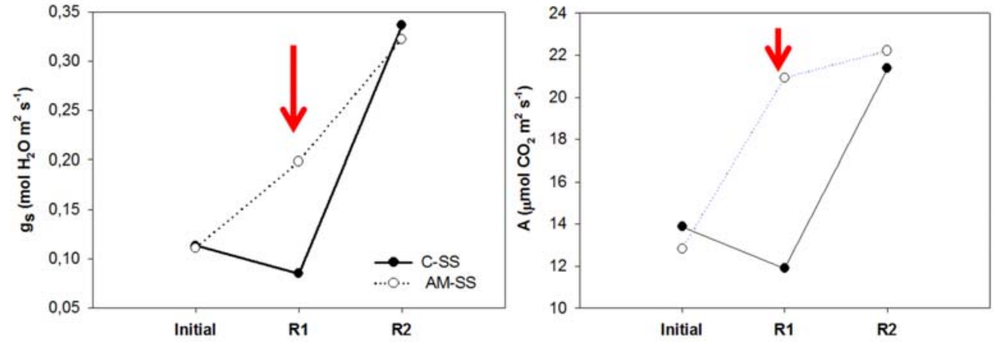


Figure 2 - UIB. Stomatal conductance and net photosynthesis of inoculated (AM) and non-inoculated (C) *Arundo donax* plants under severe drought (SS) conditions just before rewaterin (initial) and 1 (R1) and 2 (R2) days after rewatering. Values are means of 6 replicates ± standard error.

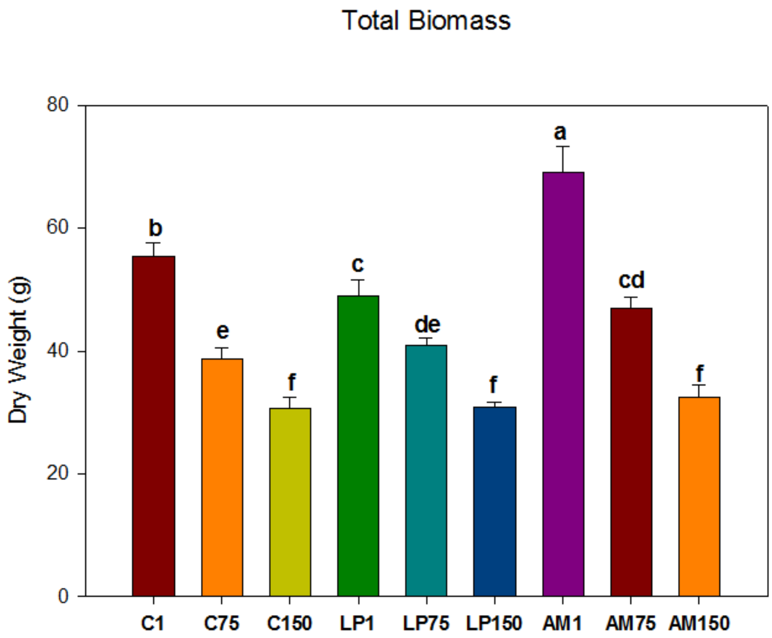


Figure 3 - UIB. Total dry biomass of inoculated (AM, LP) and non-inoculated (C) *Arundo donax* plants at three salinity levels (1, 75 and 150 mM NaCl). C and AM plants were grown at 30 mg P/l, LP plants were grown at 2 mg P/l. Values are means of 6 replicates ± standard error. Different letters indicate significant differences at $p<0.05$.

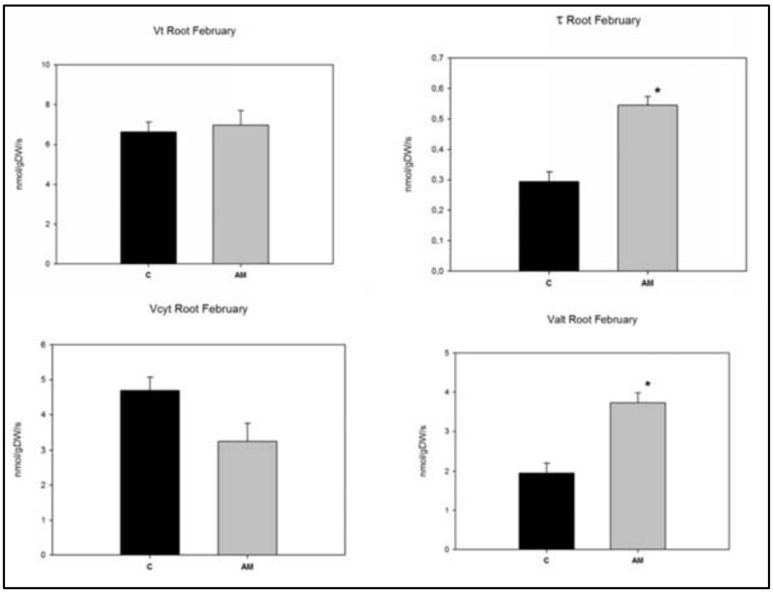


Figure 4 - UIB. Total respiration (Vt), electron partitioning to the alternative pathway (Ta), cytochrome pathway activity (vcyt), and alternative pathway activity (valt) in non-inoculated (C) and inculated (AM) Arundo donax plants. Values are means of 5 replicates ± standard error. * indicates significant differences at $p<0.05$

Table 2 - UIB. Plant biomass (g), shoot biomass (g) and plant height (mm) of micropropagated plantlets of A. donax (AM, inoculated and Non-AM, non-inoculated plants). Values are means of 10 replicates ± standard error Different letters indicate significant differences at $p<0.05$.

	AM Plants	Non-AM plants
Total dry biomass	0.235 ± 0.010a	0.163 ± 0.011b
Shoot dry biomass	0.164 ± 0.008a	0.104 ± 0.008b
Plant height	168.9 ± 6.77a	129.4 ± 5.18b

Universitat de Barcelona – UB (n. 10)

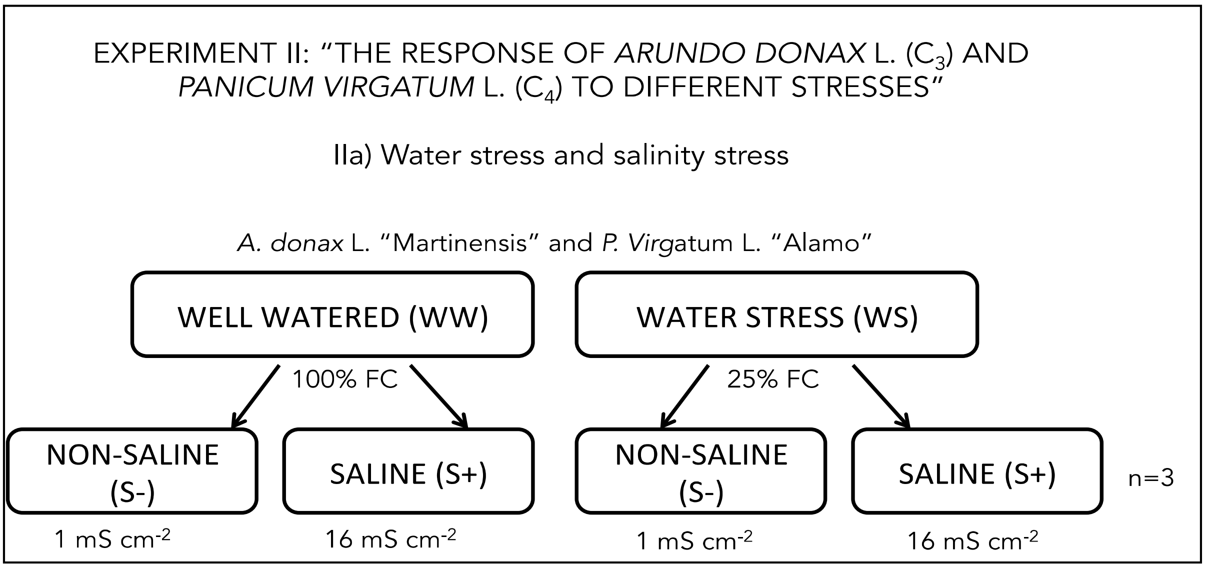


Figure 1 – UB. Scheme of the experimental design of experiment II.

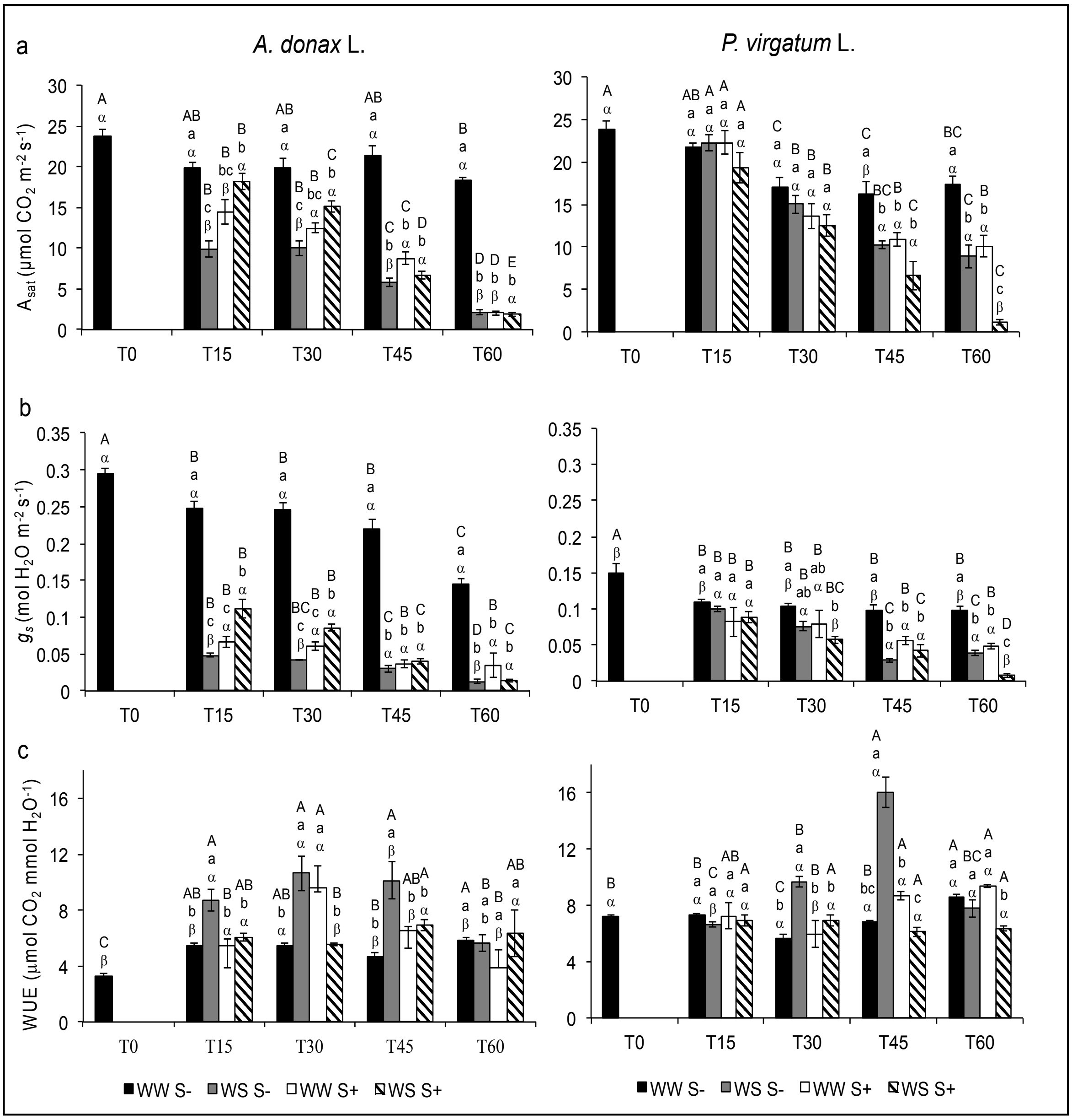


Figure 2 – UB. Representation of A_{sat} (a), g_s (b) and $_i$WUE (c) values of *A. donax* and *P. virgatum* during (T0, T15, T30, T45, T60) for each treatment: i) well-watered without salinity (WW S-); ii) low watered without salinity (WS S-); iii) well-watered with salinity (WW S+) and iv) low watered with salinity (WS S+). Values are the mean of four replicates and standard errors (*SE*) are shown. Data were analyzed with an ANOVA Tukey analysis. Different capital letters mean significant differences ($P < 0.05$) between time (T0-T60) for the same species and treatment, different small letters mean significant differences ($P < 0.05$) between treatments for the same species and time and different Greek letters mean significant differences ($P < 0.05$) between species for the same treatment and time.

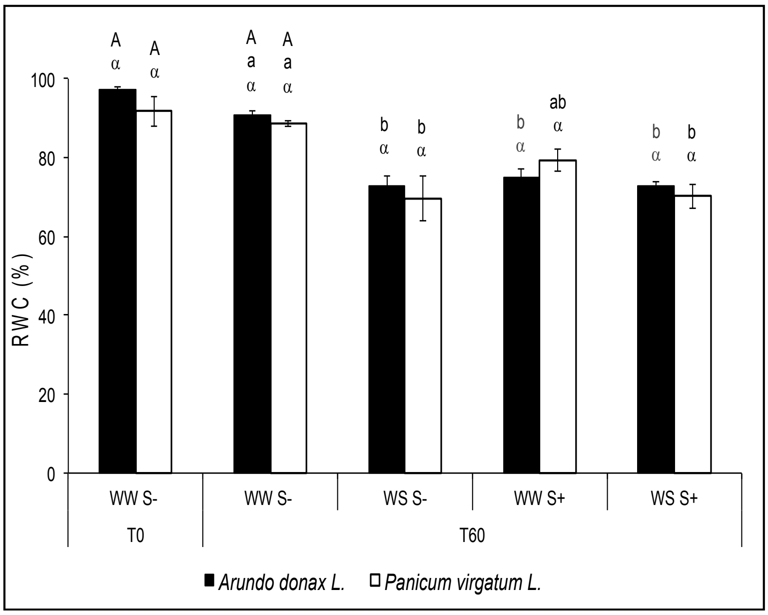


Figure 3 - UB. Changes in relative water content (RWC, %) between the beginning (T0) and the end of the experiment (T60) for both species and treatments (WW S-, WS S-, WW S+ and WS S+). Data are the means of three replicates and the standard errors (SE) are shown. Data were analysed with an ANOVA Tukey analysis. Different capital letters mean significant differences ($P < 0.05$) between time (T0 – T60) for the same species in the control treatment (WW S-), different small letters mean significant differences ($P < 0.05$) between treatments for a same species at T60 and different Greek letters mean significant differences ($P < 0.05$) between species for same treatment.

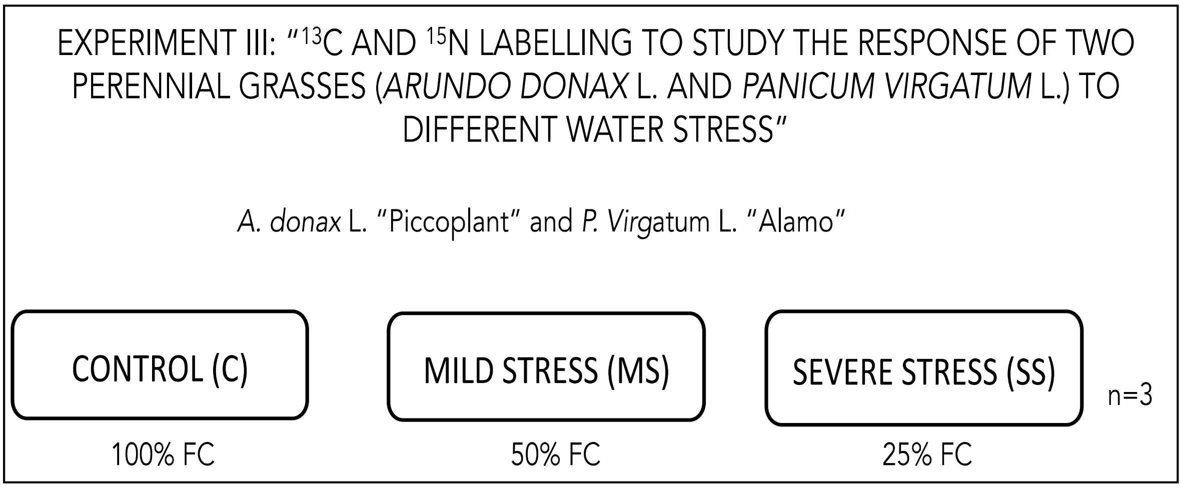


Figure 4 – UB. Scheme of the experimental design of experiment III.

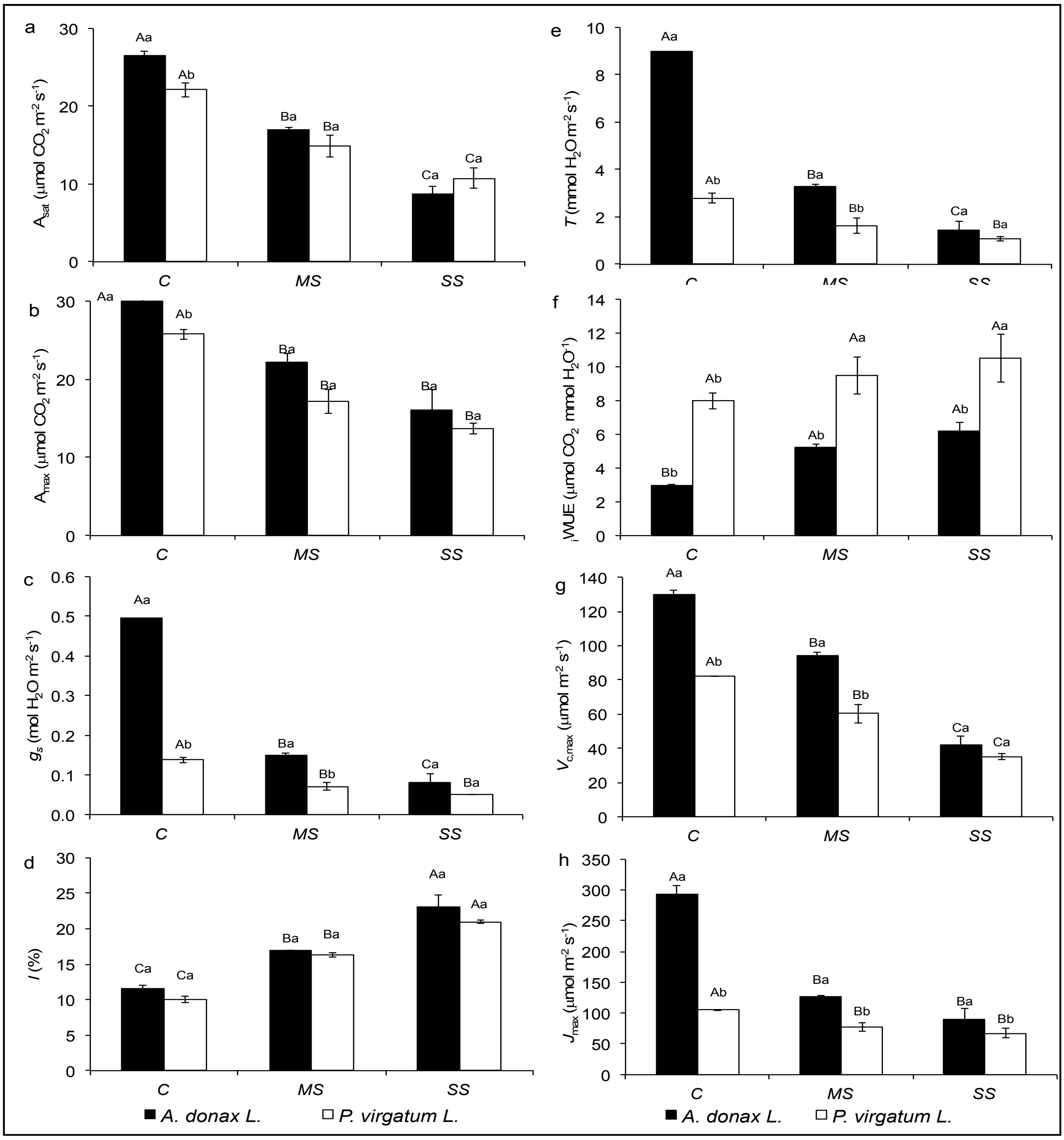


Figure 5 – UB. Photosynthesis parameters (Asat, assimilation rate at light saturation (a); Amax, maximum assimilation rate at light and CO2 saturation (b); gs, stomatal conductance (c); I, stomatal limitation (d); T, transpiration rate (e); WUE, water use efficiency (f); Vc, max, maximum carboxylation velocity of Rubisco (g); Jmax, the rate of photosynthetic electron transport (h)) in both species (A. donax and P. virgatum L.) for each treatment: i) Control (C, 100% FC), ii) Mild stress (MS, 50% FC) and iii) Severe Stress (SS, 25% FC) at the end of the experiment (Tf). Data are the means of three replicates and the standard error is shown. Data were analyzed with an ANOVA Tukey analysis. Different capital letters indicate significant differences (P < 0.05) between treatments for the same species and different small letters indicate significant differences (P < 0.05) between species for the same treatment.

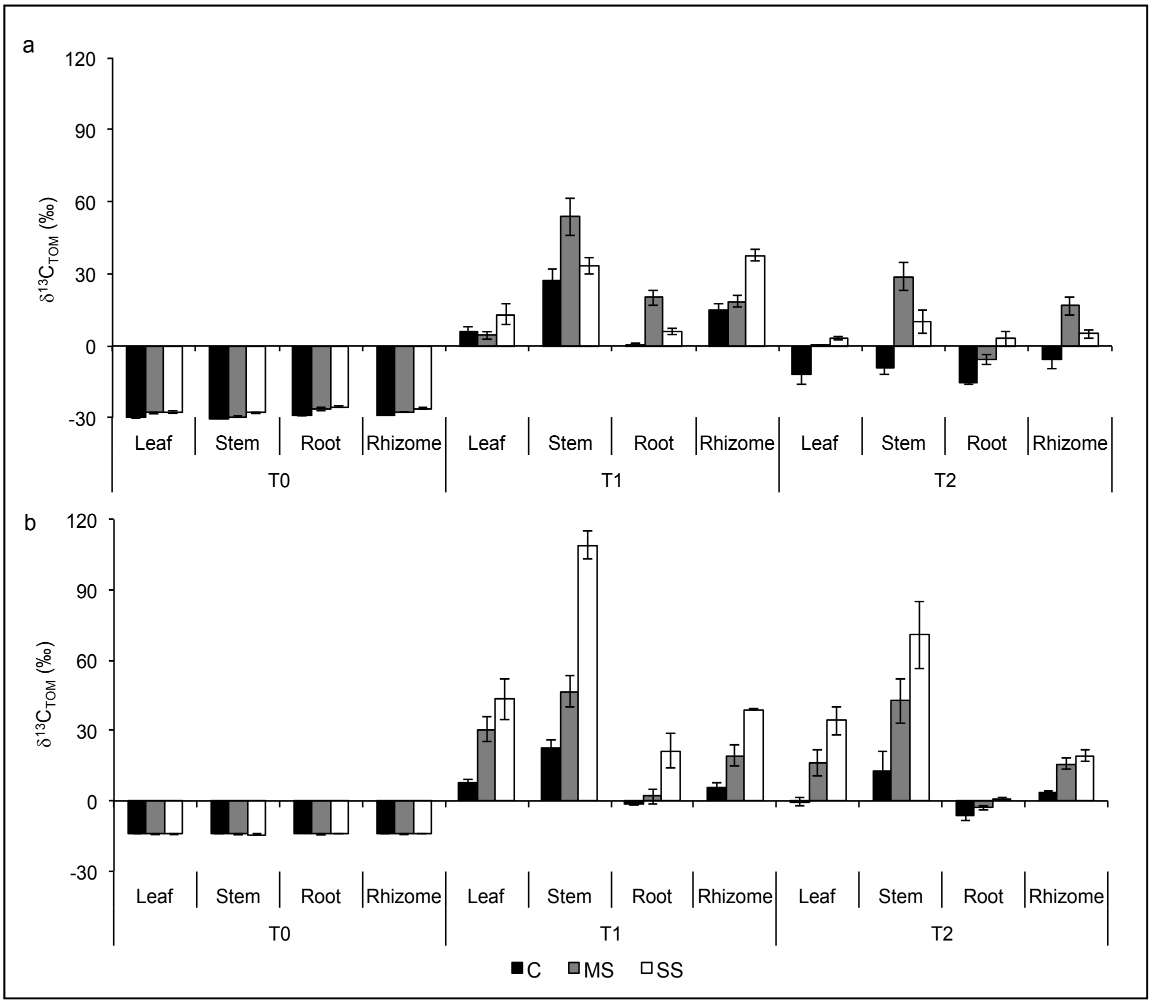


Figure 6 – UB. Water stress effects (Control (C, 100% FC), Mild Stress (MS, 50% FC) and Severe Stress (SS, 25% FC) on $\delta^{13}C$ values (‰) of CO_2 in total organic matter ($\delta^{13}CTOM$) in leaves, stems, roots and rhizomes in both species (*A. donax* (a) and *P. virgatum* (b)) before labelling (T0), 1 day after labelling (T1) and 7 days after labelling (T2).

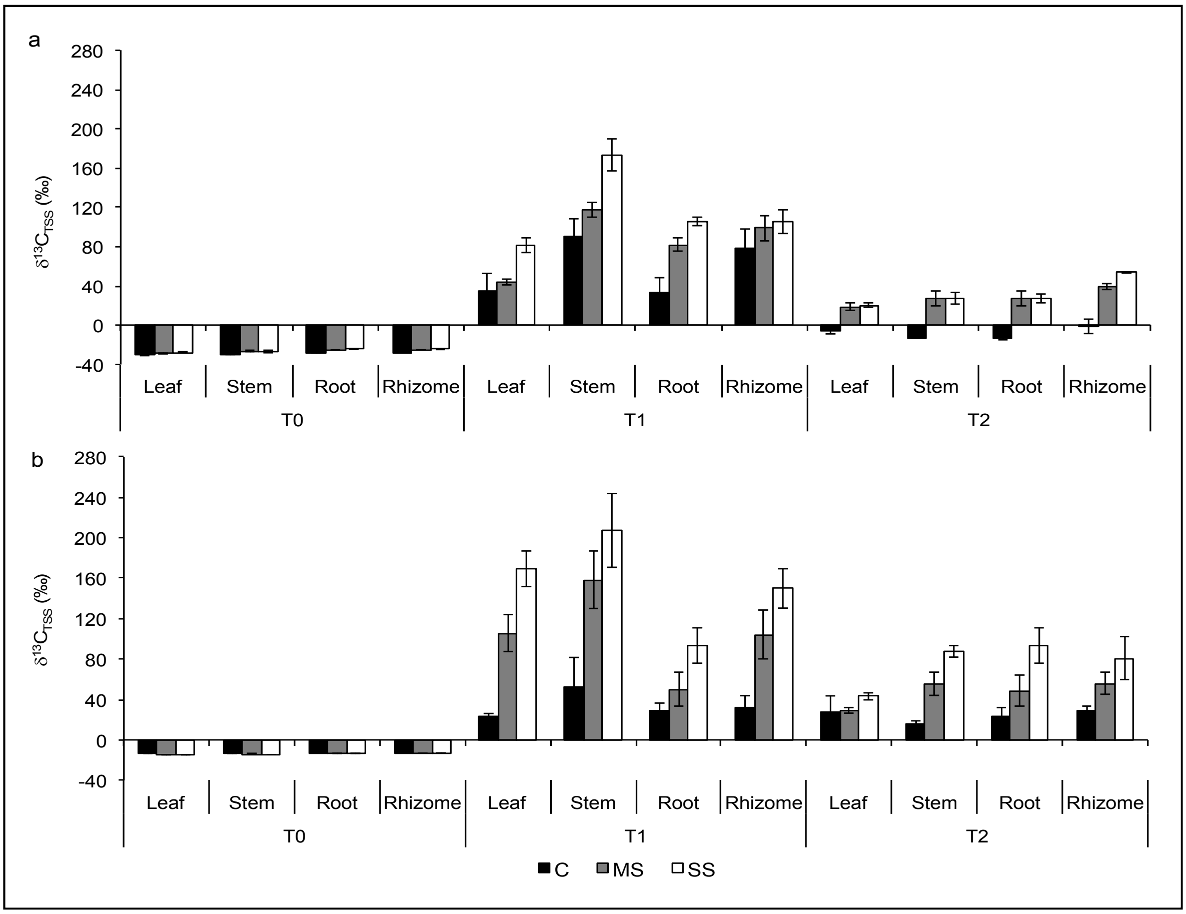


Figure 7 – UB. Water stress effects (Control (C, 100% FC), Mild stress (MS, 50% FC) and Severe Stress (SS, 25% FC) on δ^{13}C values (‰) of sugars (δ^{13}CTSS) in leaves, stems, roots and rhizomes in both species (*A. donax* (a) and *P. virgatum* (b)) before labelling (T0), 1 day after labelling (T1) and 7 days after labelling (T2).

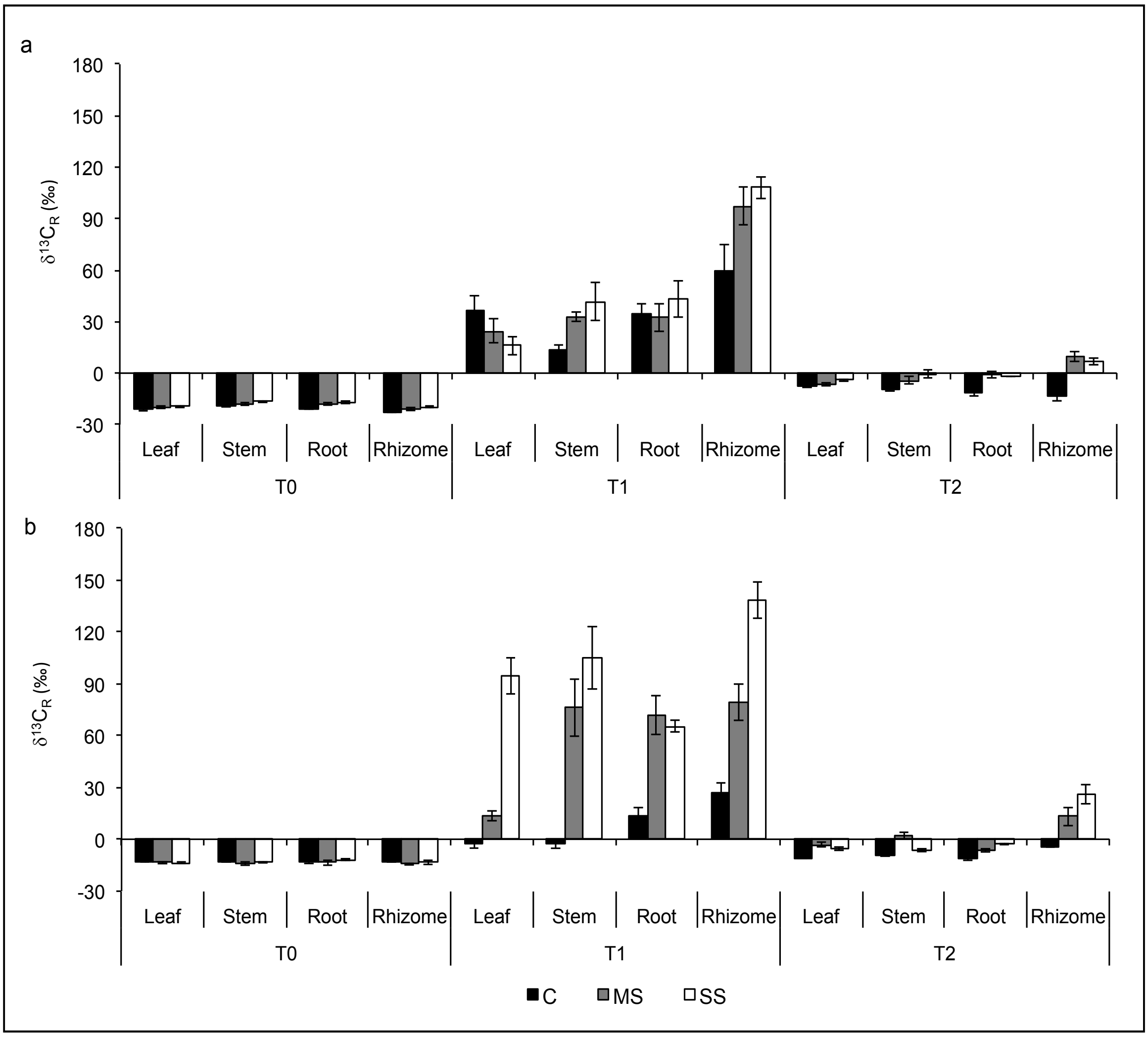


Figure 8 - UB. Water stress effects (Control (C, 100% FC), Mild Stress (MS, 50% FC) and Severe Stress (SS, 25% FC) on $\delta^{13}C$ values (‰) of respired CO_2 ($\delta^{13}CR$) in leaves, stems, roots and rhizomes in both species (*A. donax* (a) and *P. virgatum* (b)) before labelling (T0), 1 day after labelling (T1) and 7 days after labelling (T2).

WP2 – Plant biotechnology

Instituto of Agrobiotechnology Rosario – INDEAR (n. 17)

Table 1 – INDEAR. Sequencing metrics; level of the sequencing process (read 1, read 2/index, read 3), cycles of chemistry, total yield of each step and percentage of bases with quality scores equal or above Q30.

Level	Cycles	Total Yield	% ≥ Q30
Read 1	151	47.8 G	81.8
Read 2 (I)	7	1.9 G	90.0
Read 3	151	47.8 G	79.4
Total	**309**	**97.5 G**	**80.8**

Table 2 – INDEAR. Metrics per sample, sample ID/genotype, total passing filter (PF) paired-ends (PE) reads in millions (M), total bases sequenced (Gb).

Sample ID	Total PF PE reads (M)	Total bases sequenced (Gb)
Summer	98	14,9
Caddo	90	13,7
Greenville	92	13,9
Pathfinder	79	12,0
EG1101	73	11,1
Blackwell	119	18,0
EG2101	80	12,0
Total	**632**	**95,50**
Average	90	13,6
SD	15	2,3

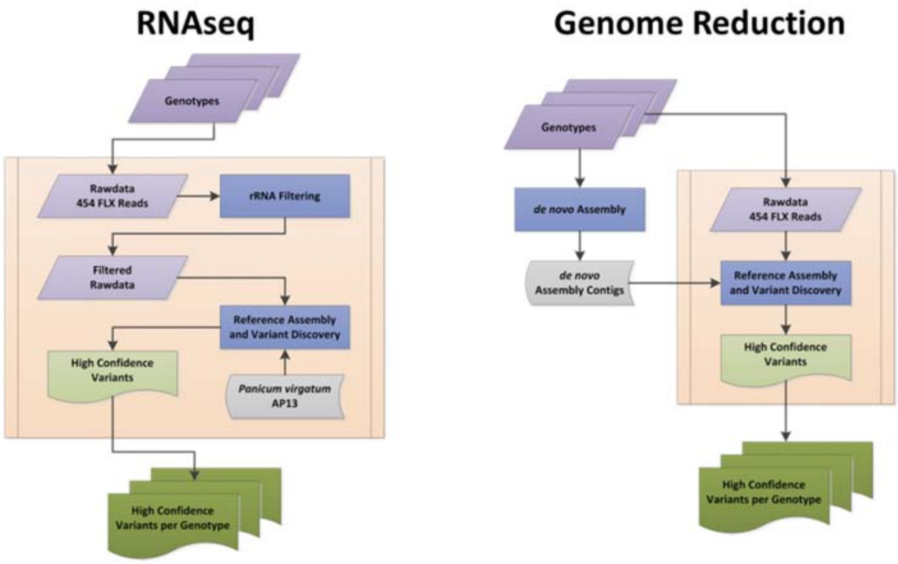


Figure 1A - INDEAR. RNA-seq pipeline for 454/Roche sequencing. **B.** Genome Reduction pipeline for 454/Roche sequencing.

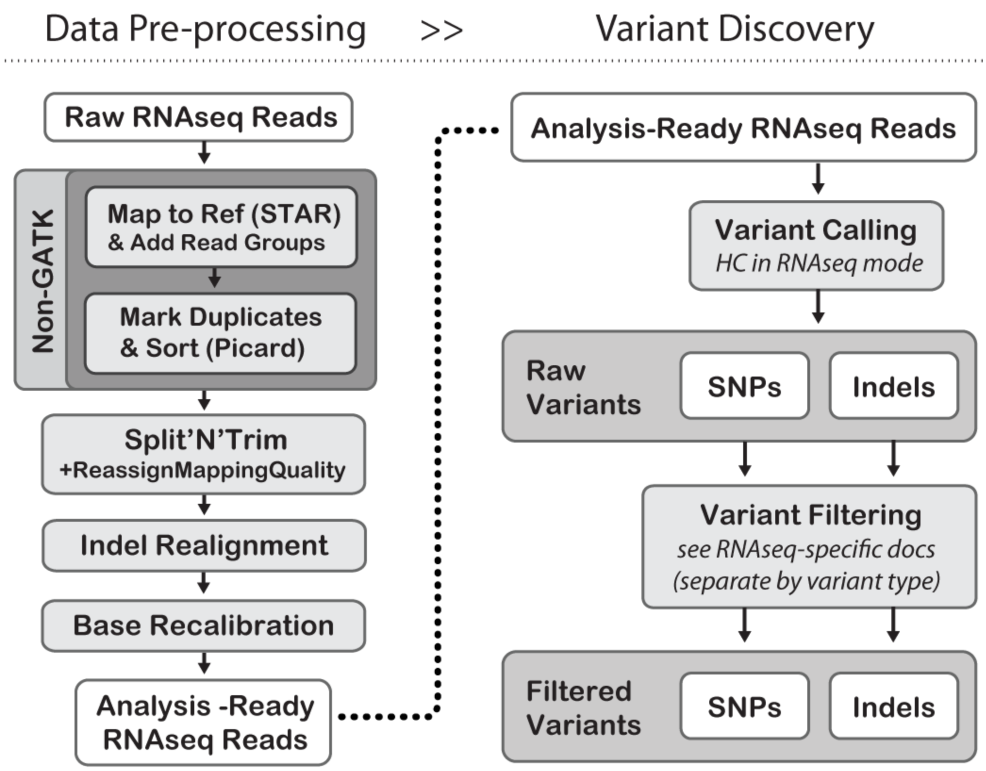


Figure 2 - INDEAR. RNA-seq variant Discovery pipeline by GATK.

Table 3 - INDEAR. Some detail about the crosses that have been carried out in INDEAR between the pre-selected switchgrass cultivars. Experimental I (Exp1 or EI) X Experimental II (Exp2 or EII) and EI X S (Summer). Exp 1 and Exp 1* correspond to two different parental plants. The crosses or lines in grey correspond to failed crosses as detection of female parent line has occurred.

Crop	Female parent	X	Male Parent	Envelope #	Sowing Date
Switchgrass	Exp 1*	x	Summer	23	28/04/15
Switchgrass	Summer	x	Exp 1	10	28/04/15
Switchgrass	Exp 1 *	x	Summer	3	28/05/15
Switchgrass	Exp 1 *	x	Summer	3	28/05/15
Switchgrass	Summer	x	Exp 1*	4	28/05/15
Switchgrass	Summer	x	Exp 1*	4	28/05/15
Switchgrass	Summer	x	Exp 1*	4	28/05/15
Switchgrass	Exp 1*	x	Summer	8	28/05/15
Switchgrass	Exp 2	x	Exp 1	3	28/05/15
Switchgrass	Exp 1	x	Exp 2	5	28/05/15
Switchgrass	Exp 1	x	Exp 2	5	28/05/15
Switchgrass	Exp 1	x	Exp 2	5	28/05/15

Figure 4 - INDEAR. Representative photograph of ongoing F_1 crosses at Indear greenhouse.

Parent Line	Allele
Summer	1
EII	1
EI	3
EI*	2

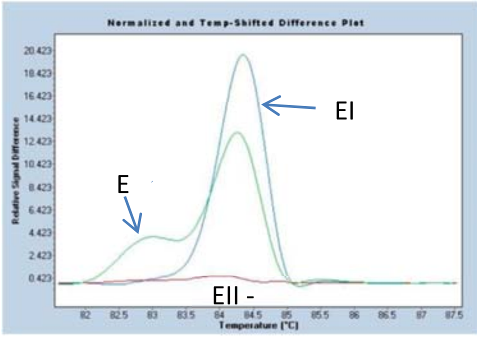


Figure 5 - INDEAR. Results obtained by HRM for marker 1 for the different parent plants. Right panel, Graphic representation of the different normalized temperatures (curves) for Marker 1. Curves that correspond to the different parent lines are indicated. Each color curve corresponds to one allele of the SNP of contig 67032, position 4.044.

Huazhong Agricultural University – HZAU (n. 14)

Table 1 – HZAU. The number of sample and SNP for GBS

Project		Samples	SNP numbers
Drought tolerance		50	319,900
Map genome	Piccoplant	27	213,057
	Fondachello	24	210,491
	Granadensis	9	31,655
	Martinensis	52	303,593
	Argentum	19	105,417
Total		181	1,184,113

Figure 1 – HZAU. DNA extraction quality (1% agarose gel of DNA quality)

a)

b)

c)

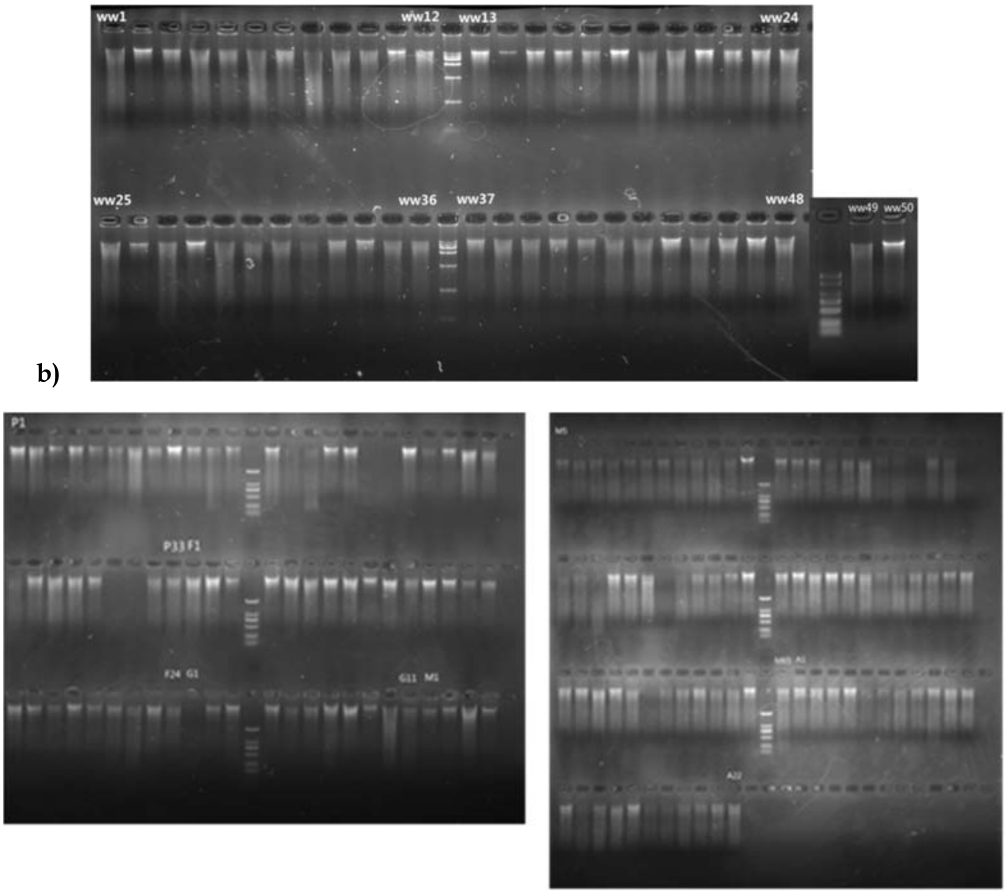


Table 1 - HZAU. GBS raw data statistic

Total read numbers	Accepted reads numbers	Accepted reads ratio	The average depth of each clones	Raw SNP numbers
197,671,204	*144,058,366*	*73%*	*0.288 Gb*	*319,900*

Table 2 – HZAU. The number of sample and SNP for GBS

Project		Samples	SNP numbers
Drought tolerance		50	319,900
Map genome	Piccoplant	27	213,057
	Fondachello	24	210,491
	Granadensis	9	31,655
	Martinensis	52	303,593
	Argentum	19	105,417
Total		181	1,184,113

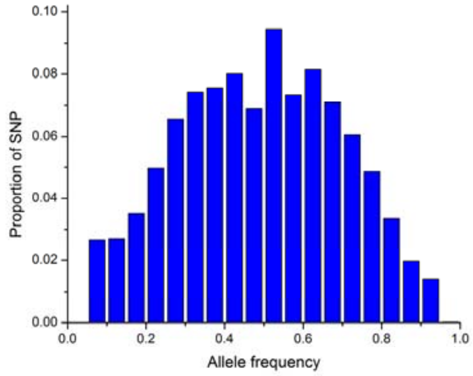


Figure 2 - HZAU. Total SNPs allele frequency distribution of drought tolerance experiment

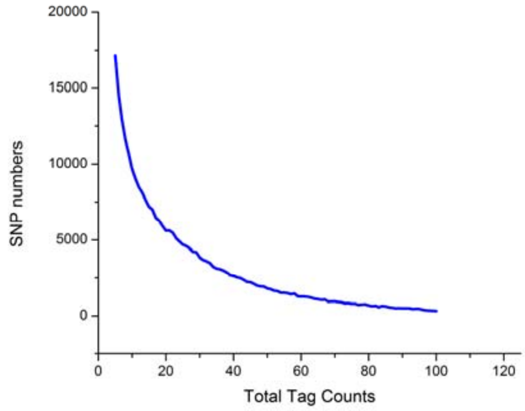


Figure 2 **- HZAU**. Tag counts depths distribution in 50 clones of drought tolerance experiment.

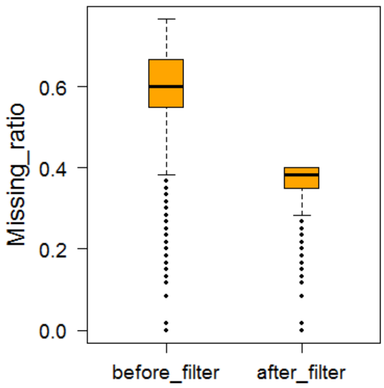


Figure 3 - HZAU. Genotype missing ratio before and after filtering.

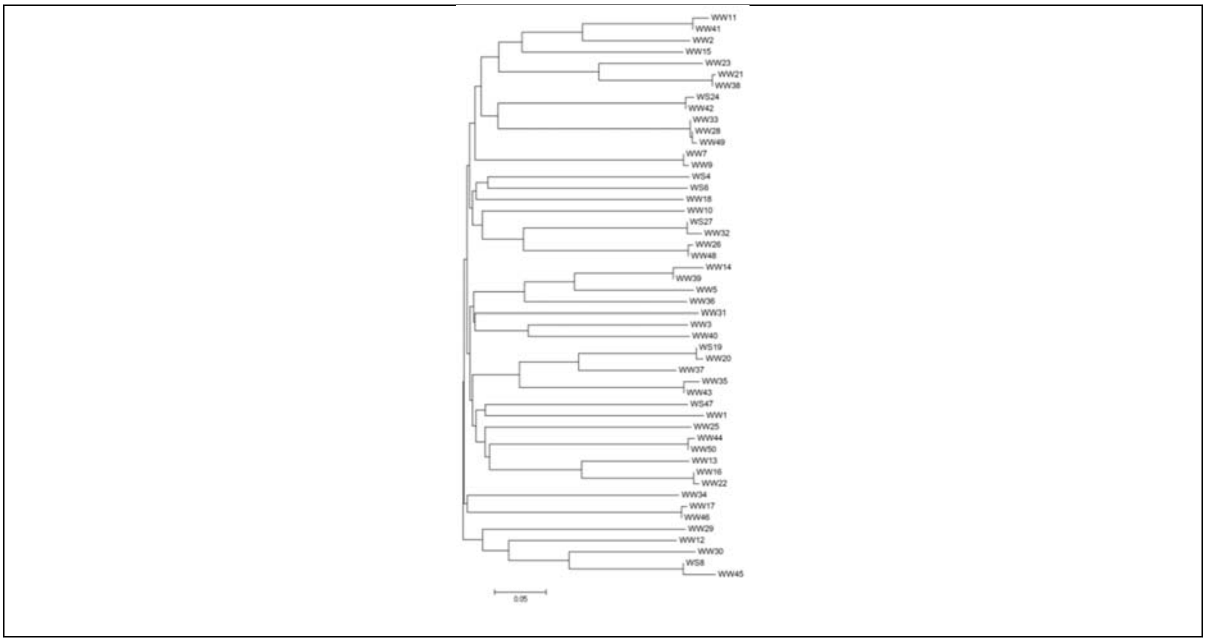


Figure 4 - HZAU. Neighbor-Joining tree of 50 samples was constructed by the 319,900 SNPs markers.

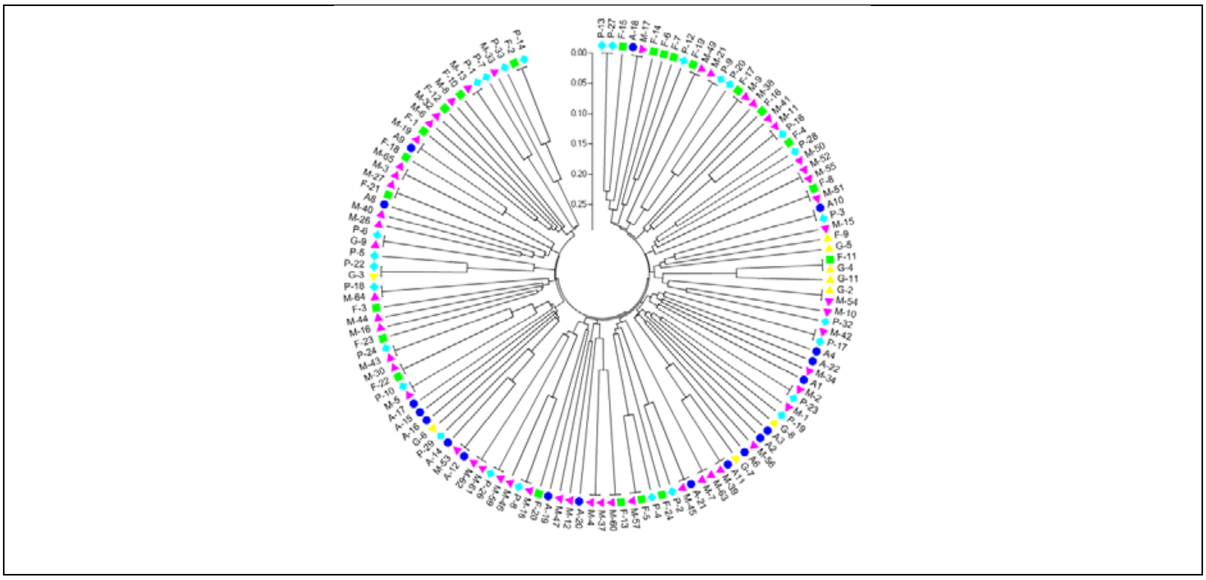


Figure 5 - HZAU. Neighbor-Joining tree of 131 samples contained 5 ecotypes was constructed.

Task 3.1 - Characterization of endemic grasses and novel plant varieties adapted to southern European conditions

Unversità di Catania - UNICT (n. 1)

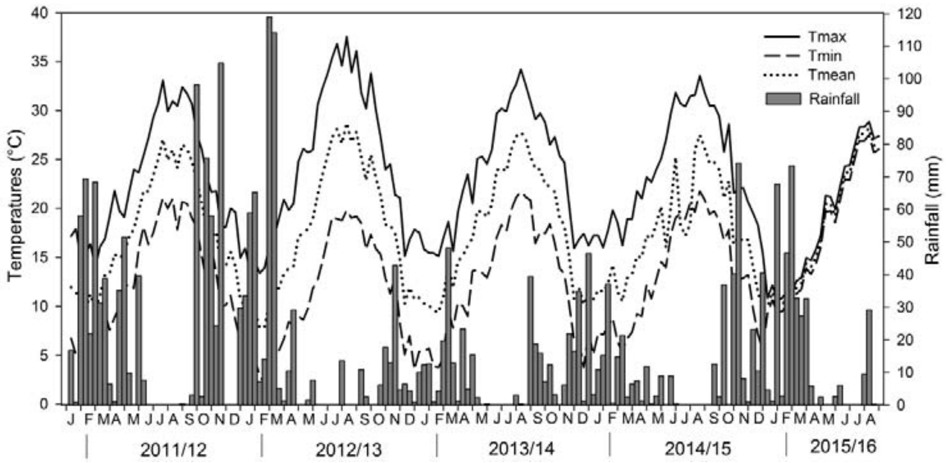


Figure 1 - UNICT. Meteorological trend from establishment up to last harvest of perennial spontaneous grasses at the UNICT Experimental farm.

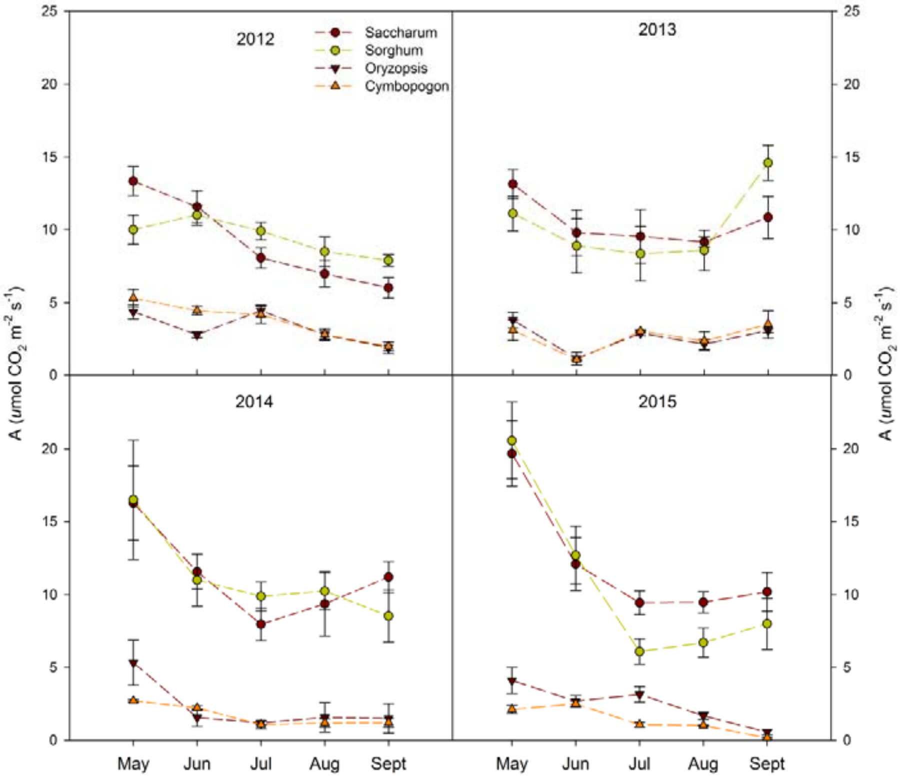


Figure 2 - UNICT. Assimilation rate (A, µmol CO_2 m^{-2} s^{-1}) of the four endemic grasses in 2012, 2013, 2014 and 2015 growing seasons.

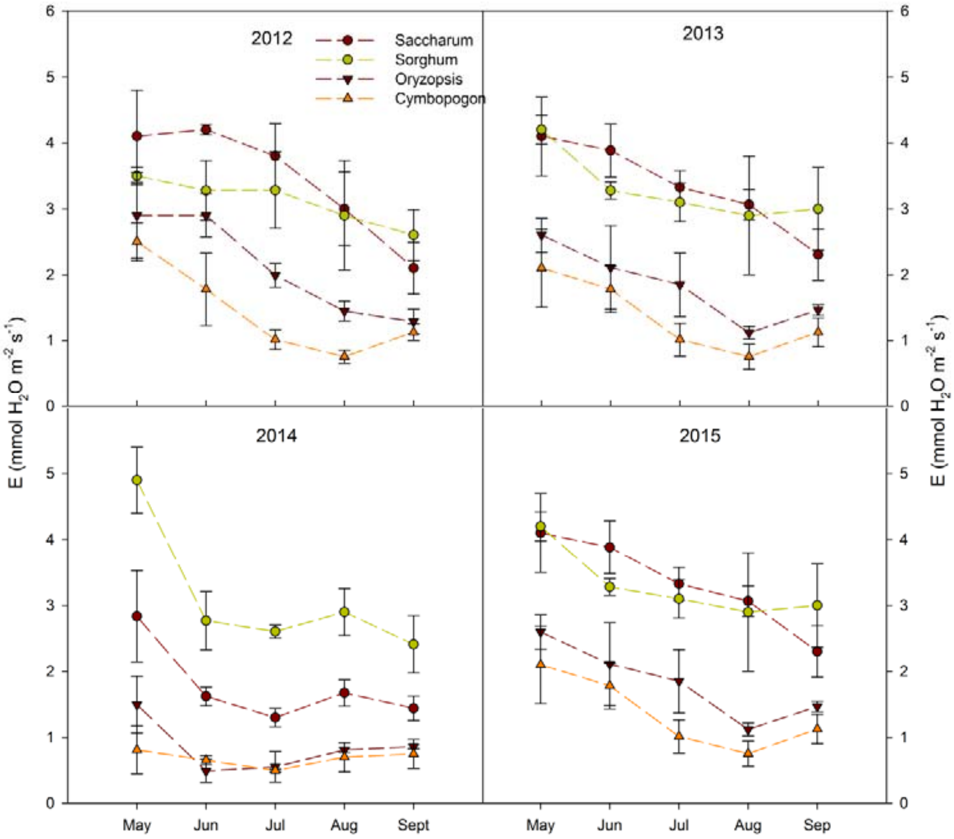
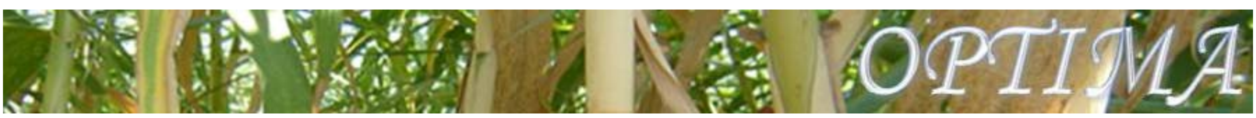


Figure 3 - UNICT. Transpiration rate (E, mmol H_2O m^{-2} s^{-1}) of the four endemic grasses in 2012, 2013, 2014 and 2015 growing seasons.



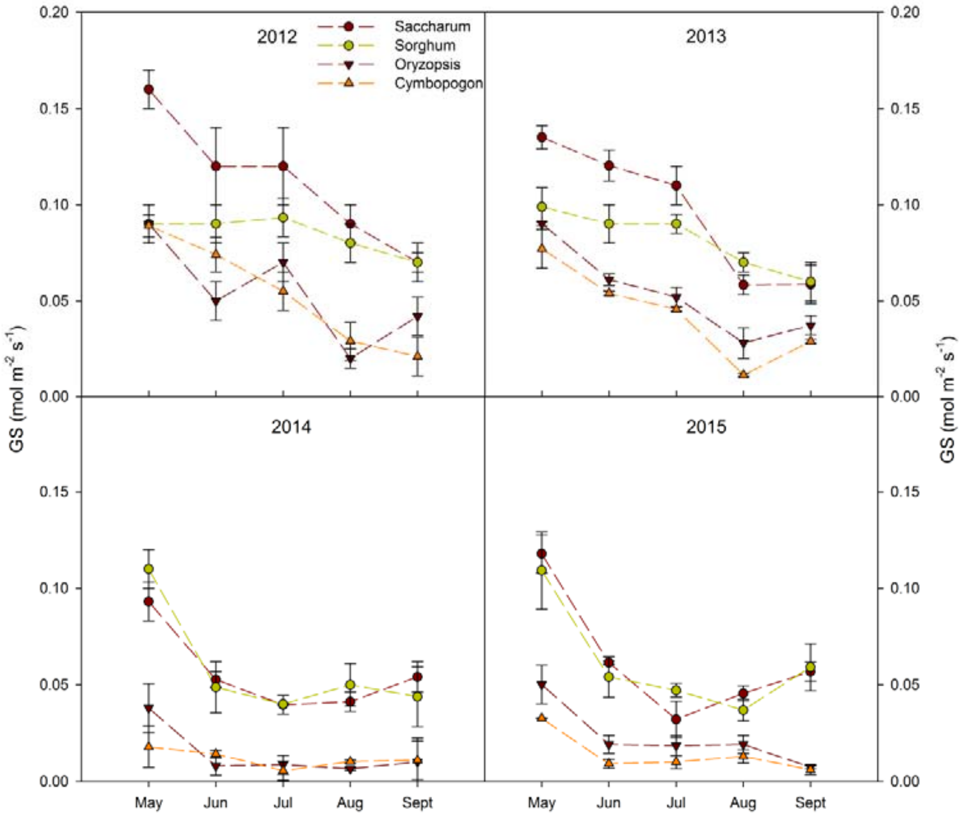


Figure 4 - UNICT. Stomatal conductance (GS, mol m^{-2} s^{-1}) of the four endemic grasses in 2012, 2013, 2014 and 2015 growing seasons.

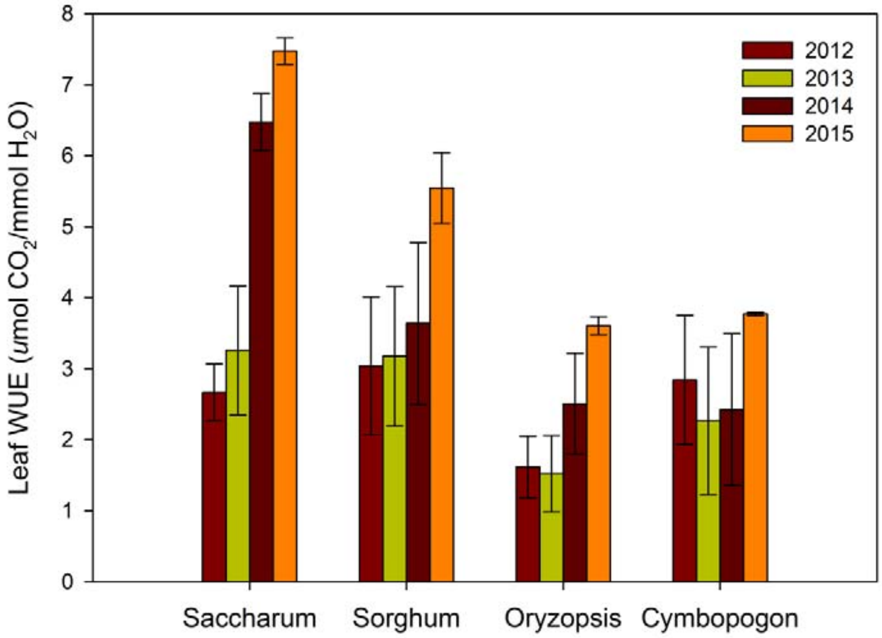


Figure 5 - UNICT. Leaf Water Use Efficiency (µmol CO_2/mmol H_2O m^{-2} s^{-1}) of the four endemic grasses in 2012, 2013, 2014 and 2015 growing seasons.

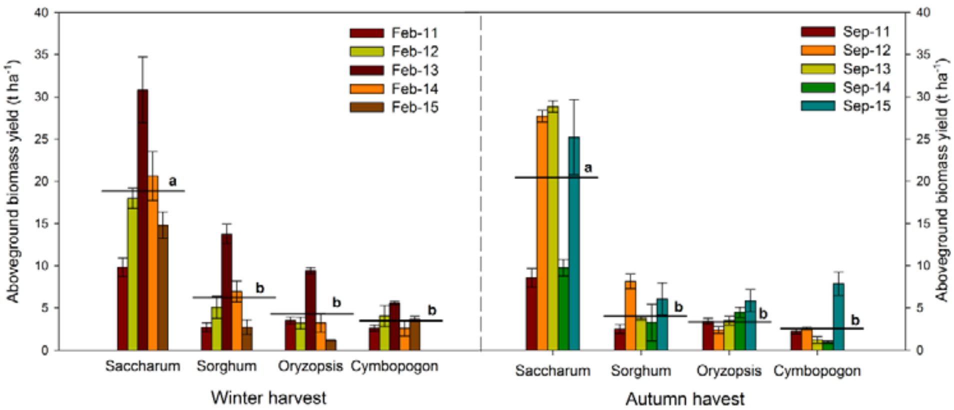


Figure 6 - UNICT. Aboveground dry biomass yield of wild grasses (*O. miliacea*, *C. hirtus*, *S. halepense* and *S. spontaneum* L. ssp. *aegyptiacum*) in different years and harvest dates. Horizontal lines represent the mean within the species. Different letters indicate significant mean according to the LSD test at $p \leq 0.05$.

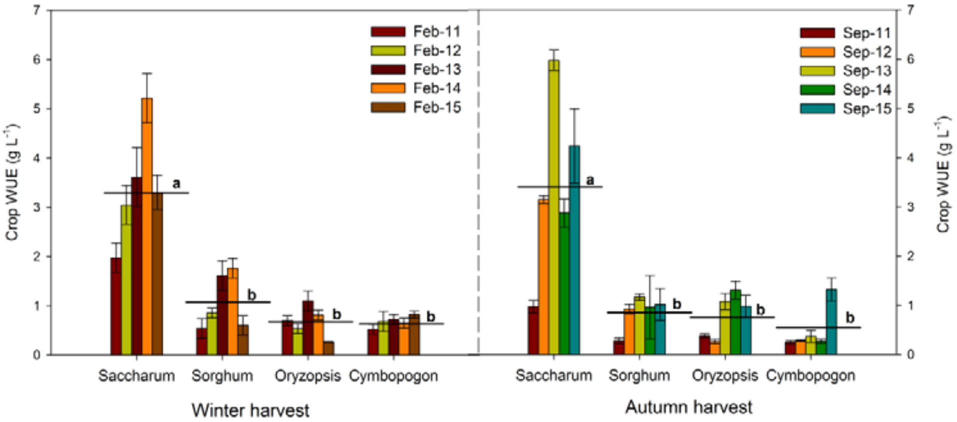


Figure 7 - UNICT. Water Use Efficiency (g L^{-1}) of wild grasses (*O. miliacea*, *C. hirtus*, *S. halepense* and *S. spontaneum* L. ssp. *aegyptiacum*) in different years and harvest dates. Horizontal lines represent the mean within the species. Different letters indicate significant mean according to the LSD test at p≤0.05.

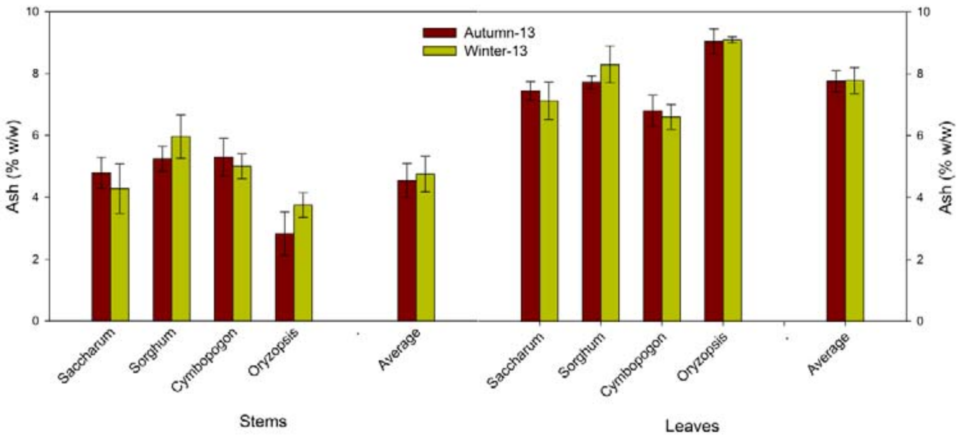


Figure 8 - UNICT. Ash content of wild grasses (*O. miliacea*, *C. hirtus*, *S. halepense* and *S. spontaneum*) in different harvest dates and biomass part (stems and leaves).

Table 1 - UNICT. Raw material composition of *O. miliacea*, *C. hirtus*, *S. halepense* and *S. spontaneum* in different harvest dates (autumn 2013 and winter 2014) and biomass part (stems and leaves).

Species	Year	Harvest	Part	NDS	Hemicellulose	Cellulose	Lignin
Saccharum	2014	Winter	Stem	20.82 ±0.51	21.16±3.95	35.62±4.30	22.23±3.53
Sorghum	2014	Winter	Stem	13.04±2.21	27.68±4.33	39.13±2.19	16.87±0.84
Cymbopogon	2014	Winter	Stem	21.08±2.94	11.27±0.66	43.27±0.89	23.48±2.09
Oryzopsis	2014	Winter	Stem	21.70±1.08	20.83±4.42	34.06±5.52	17.94±0.45
Average				***19.16*±3.54**	***20.23*±5.85**	**38.02±3.54**	**20.13±2.78**
Saccharum	2014	Winter	Leaf	19.65±0.58	27.99±1.68	30.79±1.30	15.31±1.97
Sorghum	2014	Winter	Leaf	19.43±3.23	22.06±2.63	35.29±2.40	16.26±1.18
Cymbopogon	2014	Winter	Leaf	18.27±4.66	29.70±4.39	28.90±1.58	16.39±1.13
Oryzopsis	2014	Winter	Leaf	23.01±2.15	23.81±4.42	26.73±4.56	19.69±1.33
Average				***20.07*±1.76**	***25.89*±3.07**	**30.42±3.15**	**16.91±1.65**
Saccharum	2013	Autumn	Stem	13.00±2.24	22.15±2. 95	36.72±1.18	17.46±2.59
Sorghum	2013	Autumn	Stem	25.64±1.57	15.80±2.67	31.69±1.10	14.78±2.73
Cymbopogon	2013	Autumn	Stem	13.88±0.98	25.47±1.97	35.64±3.11	19.10±1.14
Oryzopsis	2013	Autumn	Stem	19.92±2.22	27.30±0.99	23.82±3.31	29.69±2.98
Average				***18.11*±5.09**	***22.68*±4.38**	**31.96±5.06**	**20.25±5.65**
Saccharum	2013	Autumn	Leaf	13.89±2.42	28.13±0.39	36.65±2.26	19.07±2.35
Sorghum	2013	Autumn	Leaf	22.85±2.60	16.36±2.09	32.22±2.60	15.38±2.30
Cymbopogon	2013	Autumn	Leaf	22.86±2.49	27.29±0.92	27.19±3.53	17.66±2.60
Oryzopsis	2013	Autumn	Leaf	17.84±1.84	27.10±1.14	26.89±2.51	21.74±2.29
Average				***19.36*±3.76**	***24.72*±4.84**	**30.73±4.01**	**18.46±2.30**

Istituto per il Sistema Produzione Animale in Ambiente Mediterraneo – CNR-ISPAAM (n. 8)

Table 1 – CNR-ISPAAM. Total number of accessions (TotA) and accessions of Mediterranean (MedA) origin found in the main world repositories freely searchable on the Internet. The search regarded four high-yielding forage species and four native species collected in the project OPTIMA for their potential interest as bioenergy plants for marginal environments.

Species	Repository					
	GRIN		EURISCO		Margot Ford	
	TotA (no.)	MedA (no.)	TotA (no.)	MedA (no.)	TotA (no.)	MedA (no.)
D. glomerata	1491	755	13569	759	1135	421
F. arundinacea	940	572	2230	235	941	289
L. perenne	645	212	10581	380	3681	880
P. aquatica	371	265	57	26	431	147
S. spontaneum	620*	1**	2	0	0	0
A. mauritanicus	0	0	1	1	0	0
P. miliaceum	111	105	6	6	1	0
H. hirta	34	21	3	3	0	0

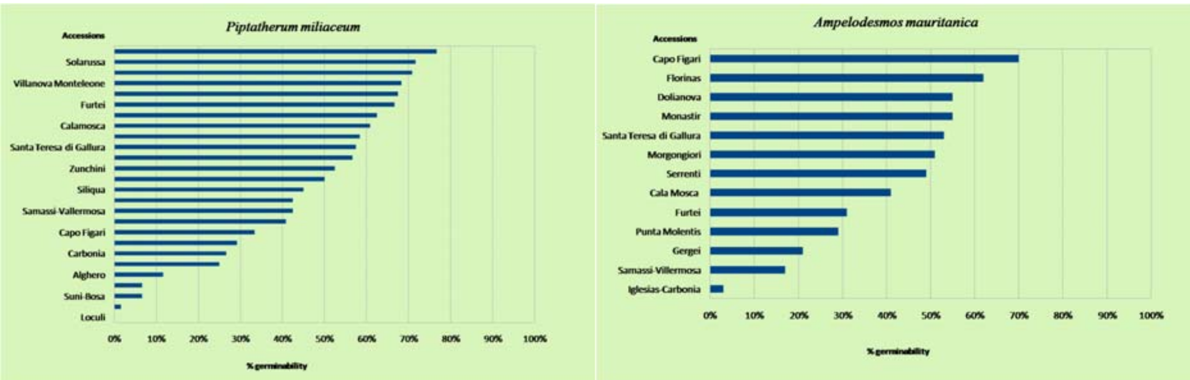


Figure 1 – CNR-ISPAAM. Germination rates of seeds harvested from wild Sardinian populations of *P. miliaceum* and *A. mauritanicus.*

Table 2 – CNR-ISPAAM. Survival rates of native populations of *P. miliaceum*, *A. mauritanicus* and *H. hirta*. The survival rate was recorded after two months from transplant of plantlets.

Species	Number of accessions	Survival rate after transplant (%)		Survival rate after summer (%)	
		mean	*range*	*mean*	*range*
A. mauritanicus	12	29.8	0-58.3	23.5	0-54.2
P. miliaceum	12	84.0	33.3-100	81.3	16.7-100
L. perenne	1	95.8	-	50.0	-
P. aquatica	1	50.0	-	16.7	-
D. glomerata	2	39.6	29.2-50	39.6	29.2-50
F. arundinacea	4	97.9	91.7-100	95.8	87.5-100
H. hirta	14	30.0	0.0-100		

Table 3 – CNR-ISPAAM. Average air temperature and intercepted PAR

Date	PAR	Max air temperature (°C)
06.06.2014	1666	28.4
07.07.2014	1560	30.6
23.04.2015	1874	23.6
13.05.2015	1954	29.7
29.05.2015	2261	26.2

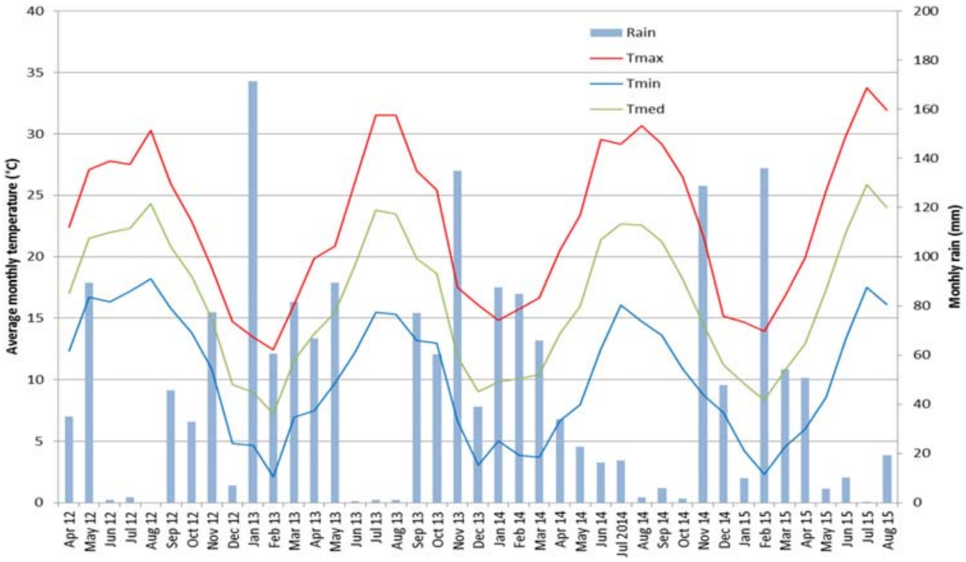


Figure 2 – CNR-ISPAAM. The weather pattern of the period from January 2012 to August 2015.

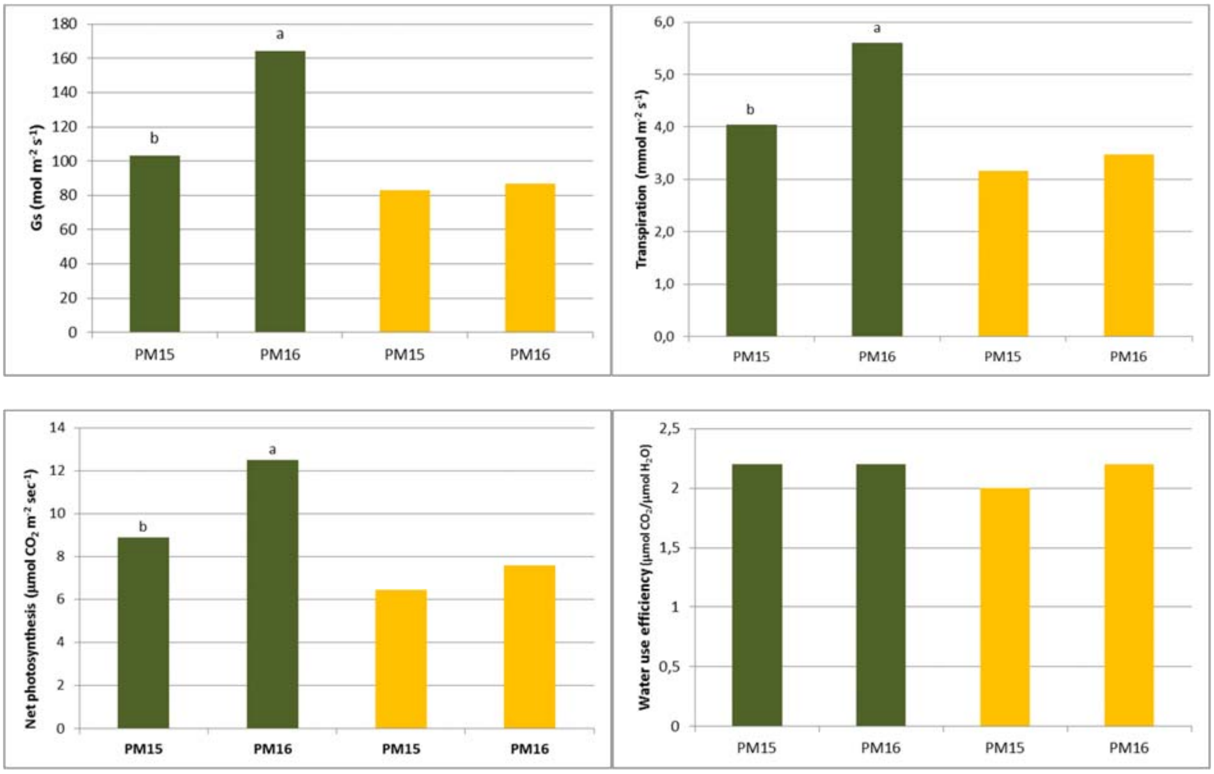


Figure 3 – CNR-ISPAAM. Stomatal conductance, transpiration, net photosynthesis and leaf water use efficiency in two accessions of P. miliaceum, measured on June 6th 2014 (green bars) and on July 7th 2014 (yellow bars).

Table 4 – CNR-ISPAAM. Stomatal conductance (Gs), instantaneous transpiration (E), instantaneous photosynthesis (PN) and photosynthetic water use efficiency (WUEi) of P. miliaceum, A. mauritanicus and F. arundinacea under rainfed conditions in Mediterranean environments. Different letters in the column indicate significant statistical differences among values (LSD test, $p<0.05$).

Species/ accession	Gs (mol m^{-2} s^{-1})			E (mmol H_2O m^{-2} s^{-1})			PN (µmol CO_2 m^{-2} s^{-1})			WUEi (µmol CO_2/mmol H_2O m^{-2} s^{-1})		
	23.04	*13.05*	*29.05*	*23.04*	*13.05*	*29.05*	*23.04*	*13.05*	*29.05*	*23.04*	*13.05*	*29.05*
AM4	1.69a	1.63a	1.63a	0.90a	0.74a	0.73a	2.59a	2.05a	2.08a	2.91b	2.88a	2.86a
PM15	1.66a	1.57b	1.56b	0.75a	0.53b	0.50b	2.85a	1.39b	1.49b	3.90ab	2.53a	3.01a
PM16	1.68a	1.63a	1.60ab	0.92a	0.76a	0.59ab	2.95a	2.03a	1.63ab	3.35ab	2.76a	2.81a
FE28	1.66a	1.54b	1.57b	0.82a	0.46b	0.51b	3.10a	1.09b	1.15b	4.09a	2.35a	2.21b

Table 5 – CNR-ISPAAM. Differences induced by mild (T50) water stress on ecophysiological performances of two accessions of *P. miliaceum*. Different letters in each column indicates significant different values for $p<0.05$ (LSD test).

Accession	Treatment	Measurement date			Measurement date		
		12.06	24.06	01.07	12.06	24.06	01.07
		Gs (mol H_2O m^{-2} s^{-1})			**E** (mmol H_2O m^{-2} s^{-1})		
PM15	T100	109.7a	124.6a	79.4a	4.2a	4.2a	2.8a
PM15	T50	21.1bc	3.9c	-	1.3c	0.9c	-
PM16	T100	41.2b	36.7b	6.0b	2.9b	2.7b	0.9b
PM16	T50	9.1c	5.4c	-	0.6c	0.8c	-
		PN (µmol CO_2 m^{-2} s^{-1})			**WUEi** (µmol CO_2/mmol H_2O m^{-2} s^{-1})		
PM15	T100	7.6a	7.4a	7.6a	7.4a	7.6a	7.4a
PM15	T50	1.8c	1.8c	1.8c	1.8c	1.8c	1.8c
PM16	T100	5.2b	4.4b	5.2b	4.4b	5.2b	4.4b
PM16	T50	0.9c	0.8c	0.9c	0.8c	0.9c	0.8c

Table 6 – CNR-ISPAAM. Relative water content (RWC) of leaves of P. miliaceum under four regimes of drought stress

Accession	Treatment	RWC
P. miliaceum PM15	T_{100}	92.8±1.94
P. miliaceum PM15	T_{50}	86.0±6.4
P. miliaceum PM15	T_{25}	78.5±16.0
P. miliaceum PM15	T_{0}	66.1±19.3
P. miliaceum PM16	T_{100}	91.4±4.9
P. miliaceum PM16	T_{50}	84.1±6.6
P. miliaceum PM16	T_{25}	79.0±8.5
P. miliaceum PM16	T_{0}	62.1±13.4

Table 7 – CNR-ISPAAM. Differences induced by mild (T50), severe (T25) and very severe (T0) water stress on some traits of *P. miliaceum*. Values refer to mean values and range (in brackets).

Accession	Treatment	Tillers height (cm)	N. tillers	Roots DW (g)	Tillers DW (g)	Panicles DW (g)	Root to shoot ratio
PM15	T100	160.0 (153-167)	26.3 (24.7-27.9)	11,1 (9.3-12.8)	31.6 (28-35.2)	4.6 (4.4-4.8)	0.3
PM15	T50	154.0 (147-161)	15.7 (14.1-17.3)	8,5 (6.8-10.2)	15.1 (11.5-18.7)	1.4 (1.0-1.9)	0.4
PM15	T25	154.3 (148-161)	11.0 (9.4-12.6)	7.3 (5.6-9)	19.8 (16.2-23.4)	1.4 (1.0-1.6)	0.3
PM15	T0	116.0 (109-123)	12.33 (10.7-13.9)	7.6 (5.9-9.4)	11.5 (7.9-15.1)	0.8 (0.6-1.1)	0.4
PM16	T100	161,7 (155-168)	15.3 (13.7-16.9)	8.3 (6.6-10.1)	29.9 (26.3-33.5)	0.8 (0.6-1.0)	0.2
PM16	T50	155.3 (149-162)	13.7 (12.1-15.2)	7.5 (5.8-9.2)	18.8 (15.2-22.4)	1.1 (0.9-1.3)	0.3
PM16	T25	136.0 (129-143)	12.7 (11.1-14.3)	5.8 (4.1-7.5)	14.0 (10.4-17.6)	0.2 (0.1-0.5)	0.3
PM16	T0	110.7 (104-117)	13.0 (11.4-14.6)	4.7 (3.0-6.5)	11.4 (7.8-15.0)	0.1 (0.1-0.3)	0.3

Table 8 – CNR-ISPAAM. Biometric traits of tillers, heads and flag leaf of accessions of *P. miliaceum*.

Accession	Tiller		Head length (cm)	Flag leaf	
	Length (cm)	No internodes		Length (cm)	Width (cm)
PM13SEM	107.3	7.4	39.3 ab	25.1 c	0.7
PM14PZS	116.3	7.5	44.3 a	30.9 ab	0.8
PM16SLR	122.2	7.4	39.3 ab	32.2 a	0.8
PM18FRT	112.4	7.1	43.7 ab	30.5 ab	0.7
PM19CMC	119.2	7.1	39.8 ab	28.8 abc	0.7
PM20PMT	119.2	6.7	40.8 ab	28.5 abc	0.6
PM21DCM	118.0	7.2	41.9 ab	31.0 ab	0.7
PM22STG	105.7	6.7	36.3 b	25.8 c	0.7
PM23ZCN	119.8	7.5	43.2 ab	27.0 bc	0.7
PM24MNR	113.4	7.6	39.3 ab	27.8 bc	0.6
average	***115.4***	***7.2***	***40.8***	***28.8***	***0.7***
minimum	***105.7***	***6.7***	***36.3***	***25.1***	***0.6***
maximum	***122.2***	***7.6***	***44.3***	***32.2***	***0.8***

Table 9 – CNR-ISPAAM. Dry weight and dry matter content in tillers, heads and flag leaf in accessions of *P. miliaceum*.

Accession	Tiller		Head		Flag leaf	
	DW (g)	DM %	DW (g)	DM%	DW (g)	DM %
PM13SEM	3.11	52.4	0.78	69.2	1.18 ab	82.7
PM14PZS	3.92	46.7	0.87	60.1	1.38 a	73.5
PM16SLR	3.57	42.5	0.71	57.1	1.23 ab	69.9
PM18FRT	3.14	44.6	0.74	63.4	1.19 ab	71.6
PM19CMC	3.57	41.9	0.82	54.0	1.10 ab	69.9
PM20PMT	3.70	53.8	0.90	67.5	1.06 ab	84.7
PM21DCM	3.03	47.4	0.72	62.2	1.06 ab	77.9
PM22STG	2.84	49.9	0.82	64.4	1.13 ab	83.4
PM23ZCN	3.90	50.5	0.94	64.7	1.06 ab	80.3
PM24MNR	2.77	46.3	0.67	60.7	0.94 b	77.6
average	***3.4***	***47.6***	***0.8***	***62.3***	***1.1***	***77.1***
minimum	***2.8***	***41.9***	***0.7***	***54.0***	***0.9***	***69.9***
maximum	***3.9***	***53.8***	***0.9***	***69.2***	***1.4***	***84.7***

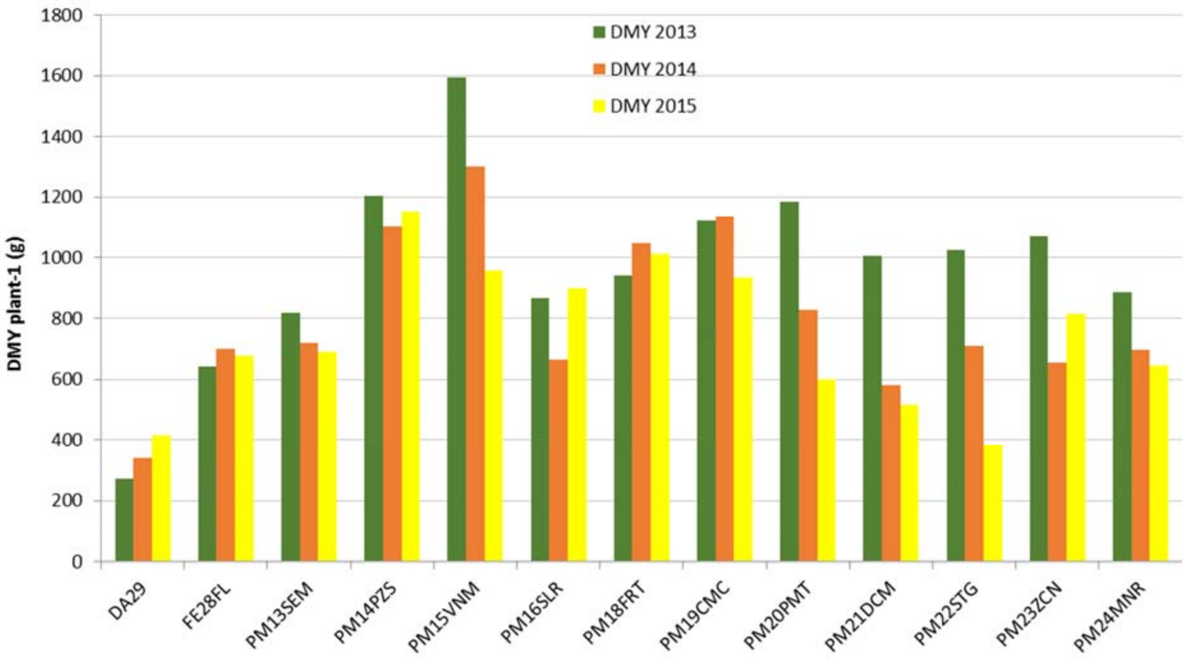


Figure 4 – CNR-ISPAAM. Dry matter yield of native Sardinian accessions of P. miliaceum in 2013, 2014, 2015 compared to conventional forage grasses D. glomerata and F. arundinacea.

Table 10 – CNR-ISPAAM. Number of tillers, water content and phytomass partitioning in *P. miliaceum*.

Accession	No. of tillers			Water content (%)			Leaves ratio (%)			Tillers ratio (%)		
	2013	*2014*	*2015*	*2013*	*2014*	*2015*	*2013*	*2014*	*2015*	*2013*	*2014*	*2015*
PM13SEM	244.2	245.0	259	37.0	39.9	47.3	28.3	16.0	17.5	71.7	84.0	82.4
PM14PZS	292.7	319.7	324	35.1	34.5	36.5	27.1	13.2	23.8	72.9	86.8	76.2
PM15VNM	300.5	246.0	255	29.3	36.2	40.2	21.0	18.0	25.4	79.0	82.0	74.6
PM16SLR	224.7	203.3	288	32.1	39.9	38.4	26.7	12.3	22.8	73.3	87.7	77.2
PM17SNS	n.a	n.a.	306	n.a.	n.a.	36.7	n.a.	n.a.	23.1	n.a.	n.a.	76.9
PM18FRT	283.0	416.0	296	36.0	42.9	41.7	29.4	15.0	25.1	70.6	85.0	74.9
PM19CMC	279.7	395.7	318	36.2	40.4	36.2	24.3	14.1	18.1	75.7	85.9	81.8
PM20PMT	316.6	328.7	277	31.0	39.3	39.1	24.0	17.4	23.3	76.0	82.6	76.6
PM21DCM	282.3	260.3	219	36.3	38.8	39.8	25.8	17.3	23.9	74.2	82.7	76.1
PM22STG	296.0	273.3	213	36.1	43.0	44.6	25.8	14.3	19.4	74.2	85.7	80.6
PM23ZCN	288.8	260.8	277	32.2	39.5	40.5	27.0	17.8	21.0	73.0	82.2	79.0
PM24MNR	241.3	292.8	262	27.8	39.4	36.1	26.5	12.9	21.7	73.5	87.1	78.3

Table 11 – CNR-ISPAAM. Number of tillers, Dry matter yield per plant and phytomass partitioning in *A. mauritanicus.*

Accession	No. of tillers		DMY per plant (g)		Water content (%)		Leaves ratio (%)		Tillers ratio (%)	
	2014	*2015*	*2014*	*2015*	*2014*	*2015*	*2014*	*2015*	*2014*	*2015*
AM1MGR	48	71	251.1	261.8	46.4	36.1	n.a.	100.0	n.a.	0.0
AM2GRG	42	90	179.5	453.0	45.8	40	n.a.	77.5	n.a.	22.5
AM3SRT	97	156	803.6	783.8	44.6	44	n.a.	67.0	n.a.	33
AM4MNR	154	190	1870.2	1633.8	43.9	46.9	n.a.	71.2	n.a.	28.8
AM5DLV	7	35	52.3	n.a.	47.1	37.7	n.a.	86.1	n.a.	9.3
AM6CPF	174	95	561.3	563.8	48.0	40.9	n.a.	94.0	n.a.	6.0
AM7SMV	163	141	1037.9	666.5	42.7	39.9	n.a.	56.3	n.a.	43.7
AM8FRT	94	161	421.7	643.2	42.3	38.9	n.a.	73.6	n.a.	26.4
AM9STG	146	119	833.3	730.7	41.6	42.8	n.a.	58.3	n.a.	41.7
AM10FLN	167	147	2028.5	1153.1	43.6	44.2	n.a.	42.2	n.a.	42.8
AM11CMC	99	117	677.2	648.1	47.5	38.4	n.a.	70.0	n.a.	30.0
AM12PMT	100	176	750.7	767.4	43.0	39.3	n.a.	76.1	n.a.	23.9

Table 12 – CNR-ISPAAM. Dry matter yield per plant, water content, number of tillers and biomass partitioning in accessions of *A. mauritanicus* (AM), *D. glomerata* (DA), *P. aquatica* (FA), *F. arundinacea* (FE), *L. perenne* (LO), and *P. miliaceum* (PM).

Accession	DMY plant^{-1} (g)		WC (%)		N. tillers		Leaves ratio (%)		Tillers ratio (%)	
AM01MGR	261.8	i-m	36.1	a-d	71	mn	100.0	a	0.0	i
AM02GRG	453.0	f-m	40.0	a-d	90	l-n	77.5	bc	22.5	gh
AM03SRT	783.8	b-h	44.0	a-c	156	f-n	67.0	b-d	33	e-g
AM04MNR	1633.8	a	46.9	ab	190	d-l	71.2	bc	28.8	gh
AM05DLV	NA	-	37.7	g	35	n	86.1	b	9.3	hi
AM06CPF	563.8	d-m	40.9	a-c	95	l-n	94.0	b-d	6.0	f-h
AM07SMV	666.5	c-i	39.9	a-d	141	h-n	56.3	c-e	43.7	d-g
AM08FRT	643.2	d-m	38.9	a-d	161	f-n	73.6	bc	26.4	gh
AM09STG	730.7	b-i	42.8	a-c	119	h-n	58.3	b-d	41.7	e-g
AM10FLN	1153.1	a-c	44.2	a-c	147	g-n	42.2	hi	42.8	d-g
AM11CMC	648.1	d-l	38.4	a-d	117	h-n	70.0	b-d	30.0	e-g
AM12PMT	767.4	b-h	39.3	a-d	176	e-m	76.1	bc	23.9	gh
DA29JA	415.0	g-m	27.5	de	145	g-n	32.7	f-h	67.2	b-d
DA30OT	159.8	lm	21.8	ef	101	i-n	35.1	f-h	64.9	b-d
FA31AU	468.8	e-m	41.2	a-c	161	f-n	30.2	f-h	69.9	b-d
FE25TA	598.6	d-m	32.4	c-e	249	a-g	55.8	c-g	44.2	c-g
FE26SI	568.1	d-m	37.2	a-d	268	a-e	30.4	f-h	69.6	b-d
FE27CE	445.9	f-m	42.6	a-c	205	c-i	41.4	e-h	58.5	b-e
FE28FL	678.2	c-i	33.3	b-e	202	c-i	42.3	d-h	57.6	b-f
LO32AZ	30.0	m	13.4	f	114	h-n	8.2	i	91.8	a
PM13SEM	690.7	c-i	47.3	a	259	a-f	17.5	hi	82.4	ab
PM14PZS	1152.8	a-c	36.5	a-d	324	a	23.8	hi	76.2	ab
PM15VNM	956.4	b-e	40.2	a-d	255	a-f	25.4	g-i	74.6	a-c
PM16SLR	899.7	b-g	38.4	a-d	288	a-d	22.8	hi	77.2	ab

PM17SNS	1200.8	ab	36.7	a-d	306	a-c	23.1	hi	76.9	ab
PM18FRT	1013.2	b-d	41.7	a-c	296	a-d	25.1	g-i	74.9	ab
PM19CMC	934.6	b-f	36.2	a-d	318	ab	18.1	hi	81.8	ab
PM20PMT	599.9	d-m	39.1	a-d	277	a-e	23.3	hi	76.6	ab
PM21DCM	516.4	d-m	39.8	a-d	219	a-h	23.9	hi	76.1	ab
PM22STG	382.6	h-m	44.6	a-c	213	b-h	19.4	hi	80.6	ab
PM23ZCN	813.4	b-h	40.5	a-d	277	a-e	21.0	hi	79.0	ab
PM24MNR	644.8	d-m	36.1	a-d	262	a-f	21.7	hi	78.3	ab

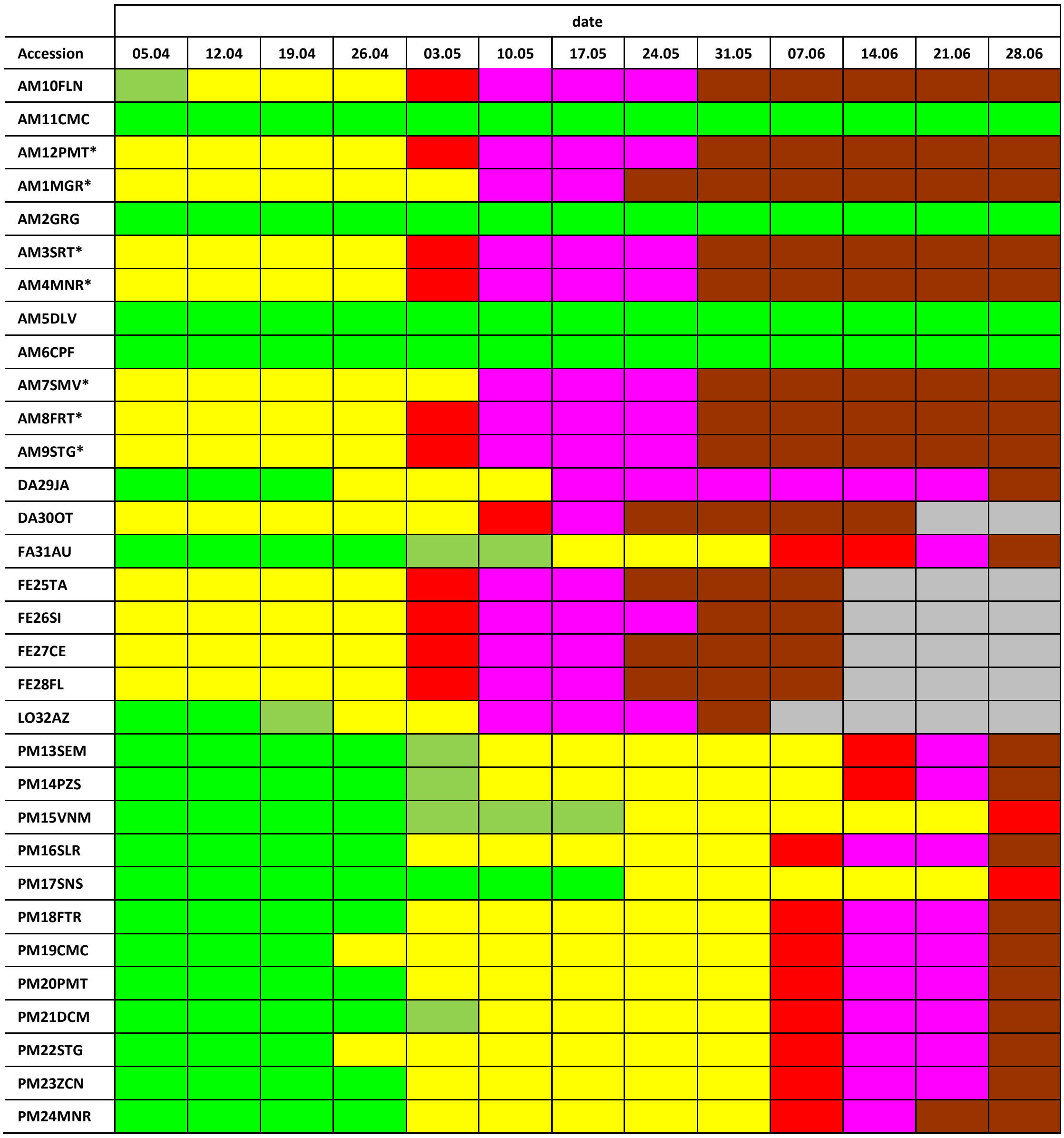


Figure 5 – CNR-ISPAAM. Phenological stages of accessions growing in the field nursery of OPTIMA project in Sardinia. Stars indicates that only a negligible number of plants reached the flowering phase in each plot, the others remaining in a vegetative stage. The phenological stages are shown with different

colours: in green the vegetative stage, in yellow the heading stage, in red the full flowering stage, in pink the end of flowering, in brown the development and ripening of seeds. *AM* indicates *A. mauritanicus*, *DA D. glomerata*, *FA P. aquatica*, *FE F. arundinacea*, *LO L. perenne*, *PM P. miliaceum* accessions.

Table 13 – CNR-ISPAAM. Content of cellulose, hemicellulose and lignin in *P. miliaceum*, at harvest time, in July 2013. Average values are the average of ten values (ten accessions).

Plant organ	Hemicellulose (%)		Cellulose (%)		Lignin (%)	
	mean	*range*	*mean*	*range*	*mean*	*range*
Tiller	28.8	26.6-30.1	38.1	36.0-40.7	13.4	12.0-15.0
Leaf	25.4	24.1-27.3	39.0	37.6-40.9	10.0	7.9-11.7
Spike	34.5	32.8-36.2	30.2	26.0-33.2	12.8	10.7-15.7

Table 14 – CNR-ISPAAM. Proximate and ultimate analysis of plant components in P. miliaceum vs miscanthus

Species	Calorific value (MJ kg^{-1})	Volatile matter (%)	Fixed carbon (%)	Ash content (%)	C (%)	H (%)	N (%)	S (%)	Cl (%)	O (%)
	Leaves									
P. miliaceum	16.0	70.0	5.0	13.0	49.0	6.1	3.6	<0.8	1.24	41.3
M. x	16.0	73.0	1.7	9.5	49.0	6.3	2.7	<0.3	<0.03	42.0
	Stalks									
P. miliaceum	17.0	77.0	11.0	5.0	49.0	6.5	1.4	<0.3	1.08	43.1
M. x	17.0	77.0	3.6	6.0	50.0	6.3	1.7	<0.3	<0.03	42.0
	Heads									
P. miliaceum	16.0	69.0	1.5	12.0	48.0	6.0	2.6	<0.8	0.98	43.4

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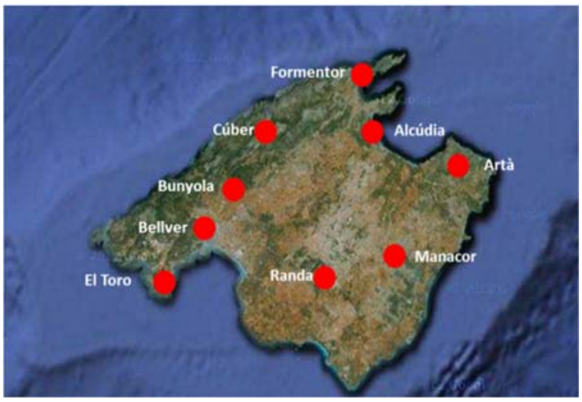


Figure 1 – UIB. Localization of the selected populations in the Island of Mallorca. *D. glomerata*: El Toro, Bellver, Alcúdia and Manacor; *P. miliaceum*: El Toro, Randa, Alcúdia, Artà and Manacor; *A. mauritanicus*: Bunyola, Randa, Alcúdia, Formentor, Cúber and Manacor.

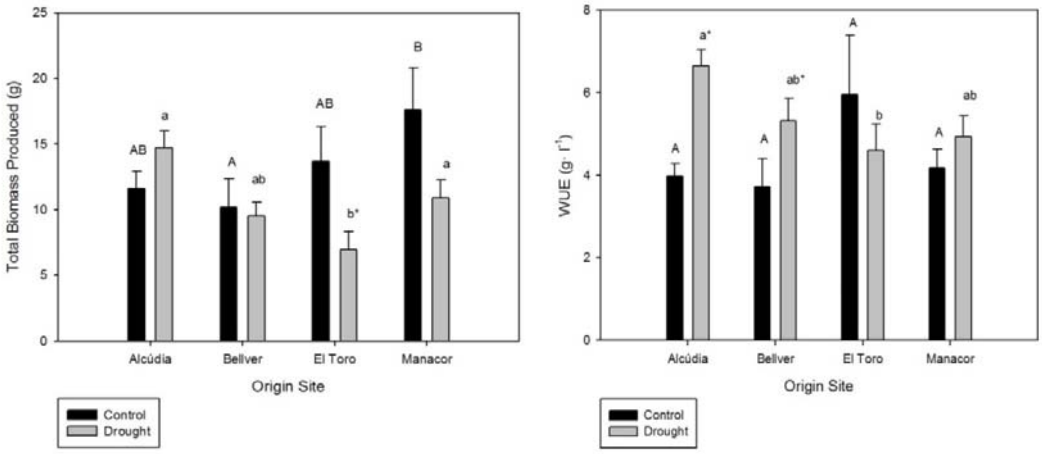


Figure 2 – UIB. Total biomass production and plant water use efficiency of four populations of *D. glomerata* under well-watered (black bars) and water-limited (grey-bars) conditions. Values are means of six replicates ± standard error. Different letters show significant differences between populations within each treatment at $p<0.05$. *Shows significant differences between treatments within each population at $p<0.05$.

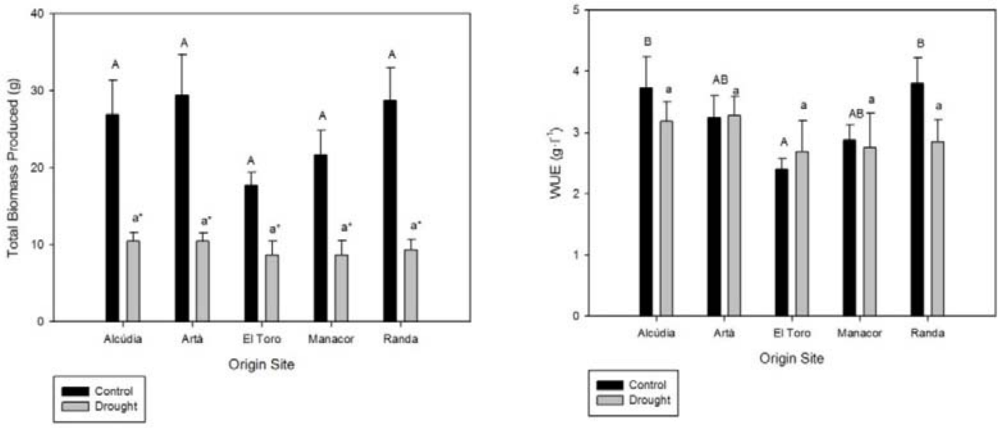


Figure 3 – UIB. Total biomass production and plant water use efficiency of four populations of *P. miliaceum* under well-watered (black bars) and water-limited (grey-bars) conditions. Values are means of six replicates ± standard error. Different letters show significant differences between populations within each treatment at p<0.05. *Shows significant differences between treatments within each population at p<0.05.

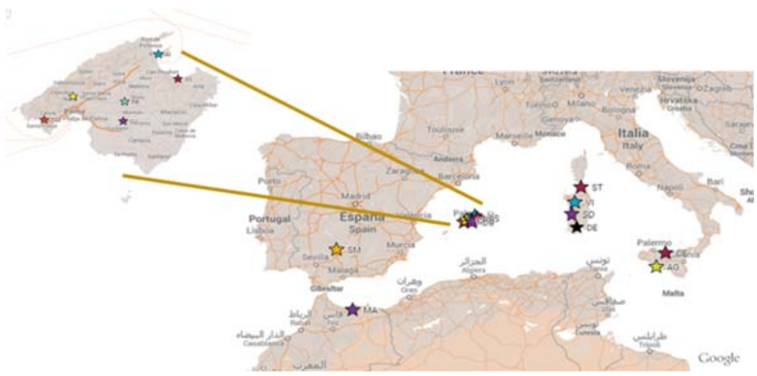


Figure 4 – UIB. Distribution of the sampled populations along the Western Mediterranean basin: Majorca (Toro, UIB, Alcúdia, Son Serra, Cura and Ruberts), Sicily (Cefalú and Agrigento), Sardinia (Santa Teresa, Solaruso, Vilanova and Décimo), Iberian Peninsula (Sierra Morena) and Morocco.

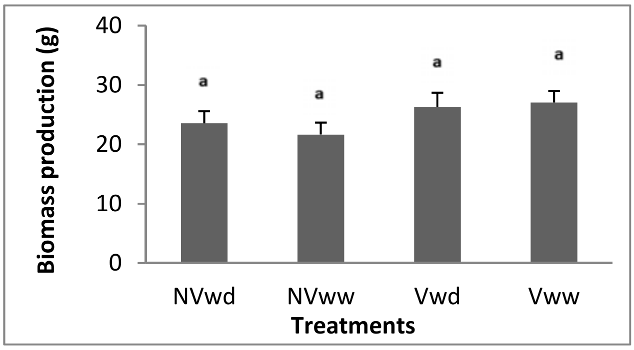


Figure 5 – UIB: Plant biomass production (g) of *D. glomerata* under four treatments: water-deficit plants without mycorrhizae (NVwd), well-watered plants without mycorrhizae (NVww), water-deficit plants with mycorrhizae (Vwd) and well-watered plants with mycorrhizae (Vww).

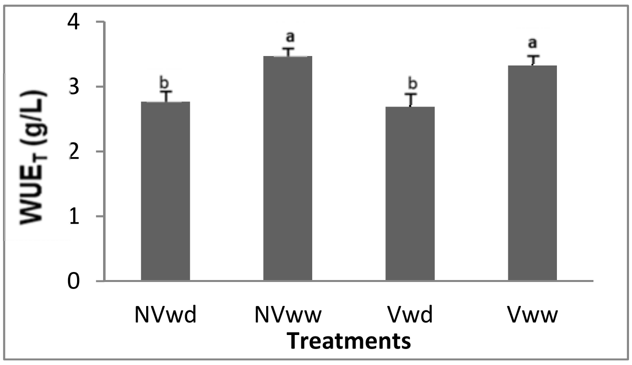


Figure 6 – UIB: Plant water use efficiency (WUE$_T$ calculated as total produced biomass per consumed water) (g/L) of *D. glomerata* under four treatments: water-deficit plants without mycorrhizae (NVwd), well-watered plants without mycorrhizae (NVww), water-deficit plants with mycorrhizae (Vwd) and well-watered plants with mycorrhizae (Vww).

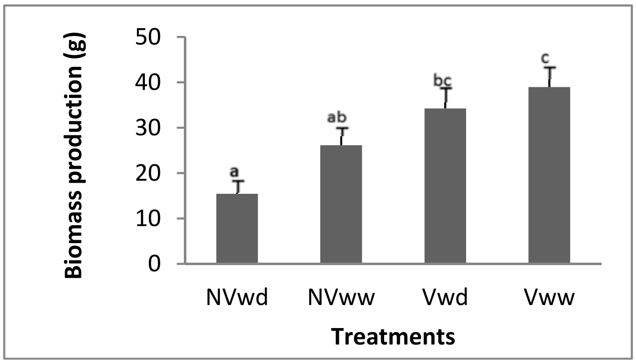


Figure 7 – UIB: Plant biomass production (g) of *P. miliaceum* under four treatments: water-deficit plants without mycorrhizae (NVwd), well-watered plants without mycorrhizae (NVww), water-deficit plants with mycorrhizae (Vwd) and well-watered plants with mycorrhizae (Vww).

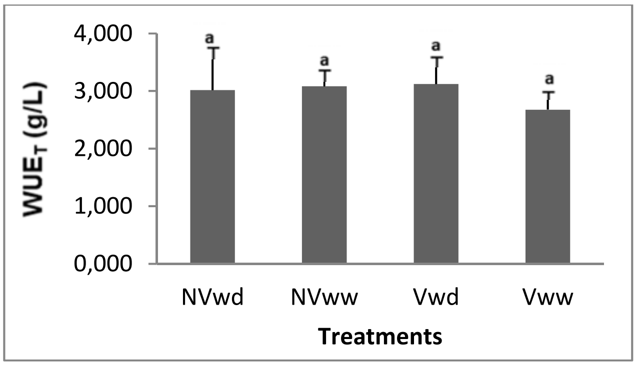


Figure 8 – UIB: Plant water use efficiency (WUE_T calculated as total produced biomass per consumed water) (g/L) of *P. miliaceum* under four treatments: water-deficit plants without mycorrhizae (NVwd), well-watered plants without mycorrhizae (NVww), water-deficit plants with mycorrhizae (Vwd) and well-watered plants with mycorrhizae (Vww).

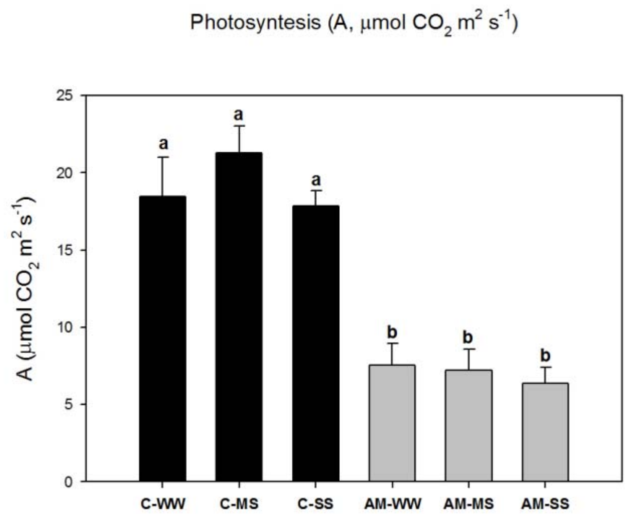


Figure 9 – UIB. Net photosynthesis of inoculated (AM) and non-inoculated (C) *Ampelodesmos mauritanicus* under different water regimes (WW: plants under 100% field capacity; MS: plants under 40% field capacity; SS: plants under 20% field capacity). Values are means of six replicates ± s.e.

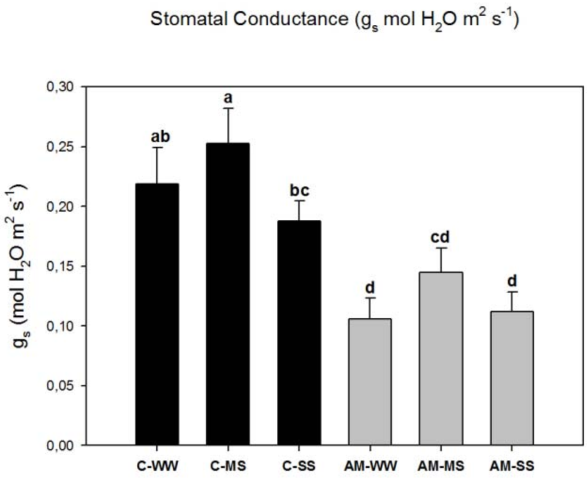


Figure 10 – UIB. Stomatal conductance of inoculated (AM) and non-inoculated (C) *Ampelodesmos mauritanicus* under different water regimes (WW: plants under 100% field capacity; MS: plants under 40% field capacity; SS: plants under 20% field capacity). Values are means of six replicates ± s.e.

Table 1 – UIB. Biomass production (g m^{-2}) of each species and population. Biomass was determined in one cut in 2013 and in two cuts in 2014. Different letters indicate statistical significant differences within each cut period at $p<0.05$.

Species	Genotype	Dry Matter Yield (g m^{-2})		
		Summer 2013	*Spring 2014*	*Summer 2014*
D. glomerata	Alcudia	236,9 ± 19,47^{c}	64.5 ± 2.93^{b}	132.6 ± 1.67^{b}
	Jana	189,1 ± 19,47^{bc}	66.0 ± 2.04^{b}	129.3 ± 1.35^{b}
	Manacor	218.4 ± 19,47^{c}	66.2 ± 3.15^{b}	131.6 ± 2.14^{b}
F. arundinacea	Flecha	69,3 ± 19,47^{a}	65.3 ± 3.51^{b}	104.6 ± 16.60^{a}
P. tomassi	Alcudia	151,7 ± 19,47^{b}	68.2± 3.23^{b}	112.9 ± 1.24^{ab}
P. miliaceum	Toro	236,1 ± 19,47^{c}	67.2 ± 3.79^{b}	100.6 ± 2.01^{a}

Table 2 – UIB. Number of tillers per plant of each species and population in 2013 and 2014. Different letters indicate statistical significant differences within each period at $p<0.05$.

Species	Genotype	Nº tillers			
		July 2013	*October 2013*	*July 2014*	*October 2014*
D. glomerata	Alcudia	22,4 ± 1,74^{c*}	16,7 ± 2,07^{b}	70.2 ± 5.25^{c}	34.9 ± 3.64^{b}
	Jana	11,1 ± 1,74^{a}	25,1 ± 2,07^{c}	59.8 ± 8.80^{bc}	30.5 ± 4.23^{b}
	Manacor	17,1 ± 1,74^{b}	15,0 ± 2,07^{ab}	59.7 ± 6.25^{bc}	40.4 ±6.15^{b}
F. arundinacea	Flecha	16,5 ± 1,74^{b}	19,6 ± 2,07^{bc}	66.2 ± 5.92^{c}	30.5 ± 5.84^{b}
P. tomassi	Alcudia	35,9 ± 1,74^{e}	20,5 ± 2,07^{bc}	40.8 ± 4.25^{a}	14.6 ± 3.63^{a}
P. miliaceum	Toro	30,7 ± 1,74^{d}	9,8 ± 2,07^{a}	45.9 ± 2.79^{ab}	5.8 ± 1.61^{a}

Table 3 – UIB. Biomass quality parameters (all parameters expressed in %). Values are means ± standard error of four replicates. Different letters indicate statistical significant differences at p<0.05

Species	Genotype	Dry matter (%)	Ash content (%)	Cellulose (%)	Hemicellulose (%)	Lignin (%)
D. glomerata	Alcudia	50.8 ± 0.15^{a}	8.8 ± 0.04^{cd}	36.7 ± 0.20^{b}	21.2 ± 0.43^{ab}	6.5 ± 0.12^{cd}
	Jana	51.6 ± 0.22^{a}	9.2 0.18^{cd}	37.1 ± 0.36^{b}	20.5 ± 0.49^{a}	5.0 ± 0.18^{b}
	Manacor	50.8 ± 0.05^{a}	8.6 ± 0.01^{c}	36.4 ± 0.38^{b}	22.2 ± 0.34^{bc}	5.8 ± 0.39^{c}
F. arundinacea	Flecha	54.5 ± 1.17^{b}	9.2 ± 0.01^{cd}	37.6 ± 0.40^{b}	23.3 ± 0.45^{c}	3.3 ± 0.09^{a}
P. tomassi	Alcudia	56.2 ±0.42^{bc}	6.8 ± 0.13^{a}	36.5 ± 0.54^{b}	27.0 ± 0.45^{d}	6.8 ± 0.15^{d}
P. miliaceum	Toro	57.4 ± 0.57^{c}	7.5 ± 0.06^{b}	35.0 ± 0.34^{a}	29.3 ± 0.36^{e}	6.0 ± 0.13^{c}

Table 4 – UIB. Biomass production of *A. donax, A. mauritanicus* and *P. virgatum*. Different letters indicate statistical significant differences at p<0.05.

Species	Fresh Biomass (g m^{-2})	Dry Biomass (g m^{-2})
A. donax	1883.3 ± 114.93^{b}	1154.8 ± 77.91^{b}
A. mauritanicus	1398.9 ± 126.3^{a}	649.7 ± 63.7^{a}
P. virgatum	1078.3 ± 86.07^{a}	535.9 ± 48.9^{a}

Table 5 – UIB. Biomass quality parameters of *A. donax, A. mauritanicus* and *P. virgatum*. (all parameters expressed in %). Values are means ± standard error of four replicates. Different letters indicate statistical significant differences at p<0.05

Species	Dry matter	Ash content	Cellulose	Hemicellulose	Lignin
A. donax	42.5 ± 0.91^{a}	6.1 ± 0.44^{b}	44.5 ± 0.35^{b}	20.9 ± 0.38^{a}	9.8 ± 0.13^{c}
A. mauritanicus	56.6 ± 1.01^{c}	6.7 ± 0.02^{c}	39.3 ± 0.36^{a}	28.3 ± 1.08^{b}	5.3 ± 0.15^{a}
P.virgatum	53.8 ± 0.73^{b}	5.0 ± 0.09^{a}	47.4 ± 0.09^{c}	28.9 ± 0.56^{b}	8.5 ± 0.09^{b}

Center for Renewable Energy Sources and Energy Saving – CRES (n. 3)

Figure 1 – CRES. Experimental layout of the screening trial (eight perennial grasses in one replication)

Figure 2 –CRES. View of the perennial grasses that were compared in sub-task 3.1.3 in Greece.

Table 2 – CRES. Growth (height) and yields data (fresh and dry matter yields) for the four endemic grasses for three subsequent years (2013-5).

Endemic grasses	Height (cm)			Fresh biomass yields (t/ha)			Dry matter yields (t/ha)		
	2013	*2014*	*2015*	*2013*	*2014*	*2015*	*2013*	*2014*	*2015*
Festuca arundinaceae	150	150	150	0.94	4.05	4.88	0.80	3.16	4.00
Dactylis glomerata	30	50	50	1.12	3.25	3.50	0.99	2.80	3.15
Phalaris Australis	140	150	140	0.95	3.88	4.30	0.85	3.22	3.44
Phalaris aquatica (GR)	108	140	143	2.67	6.35	6.10	1.87	4.49	4.93

Table 3 – **CRES.** Growth (height and tiller density) and yields data (fresh and dry matter yields) for the four known perennial grasses for two growing periods (2013-4 & 2014-5).

Known perennial grasses	Height (cm)		Tiller density (tillers/m²)		Fresh biomass yields (t/ha)		Dry matter yields (t/ha)	
	2014	*2015*	*2014*	*2015*	*2014*	*2015*	*2014*	*2015*
Giant reed	415	616	7.96	17.00	17.70	45.50	8.50	25.16
Switchgrass	168	294	410.00	387.50	12.50	23.25	7.63	17.90
Miscanthus	312	360	55.44	58.00	18.30	26.80	11.30	21.50
Elephant grass	318	414	9.50	23.50	31.25	35.00	12.50	13.93

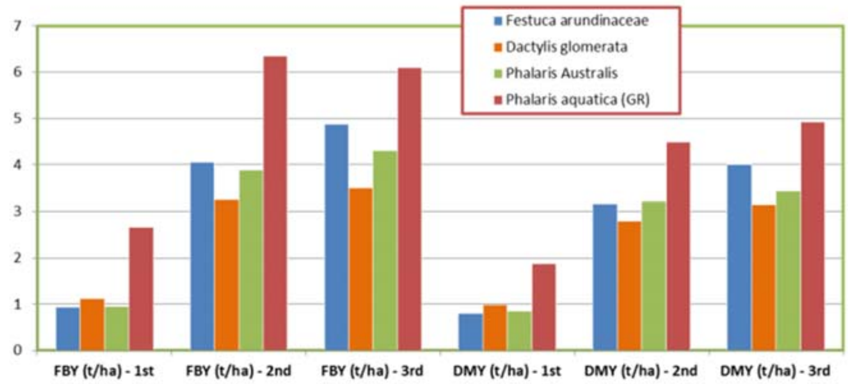


Figure 3 – **CRES.** Yields (t/ha, as harvested and oven-dried) for four endemic grasses from 2013-5.

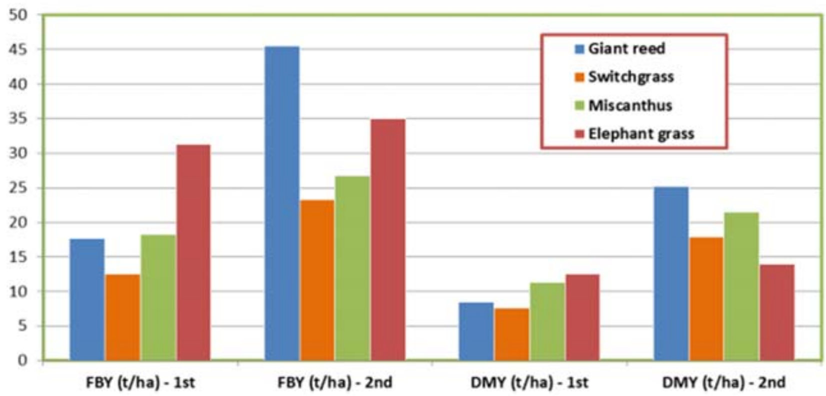


Figure 4 – **CRES.** Yields (t/ha, as harvested and oven-dried) for four known perennial grasses for two subsequent growing seasons (2013-4 & 2014-5).

Table 4 – **CRES.** Results from the calorific value (GCY, NCY) and proximate analysis (volatiles, ash and fixed carbon) on samples that were collected at the end of the second growing period.

Perennial grasses	Calorific value (kcal/kg)		Proximate analysis (%)			Elemental analysis (%)		
	GCV	NCV	Volatiles	Ash	Fixed C	C	H	N
Phalaris aquatica	**4167**	**3897**	**70.88**	**12.24**	**15.77**	**41.72**	**5.36**	**0.71**
Dactylis glomerata	**4181**	**3878**	**70.67**	**13.05**	**16.08**	**40.86**	**5.55**	**0.68**
Festuca arundinaceae	**4180**	**3901**	**72.05**	**12.14**	**15.77**	**40.53**	**5.62**	**0.61**
Phalaris aquatica (GR)	**4133**	**3834**	**70.67**	**11.20**	**18.13**	**40.91**	**5.93**	**0.76**
Elephant grass (stems, leaves, whole)	4378	4069	74.12	7.39	18.50	44.23	6.10	0.75
	41.48	3840	72.41	12.08	15.52	41.28	6.09	1.62
	4355	**4046**	**73.95**	**7.86**	**18.20**	**43.94**	**6.10**	**0.84**
Switchgrass (stems, leaves, whole)	4471	4165	80.22	1.85	17.94	47.72	6.06	0.28
	4325	4029	78.56	7.86	13.59	43.26	5.86	0.64
	4413	**4111**	**79.56**	**4.25**	**16.20**	**45.94**	**5.98**	**0.42**
Giant reed (stems, leaves, whole)	4484	4176	77.04	3.56	19.41	46.56	6.10	0.54
	4325	4029	73.52	9.95	16.53	43.04	5.83	1.42
	4452	**4147**	**76.34**	**4.84**	**18.83**	**45.86**	**6.05**	**0.72**
Miscanthus (stems, leaves, whole)	4575	4255	81.08	1.78	11.13	47.63	6.34	0.19

Task 3.2 - Good agricultural practices for perennial grasses

University of Bologna – UNIBO (n. 2)

Figure 1 - UNIBO. How a fully established switchgrass crop (Alamo) appeared at two row distances: 20 cm (left), 80 cm (right).

Table 1 - UNIBO. Main results from switchgrass density trial established in Cadriano in 2002.

Year	Inter row (m)	Aboveground biomass FM (Mg ha^{-1})	Moisture %	Aboveground biomass DM (Mg ha^{-1})
2009	0.20	60.1	56.5	26.1
	0.80	57.4	57.4	24.7
2010	0.20	53.6	57.9	22.8
	0.80	52.6	56.9	22.4
2011	0.20	45.1	55	20.2
	0.80	45.3	54.2	20.7
2012	0.20	37.2	57.5	15.8
	0.80	42.0	57.1	18.0
2013	0.20	35.5	56.5	15.4
	0.80	34.1	57.7	14.4
2014	0.20	62.08	59.38	25.26
	0.80	54.90	58.68	22.59
2015	0.20	37.3	59.5	13.6
	0.80	31.6	57.4	15.4

Table 2 - UNIBO. Hydro-seeding mixtures used in 2014 trial in Cadriano (Bologna, Italy).

Hydro-seeding type	Name/Composition*	Rate
T1	Envitotal (complete mixture of mulch, fertilizer, adhesive)	45 g m^{-2}
T2		75 g m^{-2}
T3	Cellugrùn (cellulose fiber mulch) + soil control (adhesive hydrocolloid compound)	60 g m^{-2}+ 1 g m^{-2}

*All the material for the hydro-seeding trials was supplied by Biasion S.p.A. (Bolzen, Italy) a company specialized in hydro-seeding of ski slopers and degraded lands (e.g., abandoned quarries).

Figure 2 - UNIBO. Mixing of switchgrass seeds with the hydro-seeding mulch (left). Equipment used for the hydro-seeding of switchgrass (right).

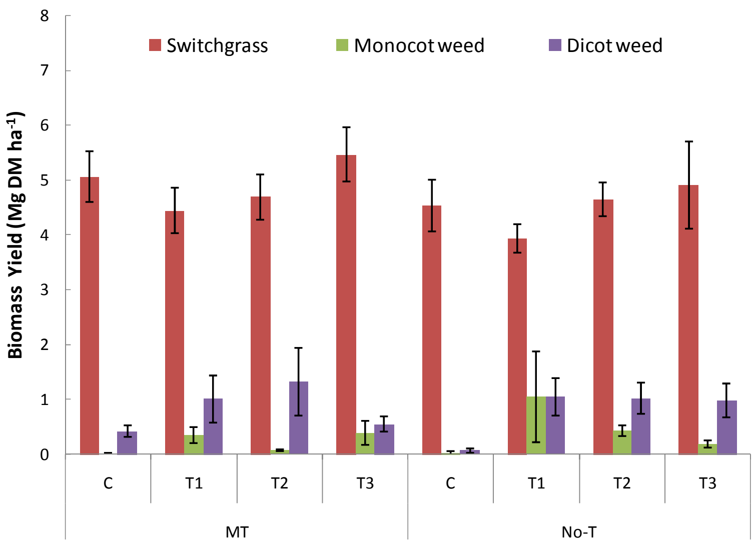


Figure 3 - UNIBO. Biomass production (switchgrass, monocot and dicot weeds) in the first year after establishment. Vertical bars: standard deviations.

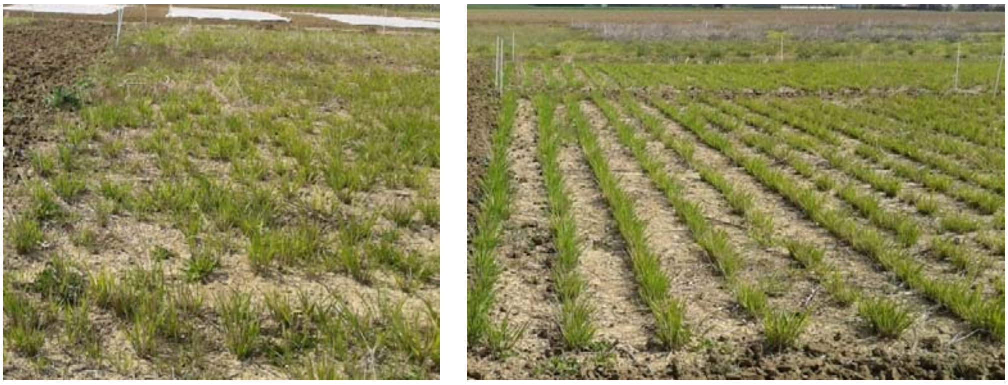


Figure 4 - UNIBO. View of the hydro-seeded (left) and conventional seeded (right) plots of switchgrass in the second year (early spring 2015).

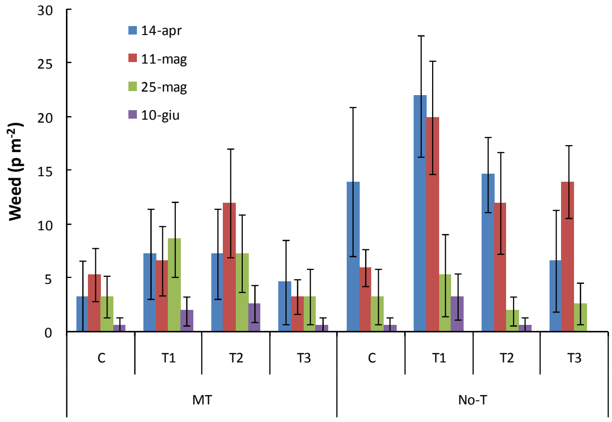


Figure 5 - UNIBO. Weed presence (p m^{-2}) in 2015 surveyed at different dates until switchgrass canopy closure. Vertical bars: standard deviations.

Figure 6 - UNIBO. View of the hydro-seeded (left) and conventional (right) seeded plots of switchgrass in the second year in June 2015.

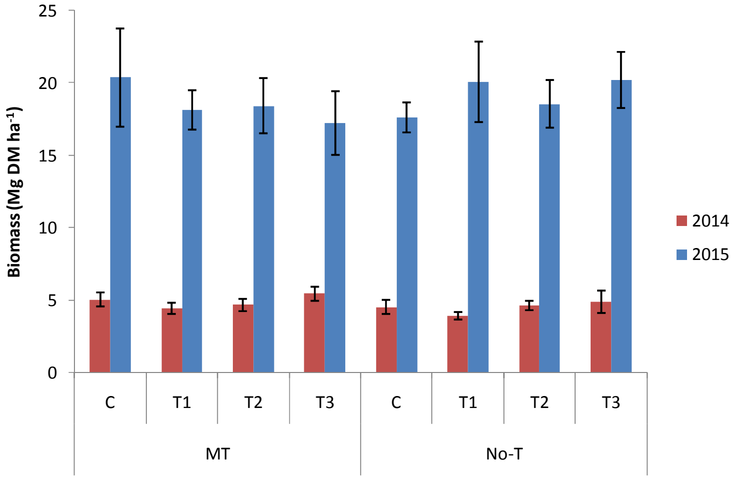


Figure 7 - UNIBO. Switchgrass biomass production in the second year after establishment (blue bars) compared to that reached in the first year (red bars). Vertical bars: standard deviations.

Figure 8 - UNIBO. Annual (left) and biennial (right) biomass of switchgrass plots established in 2008 in Cadriano (Bologna).

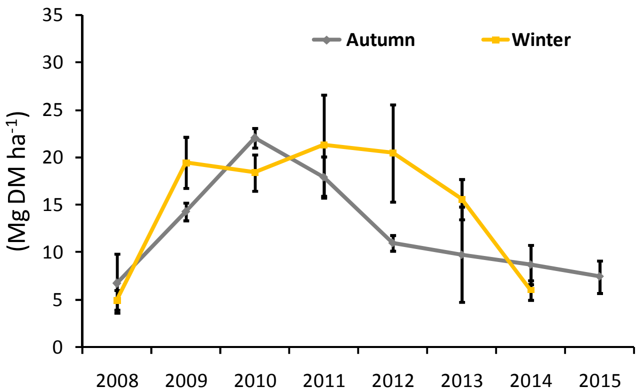


Figure 9 - UNIBO. Effect of harvest time (autumn vs. winter) on switchgrass productivity in Cadriano (Bologna) between 2008 and 2015. Vertical bars: standard deviation.

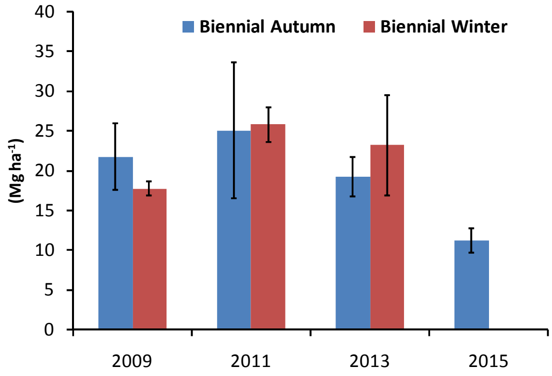


Figure 10 - UNIBO. Effect of harvest time (annual vs. biennial) on switchgrass productivity in Cadriano (Bologna) between 2008 and 2015. Vertical bars: standard deviation.

Università di Catania – UNICT (n. 1)

Figure 1 - UNICT. Basal, median and apical single node stem cuttinng of giant reed (Arundo donax L.) transplnated in pots.

Table 1 - UNICT. Average maximum and minimum air temperatures (°C) during the eight weeks after each transplanting date of giant reed (*Arundo donax* L.) single node stem cuttings at the University of Catania, Italy.

Transplanting time	Tmax	Tmin
February 25	17.6	11.5
March 18	19.7	12.4
May 14	22.6	17.3
June 3	28.2	20.9
July, 2	28.0	23.8
October 15	20.5	14.3
November 25	15.2	9.5

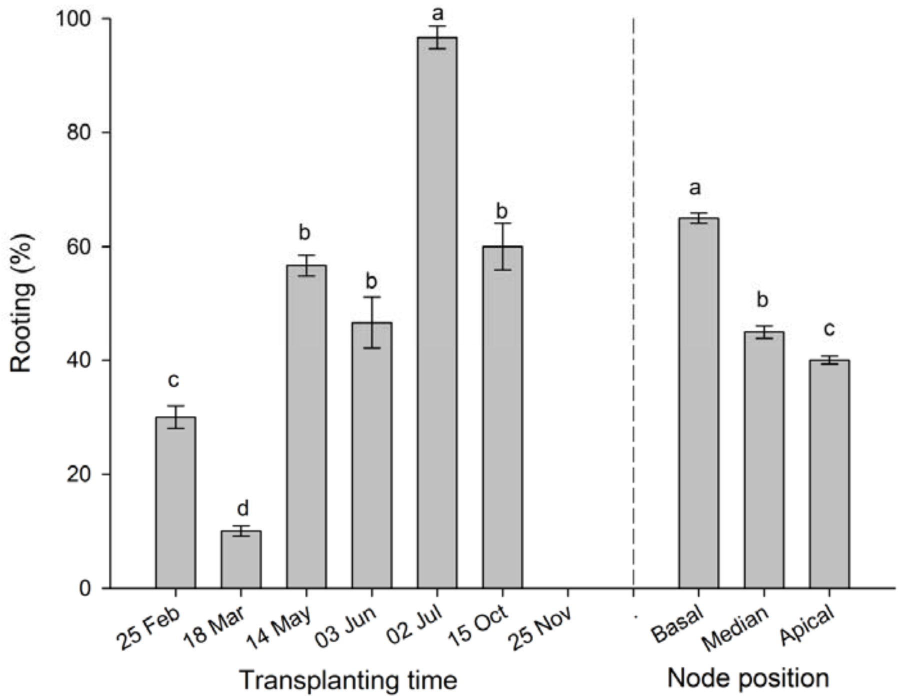


Figure 2 - UNICT. Rooting rate of giant reed (*Arundo donax* L.) in relation to the transplanting time and to the node position. Different letters represent statistically different means (*P≤0.05*).

Table 2 - UNICT. Correlation coefficients (*r*) between air temperatures and rooting rate in relation to node position on stem of giant reed (*Arundo donax* L.) at the University of Catania, Italy.

Node position	Tmax (°C)	Tmin (°C)
Basal	0.70	0.75
Median	0.74	0.84*
Apical	0.79*	0.87**

*Significant for *P≤0.05*; ** Significant for *P≤0.01*

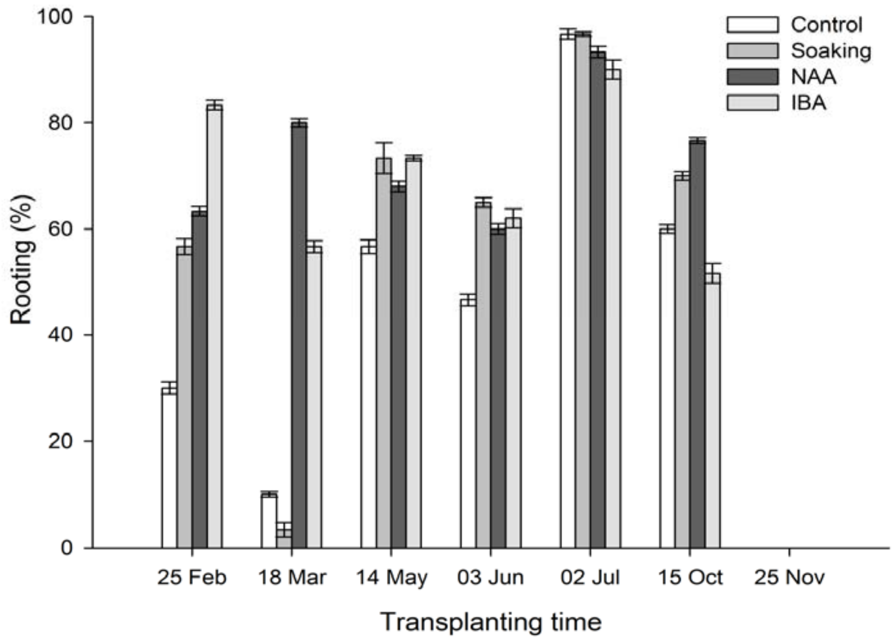


Figure 3 - UNICT. Rooting rate of giant reed (*Arundo donax* L.) in relation to the growth regulator pretreatments at different transplanting times, averaged across node position. Fisher's LSD for main effects (transplanting time and pretreatment) and interaction "transplanting time *x* pretreatment" per $P \leq 0.05$ = 12.69.

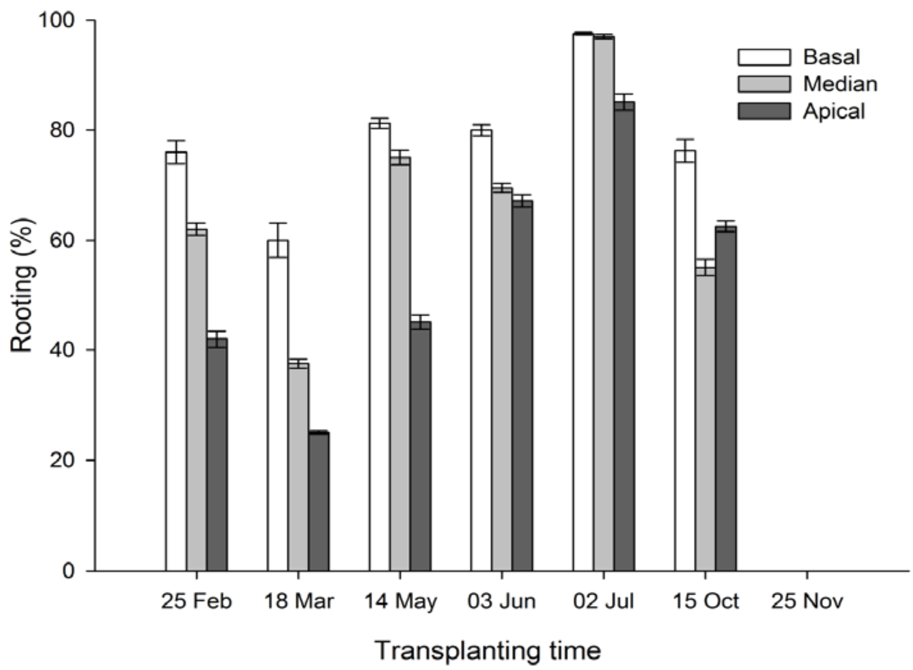
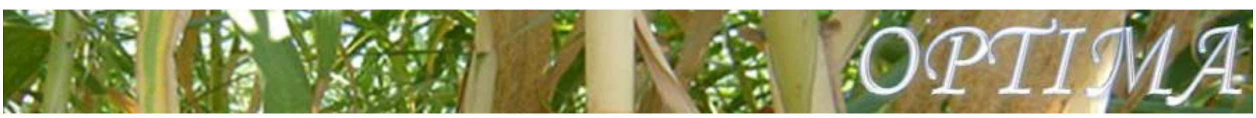


Figure 4 - UNICT. Rooting rate of giant reed (*Arundo donax* L.) in relation to node position at different transplanting times, averaged across growth regulator pretreatments. Fisher's LSD for main effects (transplanting time and node position) and interaction "transplanting time *x* node position" per $P \leq 0.05$ = 10.99.



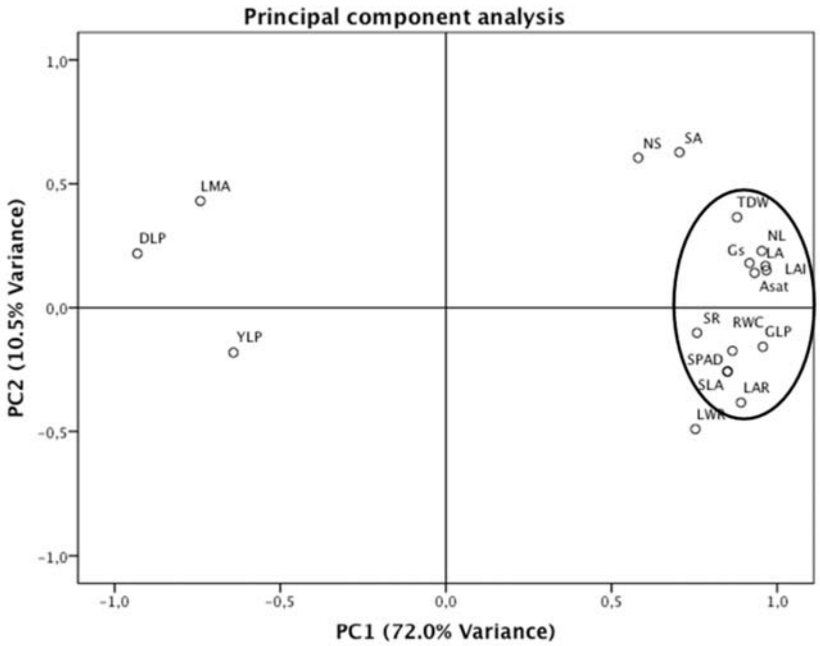


Figure 5 - UNICT. Principal component analysis (PCA) and variance (%) of each component. The most significant and positive parameters of component 1 (above 0.750) were selected: Green Leaf Area (gLA), % Green Leaves (GLP), Number of leaves (NL), A_{sat}, % Dry Leaves (DLP), g_s, Leaf Area Ratio (LAR), Total Dry Weight (TDW), Relative Water Content (RWC), Specific Leaf Area (SLA), SPAD and Shoot/Root (SR). Non-selected parameters were % Dry Leaves (DLP), Leaf Mass Area (LMA), % Yellow Leaves (YLP), Number of Stems (NS), Stem Area (SA) and Leaf Weight Ratio (LWR).

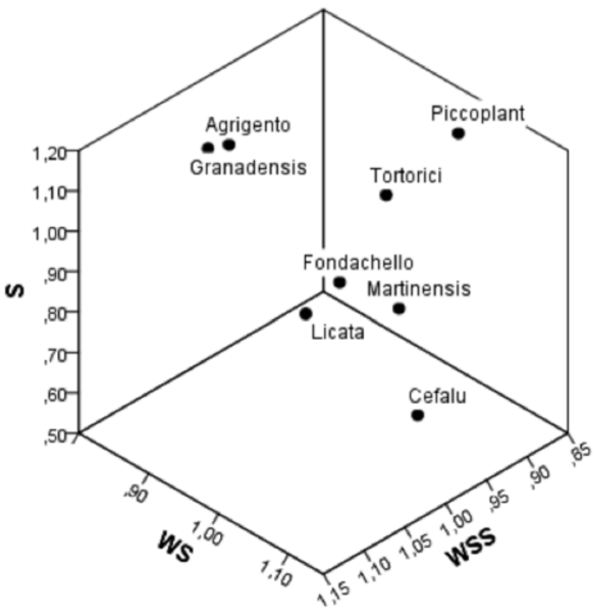


Figure 6 - UNICT. 3-D graphic representing stress susceptibility index (SSI) of each clone according to water stress (*WS*; X axis), salinity (*S*; Y axis) and double stress (*WSS*; Z axis). Higher SSI values indicate lower tolerance to stress.

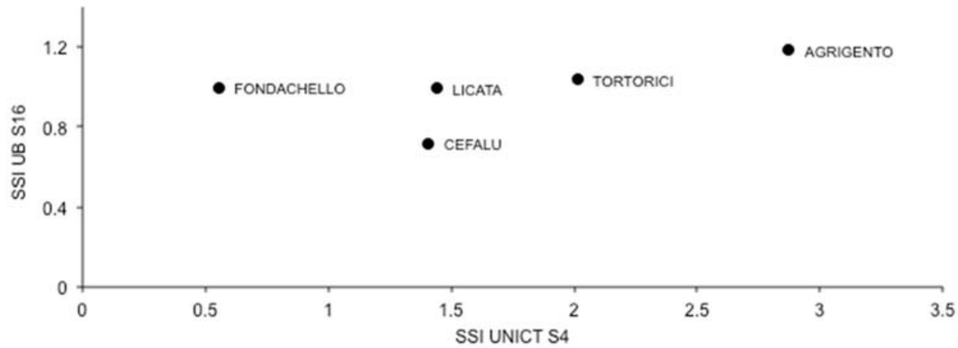


Figure 7 - UNICT. 2-D graphic representing stress susceptibility index (SSI) of each clone according to UNICT S4 (X axis) and UB S16 (Y axis). Higher SSI values indicate lower tolerance to stress.

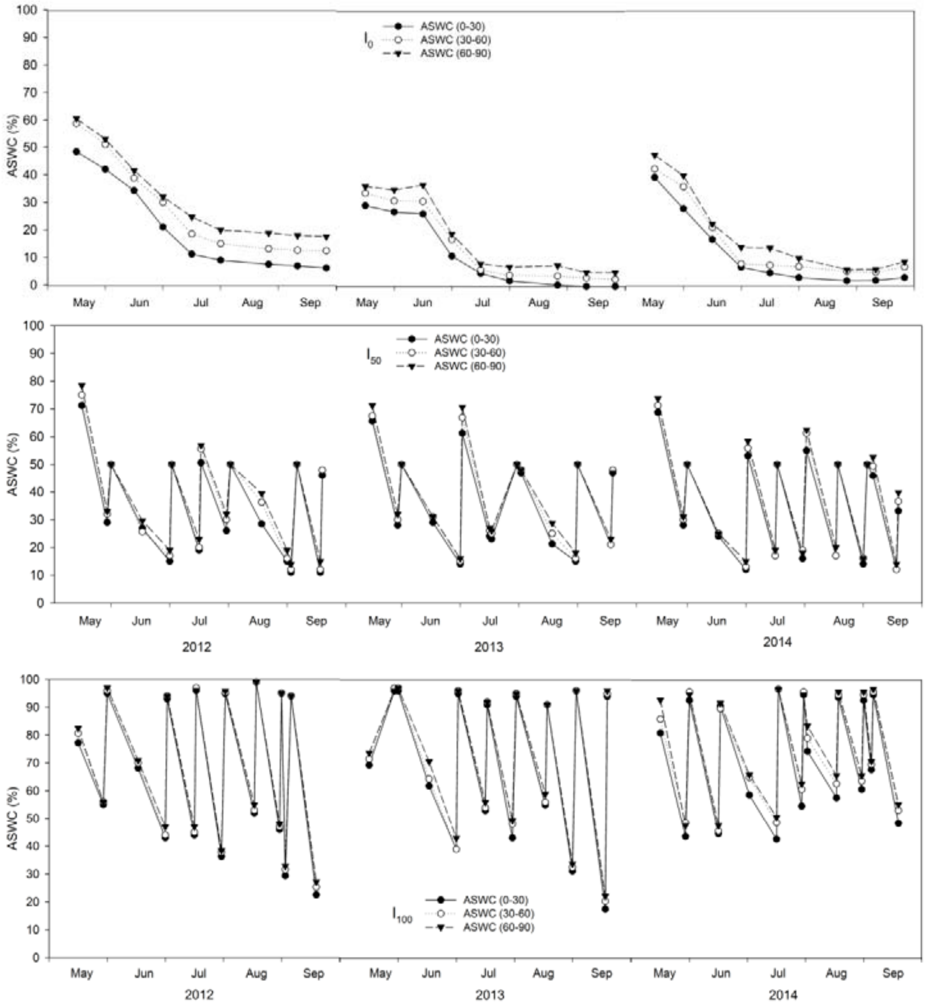
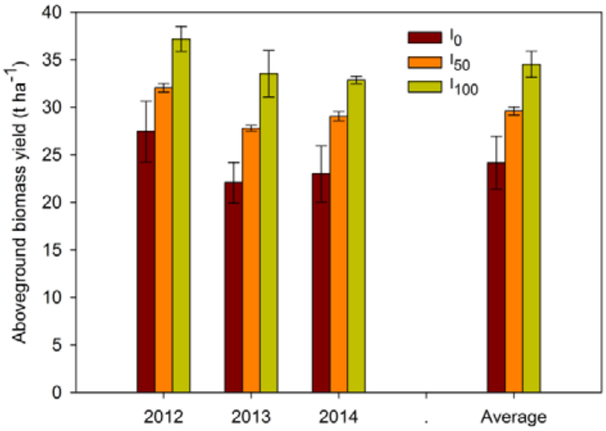


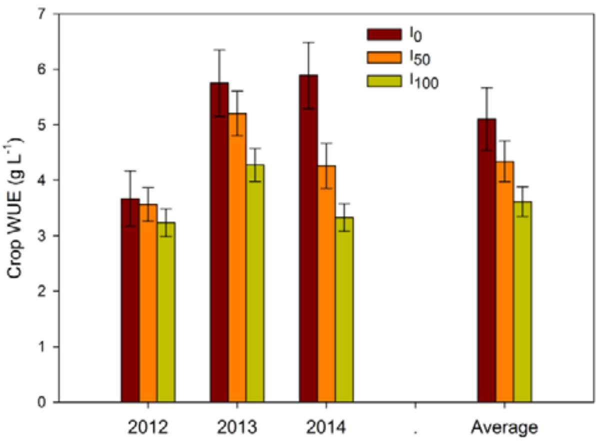
Figure 8 - UNICT. Available soil water content (ASWC, %) at three different depths (0–30, 30–60, and 60–90 cm) along the three growing seasons (2011, 2012, and 2013) of Saccharum spontaneum L. spp.

aegyptiacum (Willd.) Hack. at the Experimental farm of Catania University (10 m a.s.l., 37°25’N lat., 15°03’E long.) in I0, I50, and I100 treatment.



Biomass yield (p≤0.05)			
	2012	2013	2014
I_0	b	c	b
I_{50}	ab	b	a
I_{100}	a	a	a

Figure 9 - UNICT. Aboveground biomass yield (Mg DM ha−1) of Saccharum spontaneum L. spp. aegyptiacum (Willd.) Hack. in relation to the studied treatment.



WUE (p≤0.05)			
	2012	2013	2014
I_0	a	a	a
I_{50}	a	a	b
I_{100}	a	a	b

Figure 10 - UNICT. Crop water use (g L^{-1}) of Saccharum spontaneum L. spp. aegyptiacum (Willd.) Hack. in relation to the studied treatment.

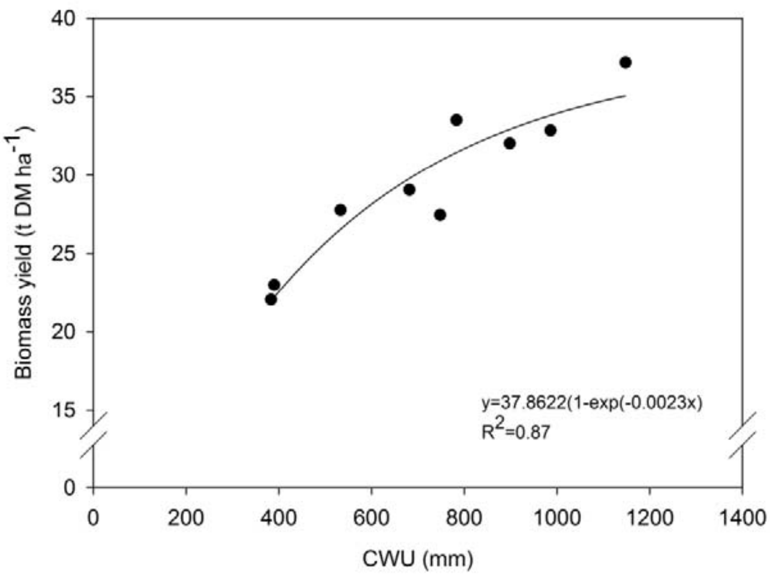


Figure 11 - UNICT. Relation between crop water use (CWU, mm) and aboveground dry biomass yield (Mg ha^{-1}) of Saccharum spontaneum L. spp. aegyptiacum (Willd.) Hack.

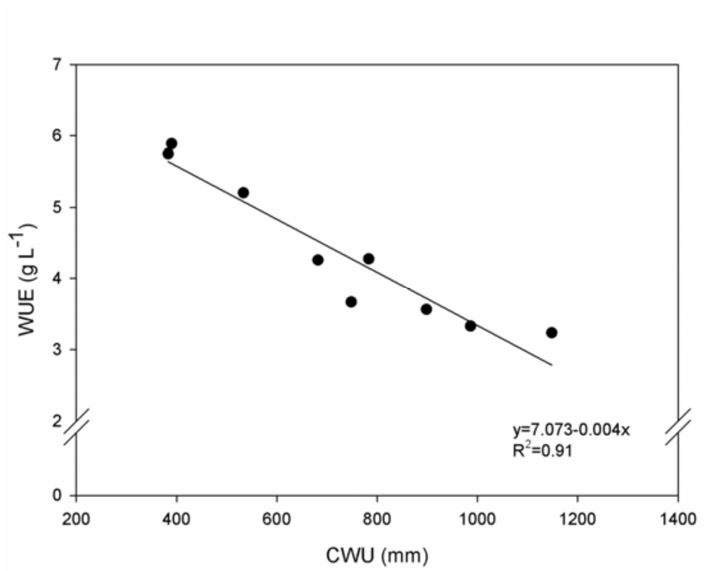


Figure 12 - UNICT. Relations between crop water use (CWU, mm) and water use efficiency (WUE, g L^{-1}) of Saccharum spontaneum L. spp. aegyptiacum (Willd.) Hack.

Mb 1093#44 26279	Mb 961#28 22618	Mb 311 GIG	Mb 1123#25 8564	Mb 933#24 23009	Mb 1023#21 22661	Mb 99 GOL	Mb 969#25 22645	Mb 1131#25 8634	Mb 967#24 23059
Mb 1122#25 8584	Mb 931#23 22998	Mb 1168#42 26157	Mb 914#22 22937	Mb 969#25 22645	Mb 933#24 23009	Mb 1122#26 8585	Mb 910#25 22930	Mb 1122#25 8584	Mb 1168#42 26157
Mb 910#28 22933	Mb 1025#22 22672	Mb 967#24 23059	Mb 1131#25 8634	Mb 1023#23 22663	Mb 931#28 23003	Mb 925#22 22967	Mb 961#28 22618	Mb 1123#25 8564	Mb 836#23 22758
Mb 99 GOL	Mb 925#22 22967	Mb 1131#24 8633	Mb 931#21 22996	Mb 1023#21 22661	Mb 914#22 22937	Mb 931#23 22998	Mb 1023#23 22663	Mb 893#21 22876	Mb 910#28 22933
Mb 910#25 22930	Mb 836#23 22758	Mb 1122#26 8585	Mb 893#21 22876	Mb 931#28 23003	Mb 931#21 22996	Mb 1093#44 26279	Mb 311 GIG	Mb 1025#22 22672	Mb 1131#24 8633
Mb 1122#25 8584	Mb 969#25 22645	Mb 910#28 22933	Mb 1023#23 22663	Mb 967#24 23059	Mb 933#24 23009	Mb 1168#42 26157	Mb 969#25 22645	Mb 931#21 22996	Mb 1131#24 8633
Mb 914#22 22937	Mb 311 GIG	Mb 925#22 22967	Mb 1168#42 26157	Mb 1122#26 8585	Mb 931#23 22998	Mb 893#21 22876	Mb 1093#44 26279	Mb 910#25 22930	Mb 1025#22 22672
Mb 933#24 23009	Mb 931#23 22998	Mb 1131#24 8633	Mb 931#28 23003	Mb 931#21 22996	Mb 910#28 22933	Mb 311 GIG	Mb 931#28 23003	Mb 99 GOL	Mb 1123#25 8564
Mb 1025#22 22672	Mb 910#25 22930	Mb 1131#25 8634	Mb 99 GOL	Mb 1093#44 26279	Mb 967#24 23059	Mb 1023#21 22661	Mb 961#28 22618	Mb 914#22 22937	Mb 925#22 22967
Mb 961#28 22618	Mb 1023#21 22661	Mb 836#23 22758	Mb 1123#25 8564	Mb 893#21 22876	Mb 1023#23 22663	Mb 1131#25 8634	Mb 1122#26 8585	Mb 1122#25 8584	Mb 836#23 22758

Mb 893#21 22876	Mb 1168#42 26157	Mb 836#23 22758	Mb 1122#25 8584	Mb 910#25 22930	Mb 925#22 22967	Mb 1123#25 8564	Mb 931#28 23003	Mb 967#24 23059	Mb 931#23 22998
Mb 925#22 22967	Mb 1023#23 22663	Mb 931#21 22996	Mb 931#23 22998	Mb 961#28 22618	Mb 1131#25 8634	Mb 931#21 22996	Mb 1122#25 8584	Mb 933#24 23009	Mb 1168#42 26157
Mb 931#28 23003	Mb 311 GIG	Mb 1131#24 8633	Mb 1025#22 22672	Mb 1131#25 8634	Mb 1023#21 22661	Mb 1023#23 22663	Mb 99 GOL	Mb 311 GIG	Mb 893#21 22876
Mb 1123#25 8564	Mb 910#28 22933	Mb 967#24 23059	Mb 969#25 22645	Mb 1023#21 22661	Mb 1093#44 26279	Mb 1122#26 8585	Mb 910#25 22930	Mb 1025#22 22672	Mb 961#28 22618
Mb 99 GOL	Mb 914#22 22937	Mb 933#24 23009	Mb 1093#44 26279	Mb 1122#26 8585	Mb 836#23 22758	Mb 969#25 22645	Mb 910#28 22933	Mb 1131#24 8633	Mb 914#22 22937
Mb 1025#22 22672	Mb 1122#26 8585	Mb 1131#24 8633	Mb 1093#44 26279	Mb 910#25 22930	Mb 931#28 23003	Mb 1131#24 8633	Mb 910#28 22933	Mb 836#23 22758	Mb 1023#21 22661
Mb 961#28 22618	Mb 1123#25 8564	Mb 311 GIG	Mb 931#23 22998	Mb 969#25 22645	Mb 910#25 22930	Mb 961#28 22618	Mb 969#25 22645	Mb 1025#22 22672	Mb 933#24 23009
Mb 1168#42 26157	Mb 967#24 23059	Mb 1131#25 8634	Mb 893#21 22876	Mb 1122#25 8584	Mb 914#22 22937	Mb 967#24 23059	Mb 99 GOL	Mb 1131#25 8634	Mb 893#21 22876
Mb 914#22 22937	Mb 925#22 22967	Mb 99 GOL	Mb 933#24 23009	Mb 931#21 22996	Mb 1023#23 22663	Mb 925#22 22967	Mb 311 GIG	Mb 931#21 22996	Mb 1122#25 8584
Mb 1023#21 22661	Mb 931#28 23003	Mb 836#23 22758	Mb 910#28 22933	Mb 1023#23 22663	Mb 1122#26 8585	Mb 1168#42 26157	Mb 1123#25 8564	Mb 1093#44 26279	Mb 931#23 22998

Figure 13 – UNICT. Experimental design overview showing the two blocks (rainfed and well watered) and the completely randomized 25 *Miscanthus* accessions replicated four times.

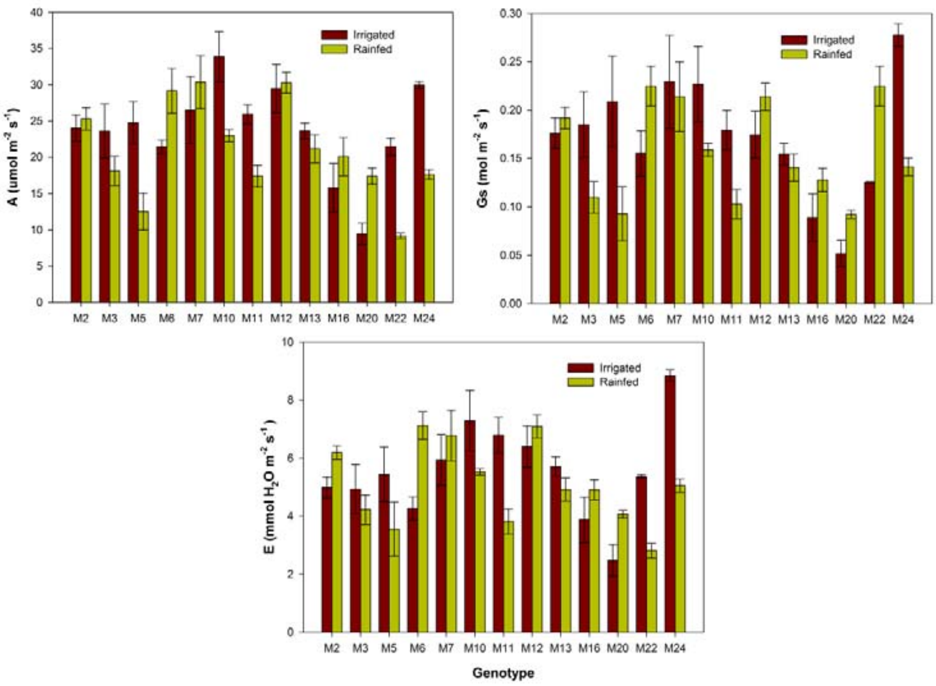


Figure 14 – UNICT. Gas exchange in June 20 of 25 Miscanthus accessions grown in drought stress (rainfed) and well watered conditions.

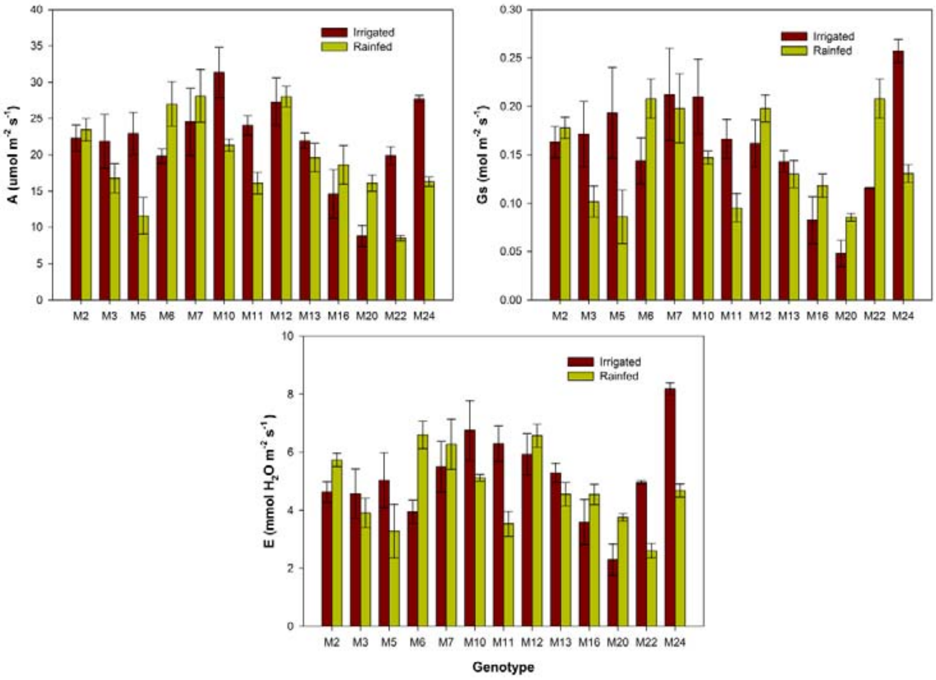


Figure 15– UNICT. Gas exchange in July 20 of 25 Miscanthus accessions grown in drought stress (rainfed) and well watered conditions.

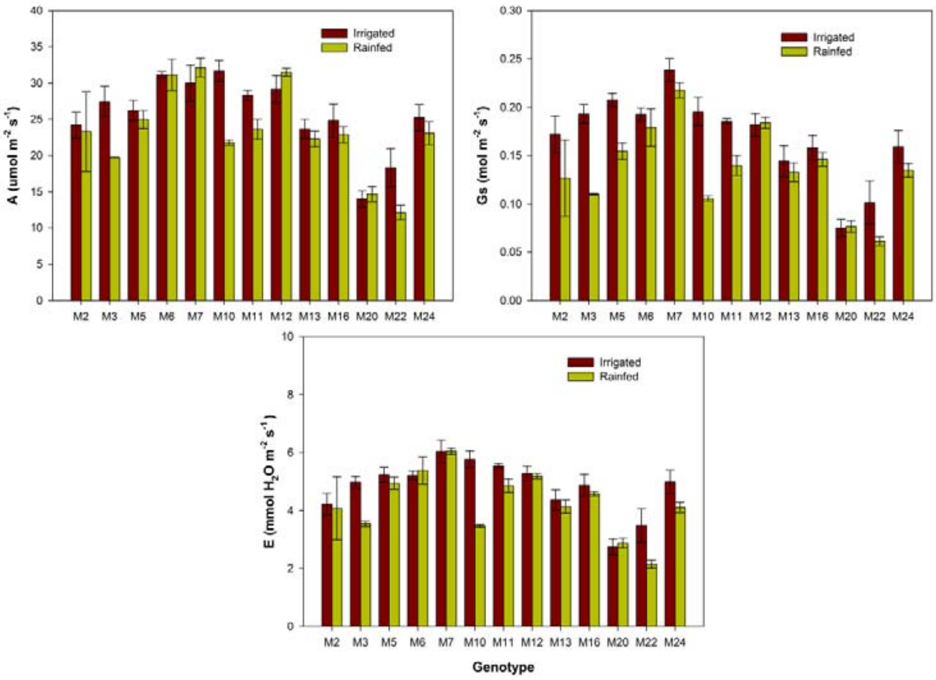


Figure 16 – UNICT. Gas exchange in August of 25 Miscanthus accessions grown in drought stress (rainfed) and well watered conditions.

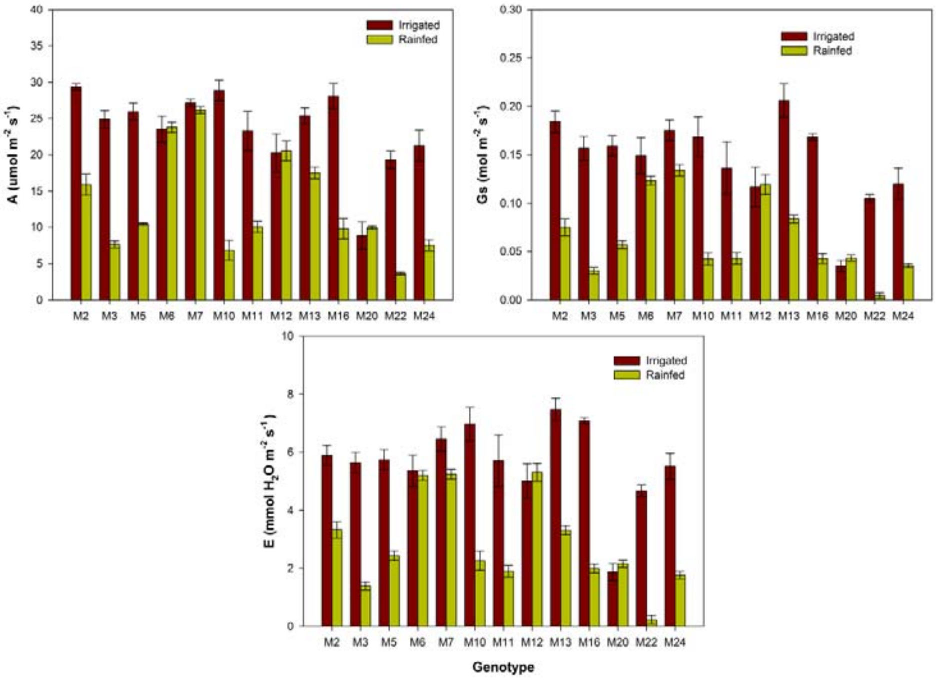


Figure 17 - UNICT. Gas exchange in September 10 of 25 Miscanthus accessions grown in drought stress (rainfed) and well watered conditions.

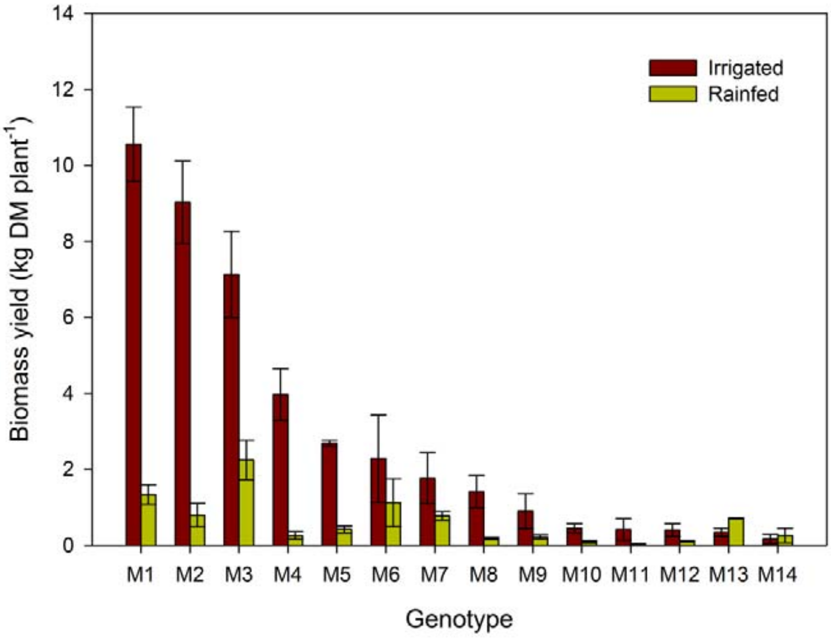


Figure 18 - UNICT. Biomass yield of Miscanthus accessions grown in drought stress (rainfed) and well watered conditions at UNICT.

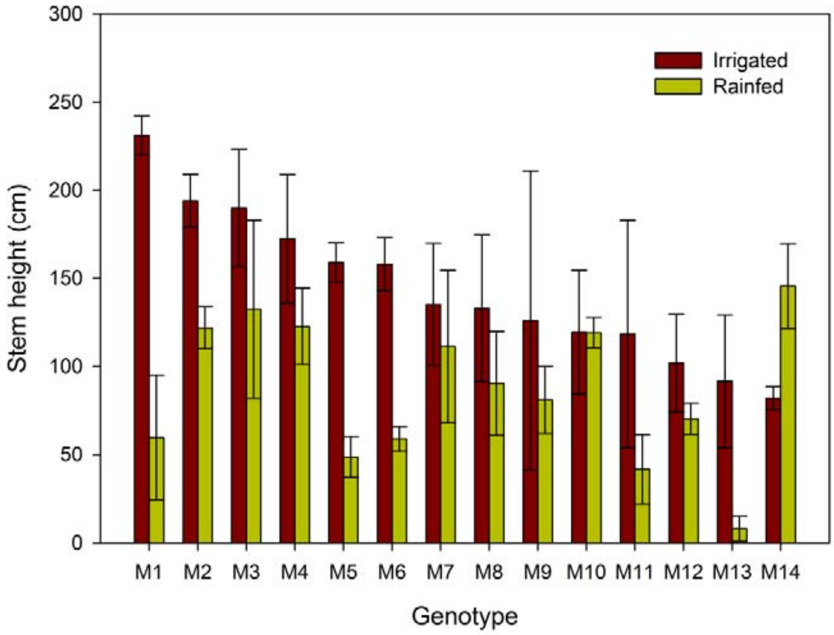


Figure 19 – UNICT. Stem height of Miscanthus accessions grown in drought stress (rainfed) and well watered conditions at UNICT.

Figure 20 - UNICT. Experimental layout of the long term plantation at Experimental farm of UNICT (Catania plain, 10 m a.s.l., 37°27' N, 15° 03' E).

Figure 21 - UNICT. February 2014 harvest of long-term giant reed (up-left), *Miscanthus* x *giganteus* (up-right) and September 2014 harvest of giant reed (down-left) and *Miscanthus* x *giganteus* (down-right).

Table 3 - UNICT. ANOVA for biomass yield and moisture content of *Arundo donax* and *Miscanthus* x *giganteus* in relation to harvest time (autumn and winter). LSD test was carried out for mean separations.

	Yield (p-value)	Moisture (p-value)
2011		
Species	***	***
Harvest	***	***
Species x Harvest	*	***
2012		
Species	***	***
Harvest	***	***
Species x Harvest	**	***
2013		
Species	***	***
Harvest	***	***
Species x Harvest	ns	***
2014		
Species	**	***
Harvest	**	***
Species x Harvest	ns	***

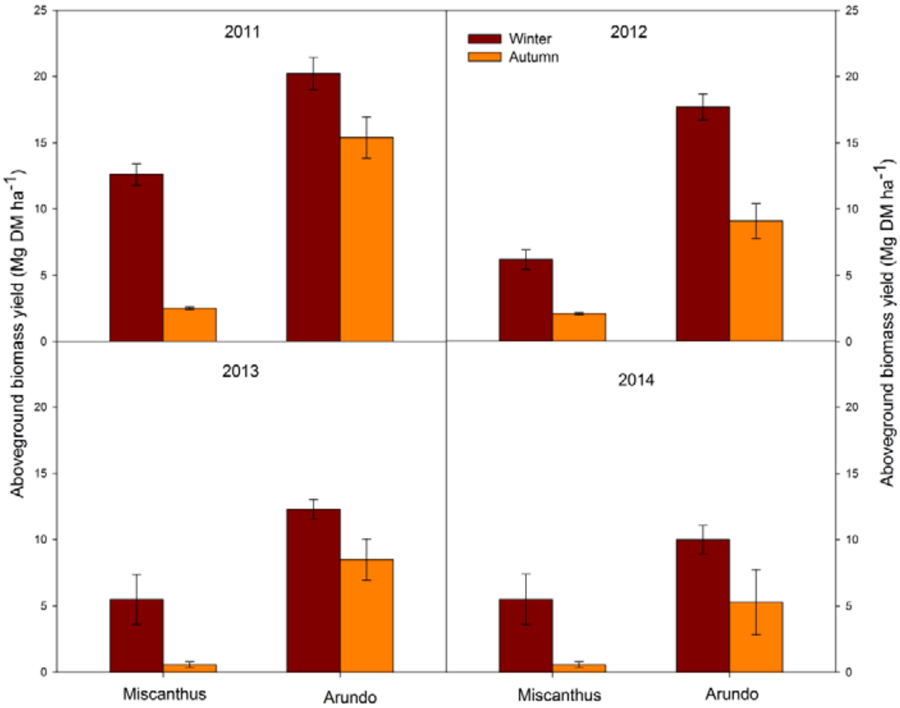


Figure 22 - UNICT. Aboveground biomass yield (Mg DM ha^{-1}) of giant reed and miscanthus harvested in autumn and winter, in 2011, 2012, 2013 and 2014.

Table 4 - UNICT. ANOVA for biomass quality of *Arundo donax* and *Miscanthus* x *giganteus* in relation to harvest time (autumn and winter) and year (2011, 2012 and 2013 growing seasons) in Catania trial. LSD test was carried out for mean separations.

Statistics (p values)	NDS	NDF	ADF	ADL	ASH
Harvest time	***	***	***	ns	***
Species	***	***	*	***	***
Year	*	***	***	***	***
Harvest time × Species	***	***	***	ns	ns
Harvest time × Year	***	ns	*	ns	ns
Species × Year	ns	***	***	**	ns
Harvest time × Species × Year	**	***	***	***	ns

*significant per p≤0.05; ** significant per p≤0.01; *** significant per p≤0.001; ns (non-significant)

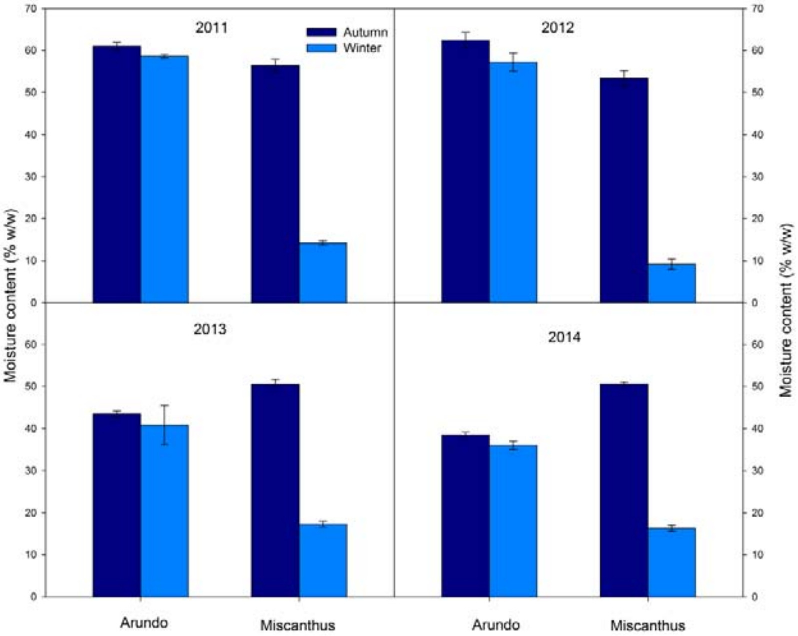


Figure 23 - UNICT. Moisture content (% w/w) of giant reed and miscanthus harvested in autumn and winter, in 2011, 2012, 2013 and 2014.

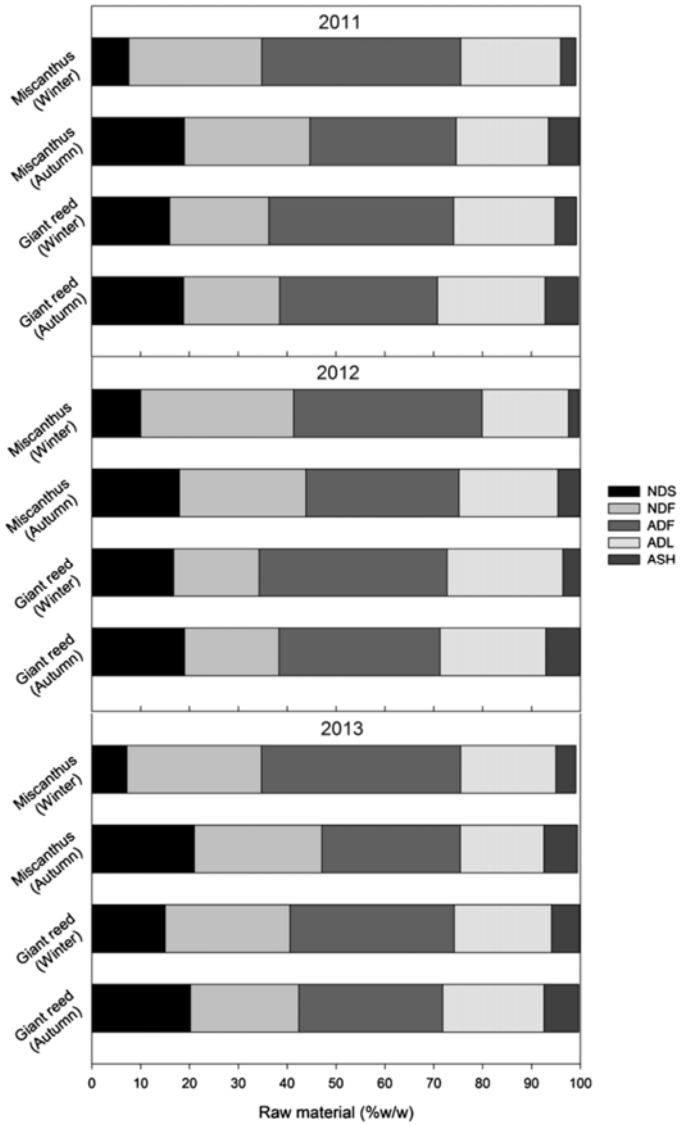


Figure 24 - UNICT. Qualitative traits of giant reed and miscanthus on whole biomass (raw material) harvested in autumn and winter, in 2011, 2012 and 2013. NDS: soluble compounds, NDF: hemicellulose, ADF: cellulose, ADL: lignin, ASH: ashes.

Universidad Politecnica De Madrid – UPM (n. 5)

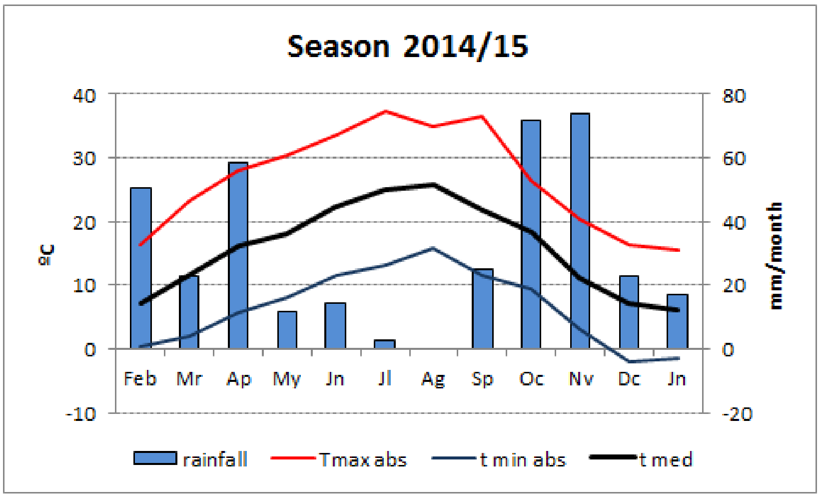


Figure 1 - UPM. Records of temperature and rainfall in the season 2014/15. Data from AEMET, Meteorological Station of Madrid-Retiro, Longitude 34041 W, Latitude 402443, Altitude 667 m.a.s.l.

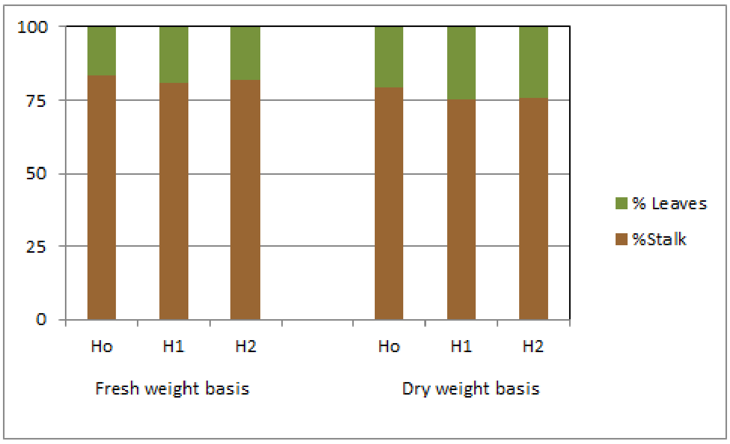


Figure 2 - UPM. Mean biomass partitioning of Arundo biomass under limiting water and soil conditions, 2015' harvest.

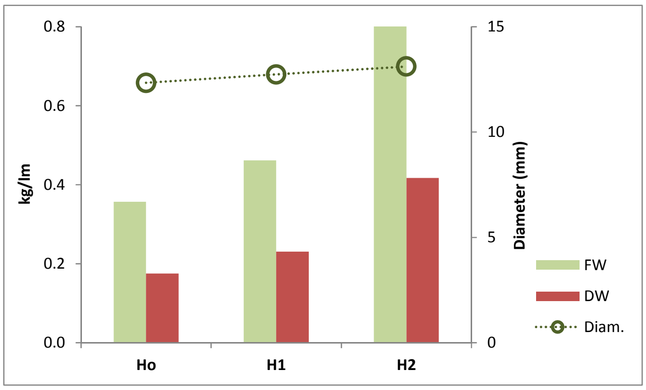


Figure 3 - UPM. Mean biomass production and mean cane diameter versus hydric regime, in the 2014' harvest of a crop of Arundo grown under limiting water and soil conditions. H0=dry farming; H1= target water regime of 450 mm; H2= target water regime of 650 mm.

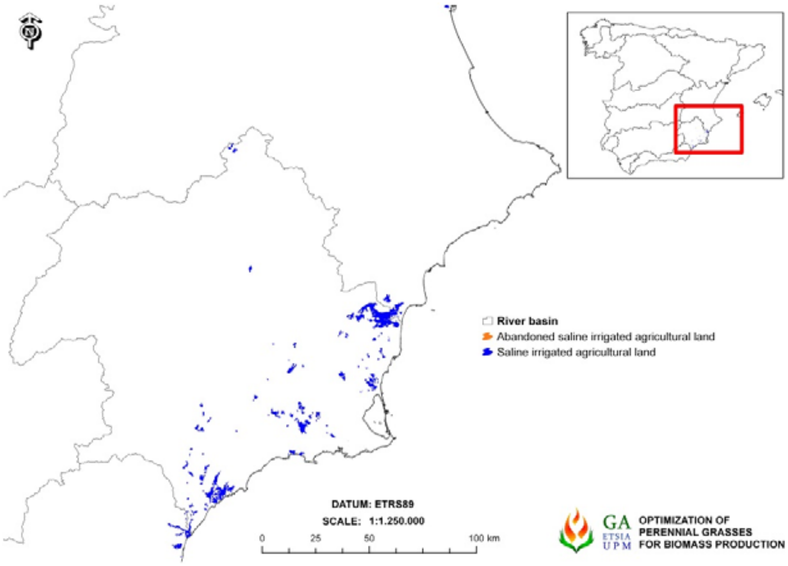


Figure 4 - UPM. Saline and prone-saline agricultural areas suitable for growing giant reed.

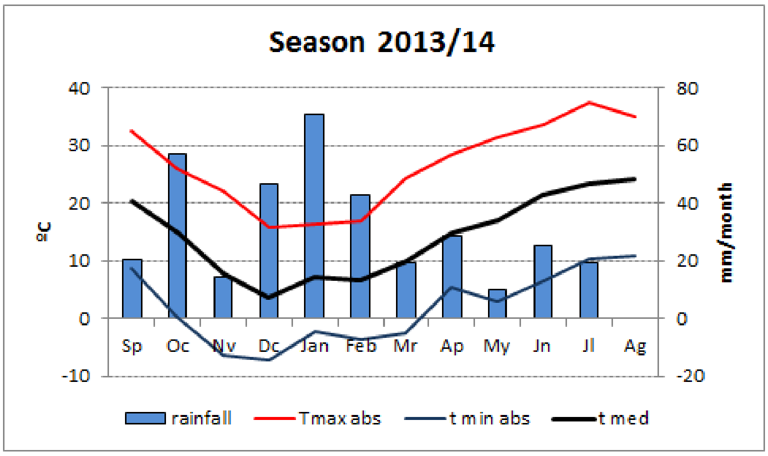


Figure 5 - UPM. Temperature and rainfall in 2013/2014 season. Data from the Meteorological Station of San Fernando de Henares. UTM X: 457867, UTM Y: 4473610; Huse 30; altitude 604 m.a.s.l.

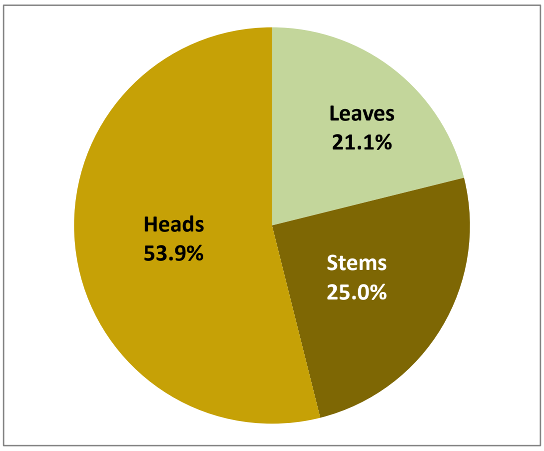


Figure 6 - UPM. Mean biomass partitioning (w/w). Cynara grown at demonstrative scale. Daganzo (Spain), 2014 harvest. Annual rainfall (San Fernando de Henares, 2013/2014): 356 mm.

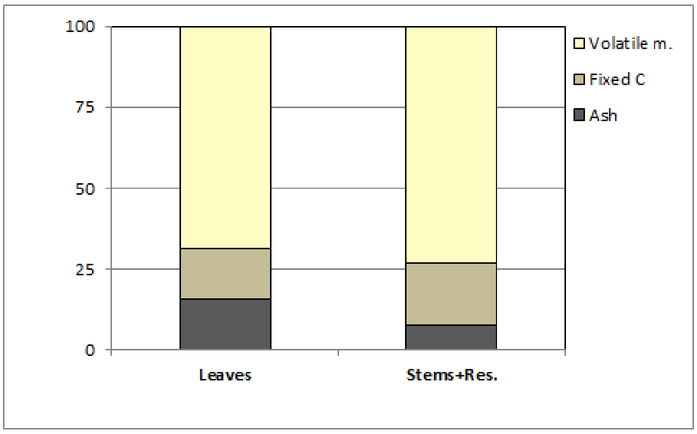


Figure 7 - UPM. Proximate analysis of cynara biomass as harvested (no biomass pre-treatments, no washing). Cynara crop grown at demonstrative scale. Daganzo (Spain), 2014 harvest. Annual rainfall (San Fernando de Henares, 2013-14): 356 mm.

Center for Renewable Energy Sources and Energy Saving – CRES (n. 3)

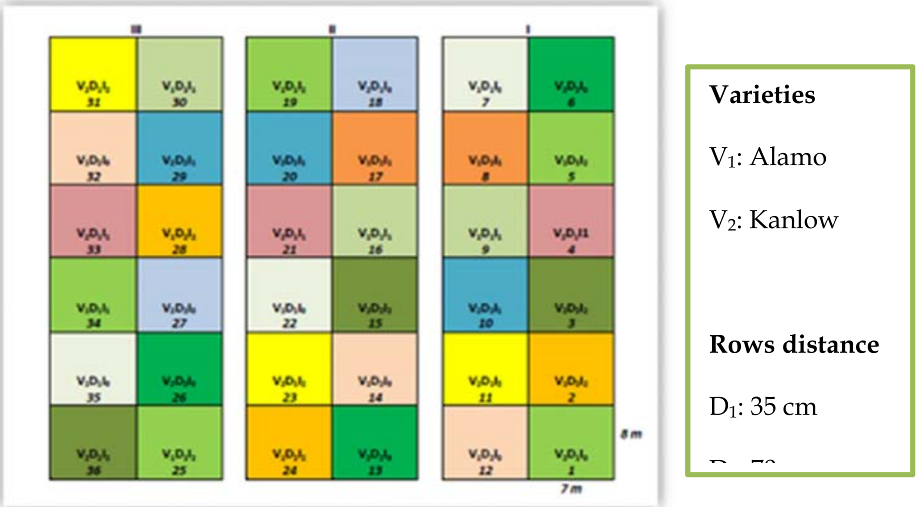


Figure 1 – CRES. View of the experimental layout of switchgrass trial in central Greece (tested factors: variety, density and irrigation rates).

Figure 2 – CRES. View of the switchgrass trial at the establishment (25/6/12); D_1: 35 cm between the rows on the left and D_2: 70 cm on the right.

Figure 3 – CRES. View of the switchgrass trial with lodging problems (in September on the left and in November 2012 on the right).

Table 1 – CRES. Growth characteristics (plant height, number of tillers/m² and tiller density) for three subsequent growing periods.

	Plant height (cm)			Number of tillers/m²			Tiller diameter (mm)		
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
				Varieties					
Alamo	163	226	208	384	462	471	3.55	4.41	4.48
Kanlow	156	227	198	467	613	603	3.37	4.18	4.22
				Distances between the rows					
D1: 35 cm	144	221	196	404	555	546	3.06	3.97	4.06
D1: 70 cm	157	231	210	406	510	528	3.51	4.62	4.56
				Irrigation rates					
I0	-	224	201	-	491	465	-	4.02	4.37
I1	-	226	202	-	580	552	-	4.48	4.10
I2	-	228	206	-	527	597	-	4.38	4.46
Mean	151	226	203	405	533	537	3.29	4.29	4.31

Table 2 – CRES. Yields results (fresh and dry matter yields, % stems on dry basis) from three subsequent growing seasons.

	Fresh biomass yields (t/ha)			**Dry matter yields (t/ha)**			**% stems on the biomass (oven-dried)**		
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
				Varieties					
Alamo	12.01	32.74	33.83	7.62	23.52	23.23	60.63	67.89	65.69
Kanlow	12.92	34.79	35.75	8.57	26.31	25.35	61.37	66.63	64.73
				Distances between the rows					
D1: 35 cm	11.10	31.18	32.14	7.07	23.26	22.85	60.82	64.53	63.64
D1: 70 cm	13.83	36.34	37.43	8.18	26.57	27.49	61.25	67.78	66.54
				Irrigation rates					
I0	-	31.41	32.42	-	22.53	22.43	-	63.83	65.27
I1	-	35.06	35.96	-	26.01	24.55	-	67.62	64.85
I2	-	34.81	35.98	-	26.22	25.88	-	67.39	65.46
Mean	**12.47**	**33.76**	**34.79**	**7.63**	**24.92**	**24.29**	**61.07**	**66.41**	**64.80**

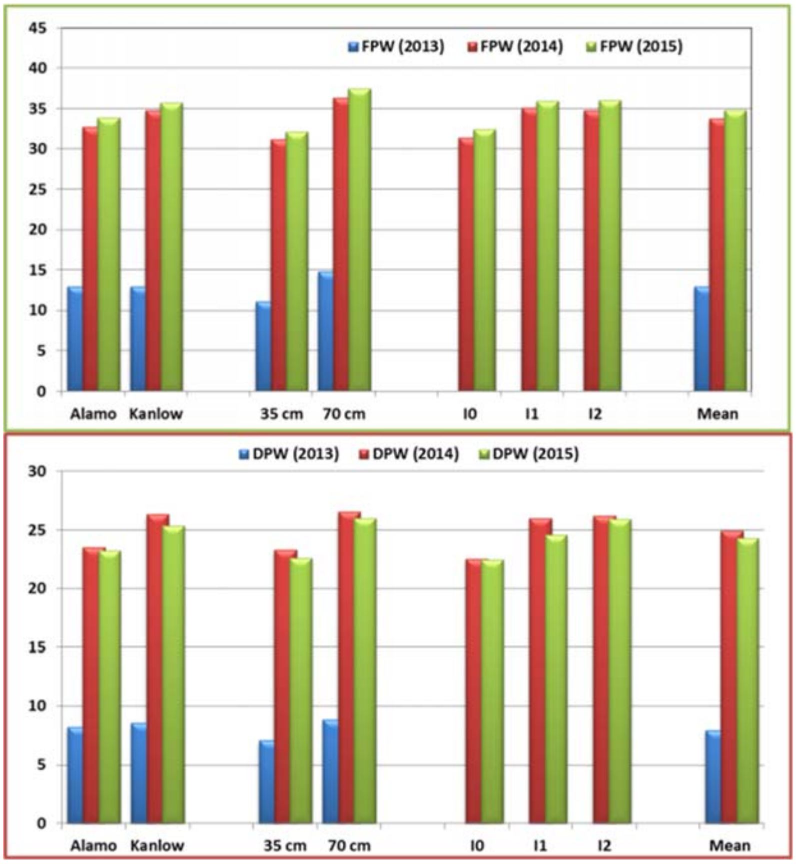


Figure 4 – CRES. Comparison in terms of fresh and dry matter yields (t/ha) among the three growing periods (2012-3, 2013-4 & 2014-5) for the tested factors (varieties, row distances and irrigation rates)

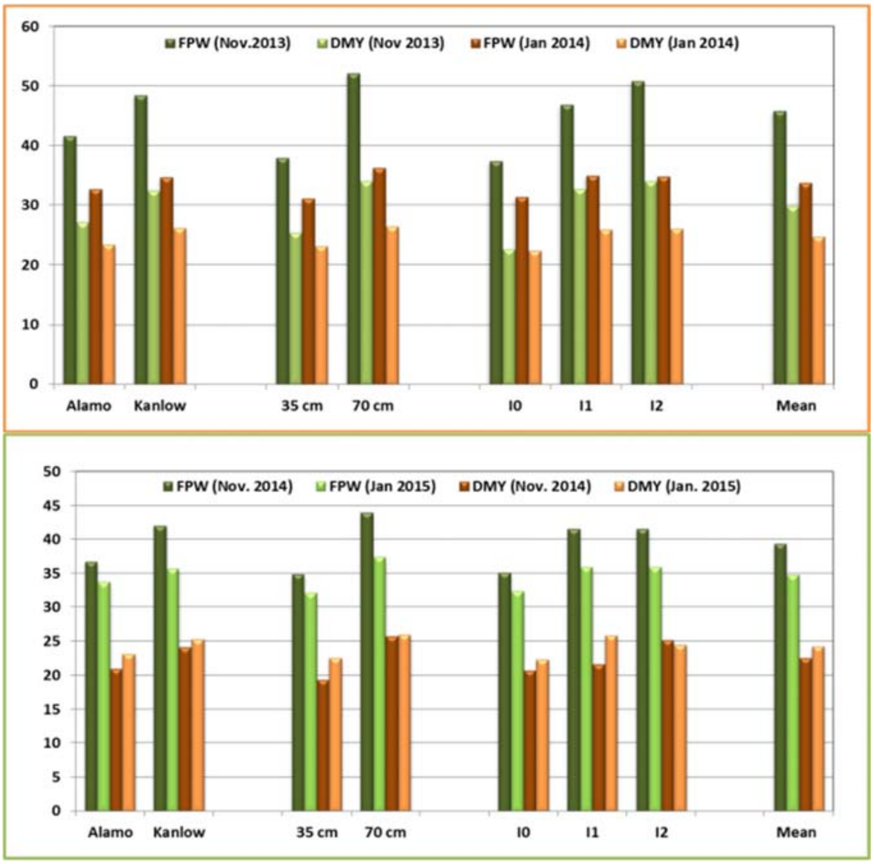
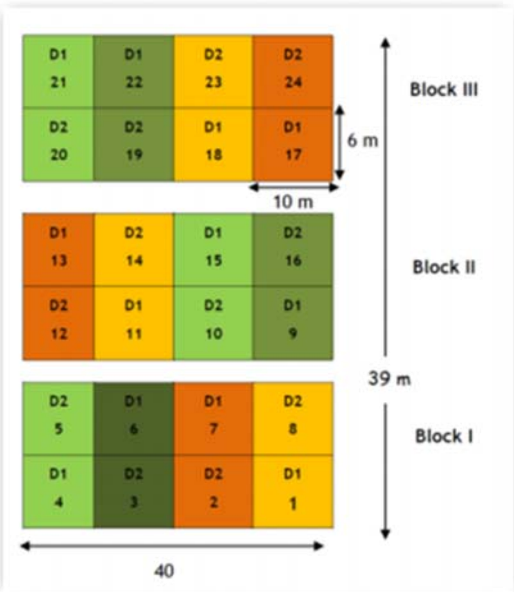


Figure 5 – CRES. Comparison in term of fresh and dry matter yields (t/ha) between the autumn and winter harvest in the second and the third growing period.

Figure 6 – CRES. View of the switchgrass (at the front) and giant reed (at the back) in the beginning of November.

Table 3 – CRES. Results from the calorific value (GCY, NCY) and proximate analysis (volatiles, ash and fixed carbon) on samples that were collected at the end of the second growing period.

	Calorific value (Kcal/kg)		Proximate analysis (%)		
	GCV	NCV	Volatiles	Ash	Fixed carbon
Alamo (stems)	4624	4321	79.77	1.86	14.38
Alamo (leaves)	4471	4168	78.59	7.31	14.12
Alamo	**4563**	**4260**	**79.30**	**4.01**	**16.70**
Kanlow (stems)	4644	4341	80.06	1.65	18.30
Kanlow (leaves)	4499	4196	78.43	7.45	14.13
Kanlow	**4588**	**4285**	**79.43**	**3.89**	**16.69**
D1 (stems)	4637	4334	80.21	1.73	18.07
D1 (stems)	4492	4189	78.62	7.55	13.85
D1	**4580**	**4277**	**79.58**	**4.02**	**16.41**
D2 (stems)	4631	4328	79.62	1.78	18.62
D2 (leaves)	4477	4174	78.41	7.22	14.39
D2	**4571**	**4268**	**79.15**	**3.88**	**16.98**
Mean	**4576**	**4273**	**79.37**	**3.95**	**16.69**



Nitrogen rates

Light orange: no irrigation

Dark orange: 25% of PET

Light green: 50% of PET

Dark green: 100% of PET

Figure 7 – CRES. View of the experimental layout of miscanthus trial (tested factors: nitrogen rates and plant densities in three blocks)

Figure 8 – CRES. View of the experimental field of miscanthus at the end of June 2012 (young plants) and at the end of July 2012.

Table 4 – CRES. Growth characteristics (plant height, number of tillers/m^2 and tiller density) for three subsequent growing periods.

	Plant height (cm)			Number of tillers/m^2			Tiller diameter (mm)		
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
				Distances between the rows					
D1: 50 cm	242	308	326	230	228	227	7.60	8.65	8.83
D2:100 cm	261	311	300	214	235	242	7.69	8.90	9.08
				Irrigation rates					
I0	-	266	278	-	166	192	-	8.40	8.85
I1	-	312	296	-	202	212	-	8.67	8.90
I2	-	320	308	-	269	262	-	8.70	8.98
I3	-	341	369	-	289	272	-	9.37	9.09
Mean	**252**	**309**	**313**	**222**	**231**	**234**	**7.65**	**8.78**	**8.95**

Table 5 – CRES. Yields results (fresh and dry matter yields, % stems on dry basis) from three subsequent growing seasons.

	Fresh biomass yields (t/ha)			**Dry matter yields (t/ha)**			**% stems on the biomass (oven-dried)**		
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
				Distances between the rows					
D1: 50 cm	20.92	37.17	27.13	12.92	25.04	17.22	52.50	72.01	60.40
D2:100 cm	15.64	41.35	31.93	9.64	26.78	18.70	49.70	70.75	67.86
				Irrigation rates					
I0	-	22.92	20.50	-	16.96	12.19	-	69.53	58.29
I1	-	29.29	27.25	-	19.70	16.70	-	67.94	55.60
I2	-	52.54	34.45	-	33.02	19.51	-	70.62	70.65
I3	-	52.29	35.91	-	33.96	23.45	-	77.74	72.53
Mean	**18.27**	**39.26**	**29.53**	**11.27**	**25.91**	**17.96**	**51.10**	**71.38**	**64.27**

Figure 9 – CRES. Effect of irrigation rate on the miscanthus growth.

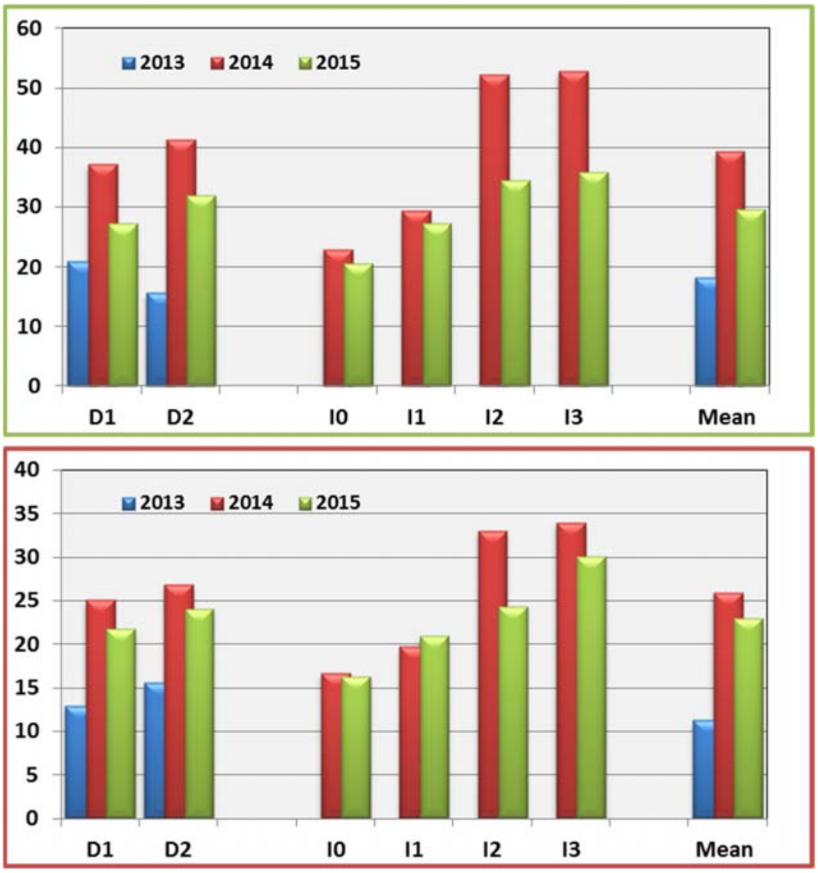


Figure 10 – CRES. Comparison of fresh and dry matter yields (t/ha) among the three growing seasons (Jan 2013/Jan 2014/Jan 2015).

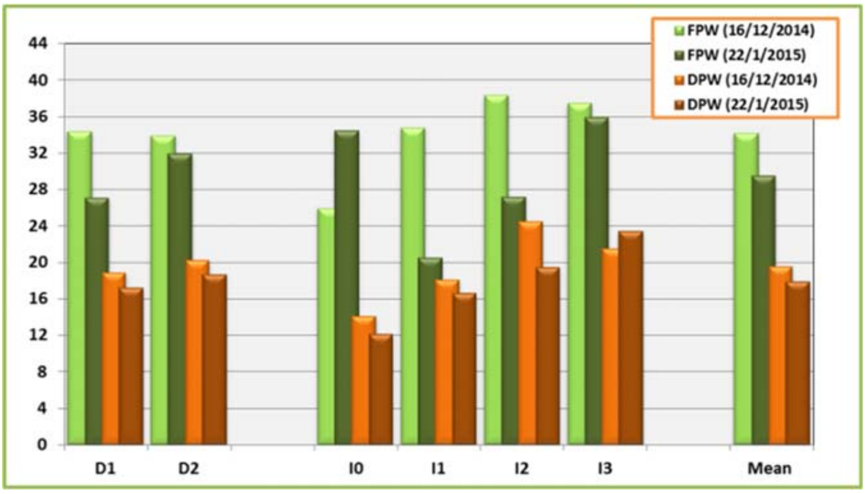


Figure 11 – CRES. Comparison of fresh and dry matter yields (t/ha) between the two harvest times (Dec 2014 and Jan. 2015)

Table 6 – CRES. Results from the calorific value (GCY, NCY) and proximate analysis on samples that were collected at the end of the second growing period

Perennial grasses	Calorific value (kcal/kg)		Proximate analysis (%)		
	GCV	NCV	Volatiles	Ash	Fixed carbon
I0D1 (stems)	4651	4348	80.53	1.68	17.79
(leaves)	4307	4004	73.00	11.84	15.16
I0D2 (stems)	4621	4318	80.99	1.72	17.30
(leaves)	4325	4022	73.72	11.29	15.00
I1D1 (stems)	4701	4398	80.82	1.80	17.39
(leaves)	4230	3927	72.95	12.59	14.46
I1D2 (stems)	4635	4332	80.52	1.70	17.79
(leaves)	4309	4006	73.78	11.67	14.57
I2D1 (stems)	4644	4341	80.70	1.57	17.74
(leaves)	4451	4118	76.44	8.63	14.94
I2D2 (stems)	4613	4310	80.81	1.55	17.65
(leaves)	4369	4066	75.61	9.42	14.98
I3D1 (stems)	4637	4334	80.94	1.79	17.28
(leaves)	4326	4023	74.90	10.37	14.47
I3D2 (stems)	4682	4337	80.90	1.67	17.44
(leaves)	4328	4025	75.25	10.21	14.56

Table 7 – CRES. Results from the calorific value (GCY, NCY) and proximate analysis (volatiles, ash and fixed carbon) on samples that were collected at the end of the second growing period

Perennial grasses	Calorific value (kcal/kg)		Proximate analysis (%)		
	GCV	NCV	Volatiles	Ash	Fixed carbon
I0D1 stems	4660	4357	81.46	1.59	16.96
leaves	4389	4086	75.89	9.31	14.81
I0D2	4685	4382	81.14	1.69	17.17
	4331	4028	74.21	10.86	14.94
I1D1	4678	4375	80.95	1.79	17.26
	4362	4060	75.24	10.13	14.64
I1D2	4660	4357	80.88	1.81	17.32
	4309	4006	74.46	11.28	14.27
I2D1	4706	4403	81.46	1.44	17.11
	4443	4140	75.47	9.27	15.26
I2D2	4670	4367	81.08	1.64	17.28
	4436	4133	76.25	8.68	15.07
I3D1	4650	4347	80.76	1.76	17.49
	4364	4061	75.62	10.03	14.36
I3D2	4681	4378	81.28	1.59	17.14
	4352	4049	75.73	10.09	14.19

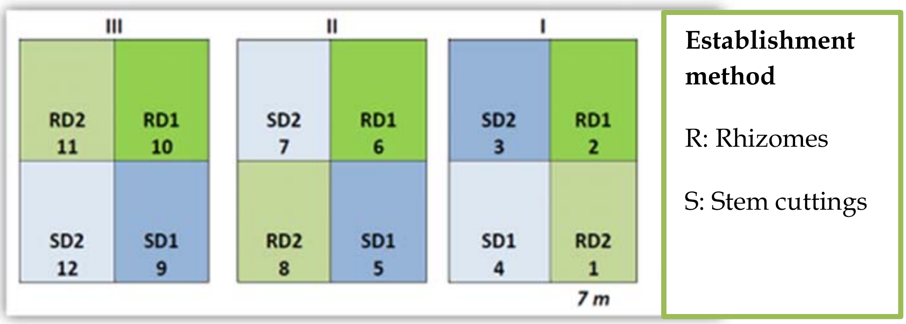


Figure 12 – CRES. Experimental layout of giant reed established in Aliartos in 2012.

Table 8 – CRES. Effect of way of establishment (rhizomes or stem cuttings) and plant density on growth (plant height, tiller density per square meter and tiller diameter) for three subsequent growing periods.

	Plant height (cm)			Number of tillers/m^2			Tiller diameter (mm)		
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**
				Propagation methods					
Rhizomes	414	603	625	8.0	14.3	16.0	-	24.04	24.82
S. cuttings	244	601	610	4.6	10.6	18.2	-	25.40	24.64
				Densities within the rows					
D1: 75 cm	337	599	623	6.4	10.9	14.4	-	25.18	25.43
D2: 150 cm	322	605	613	6.2	13.8	17.7	-	24.27	24.03
Mean	**329**	**602**	**618**	**6.3**	**12.4**	**16.0**	**-**	**24.72**	**24.73**

Table 9 – CRES. Effect of way of establishment (rhizomes or stem cuttings) and plant density on yields (plant height, tiller density per square meter and tiller diameter) for three subsequent growing periods.

	Fresh yields (t/ha)			Dry matter yields (t/ha)			Early harvest (2/12/13)	
Years	**2013**	**2014**	**2015**	**2013**	**2014**	**2015**	**FFY**	**DMY**
				Propagation methods				
Rhizomes	16.85	94.58	103.37	8.24	45.63	54.67	103.38	41.85
S. cuttings	9.78	57.83	53.00	4.93	28.49	30.83	53.00	21.22
				Densities within the rows				
D1: 75 cm	13.50	62.88	80.21	6.78	30.29	43.91	80.21	28.86
D2: 150 cm	13.13	89.54	76.17	6.38	43.82	41.59	76.16	34.22
Mean	**13.31**	**76.21**	**78.18**	**6.58**	**37.06**	**42.75**	**78.18**	**31.54**

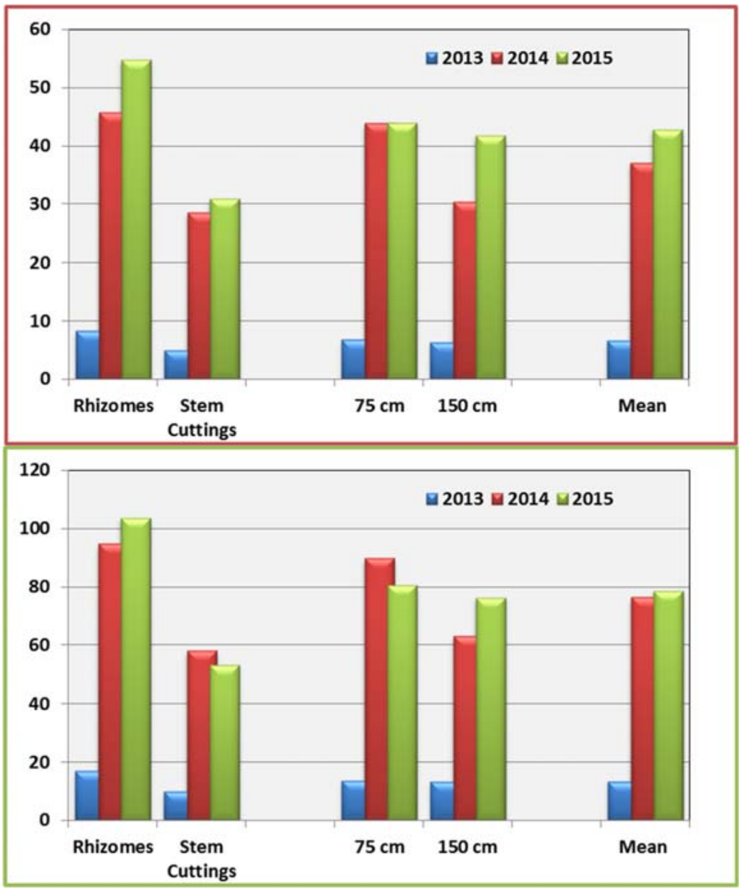


Figure 13 – CRES. Comparison of fresh and dry matter yields (t/ha) between the first and the second growing season (Jan 2013 vs. Jan 2014).

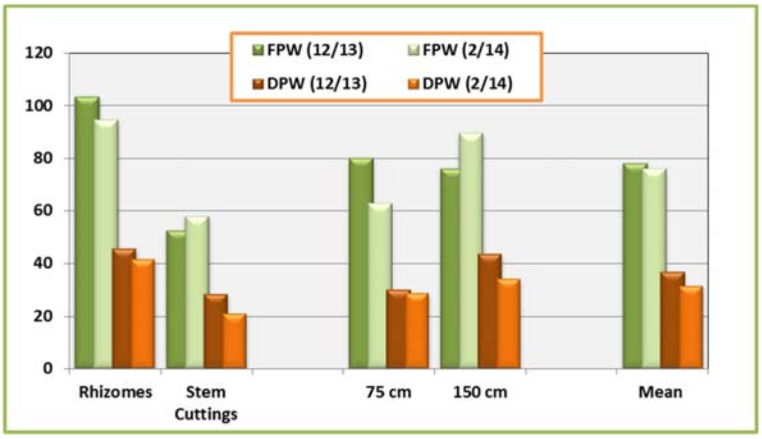


Figure 14 – CRES. Fresh and dry matter yields (t/ha) for the two tested factors (ways of establishment and densities within the rows) in two harvest times (Dec. 2013 and Feb. 2014)

Table 10 – CRES. Results from the proximate analysis (volatiles, ash and fixed carbon) on samples that were collected at the end of the second growing period.

	Proximate analysis (%)		
	Volatiles	**Ash**	**Fixed carbon**
	2/12/13		
RD1 (stems)	**77.86**	**2.86**	**12.29**
(leaves)	**71.92**	**12.59**	**15.49**
RD2 (stems)	**77.84**	**2.91**	**12.26**
(leaves)	**65.88**	**20.12**	**14.00**
SD1 (stems)	**78.22**	**2.86**	**18.93**
(leaves)	**69.09**	**16.36**	**14.56**
SD2 (stems)	**77.82**	**2.78**	**19.41**
(leaves)	**70.04**	**15.35**	**14.62**
	4/2/14		
RD1 (stems)	**76.96**	**3.43**	**19.62**
(leaves)	**71.71**	**13.12**	**15.19**
RD2 (stems)	**77.52**	**3.42**	**19.07**
(leaves)	**71.82**	**12.75**	**15.46**
SD1 (stems)	**77.54**	**3.07**	**19.39**
(leaves)	**72.50**	**11.73**	**15.77**
SD2 (stems)	**77.56**	**3.13**	**19.29**
(leaves)	**73.52**	**9.96**	**16.53**

Table 11 – CRES. Results from the calorific value (GCY, NCY) and elemental analysis (C, H, N) on samples from stems and leaves that were collected in February 2014.

	Calorific value (kcal/kg)		Elemental analysis (%)		
	GCV	**NCV**	**C**	**H**	**N**
Stems	**4485.16**	**4189.23**	**46.58**	**5.86**	**0.28**
Leaves	**4068.45**	**3808.88**	**38.38**	**5.19**	**0.78**

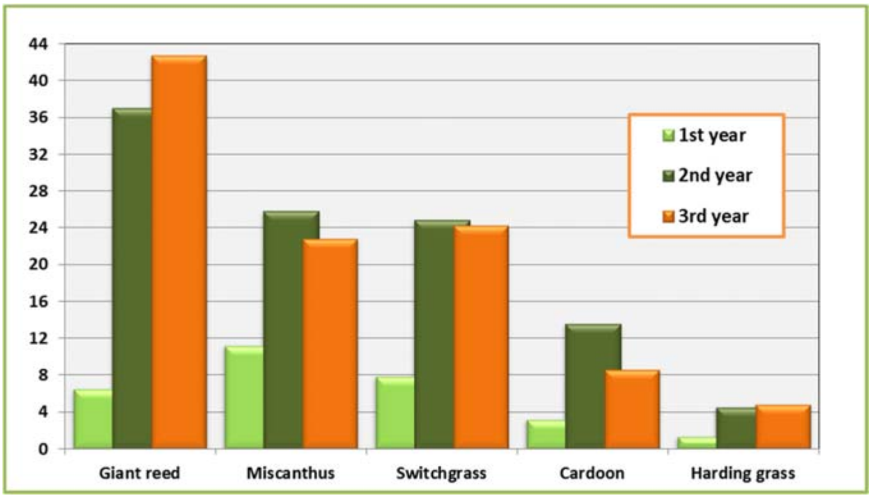


Figure 15 – CRES. Comparison among five perennial crops (switchgrass, giant reed, miscanthus cardoon and Harding grass) in terms of dry yields for three subsequent years.

Primus Ltd. – PRIMUS (n. 20)

Table 1 - PRIMUS. Maximum and minimum air temperatures (°C) during transplanting dates (2012) of miscanthus (*Miscanthus* x *giganteus* Greef et Deuter) stem cuttings at the experimental farm of PRIMUS Ltd., Hungary.

Transplanting time	Tmax	Tmin
July 6	25	15
July 23	34	21
August 18	29	14
September 7	28	5
September 23	19	4

Figure 1 – PRIMUS. Pictures of non-sprouting (non-activated) and shooting stems after 3-4-week-growth in ‘quasi in vitro’ nursing systems (left2). BAP in high concentration induced shoot multiplication on newly developed shoots. High concentration of BAP caused heavy trichome production on leaves also. BAP-induced shoot proliferation and trichome production can be seen on right 2 pictures.

Figure 2 – PRIMUS. Usage of new type of propagating materials is plots. Left to right: plantlets derived from activated stem cuttings and its usage as planting material in autumn; shoot development on activated stems was used as direct planting material; plantlets were developed from activated shoots collected in the same year (establishment was in early July, picture made in autumn)

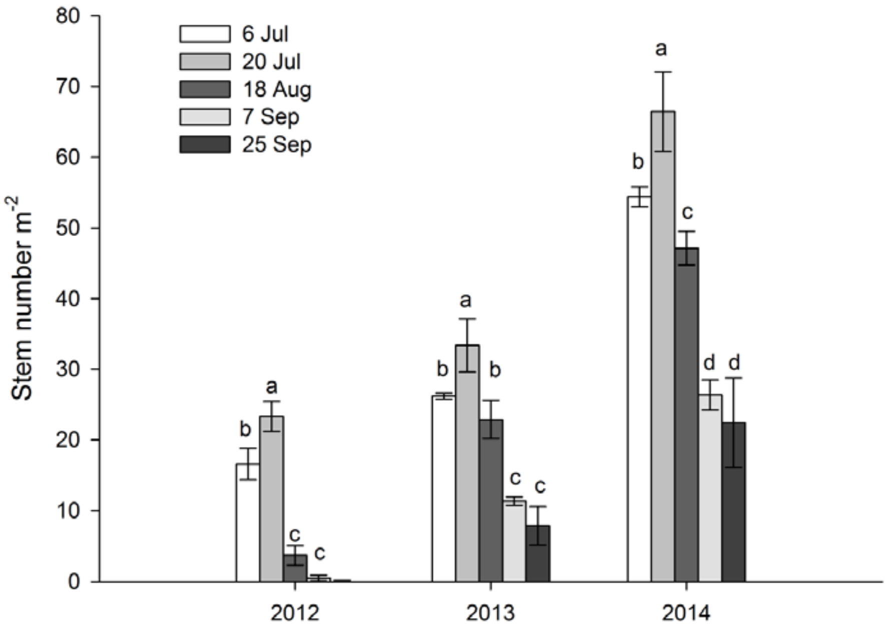


Figure 3 - PRIMUS. Stem number in a square meter (no. m-2) of Miscanthus x giganteus at first, second and third growing season (2012, 2013 and 2014, respectively) at PRIMUS Ltd, Hungary. Different letters within the same year represent statistically different means (P≤0.05).

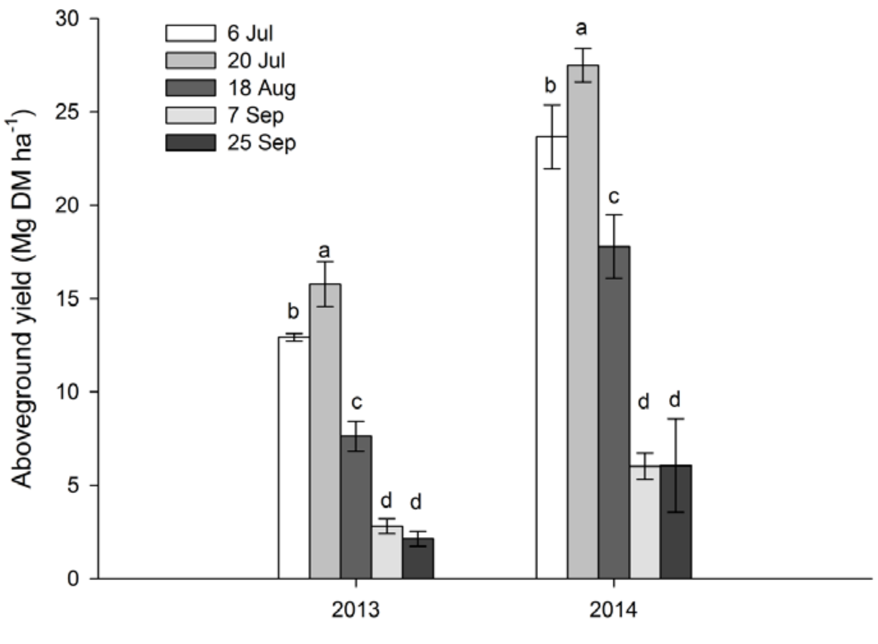


Figure 4 - PRIMUS. Aboveground dry matter yield (Mg DM ha^{-1}) of *Miscanthus* x *giganteus* at second and third growing season (2013 and 2014, respectively) at PRIMUS Ltd, Hungary. Different letters within the same year represent statistically different means (*P≤0.05*).

Figure 5 - PRIMUS. Growth of several-year-old *Miscanthus* plants after 3 dry and 2 rainy summers in a sandy hill (Autumn, 2015).

Task 4.1 Intercropping on marginal land

Center for Renewable Energy Sources and Energy Saving – CRES (n. 3)

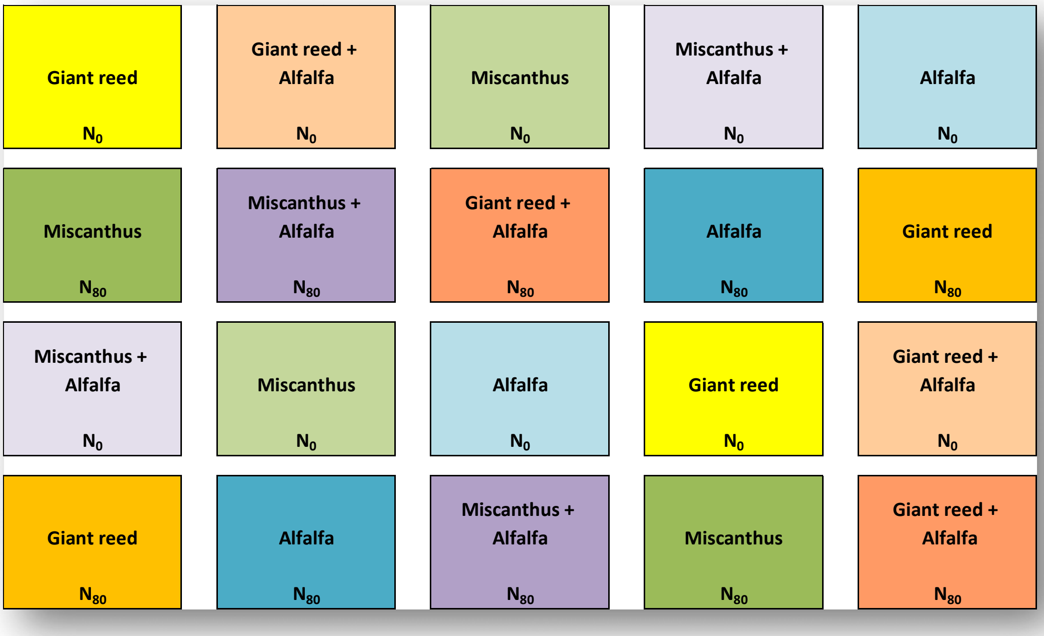


Figure 1 - CRES. Experimental design

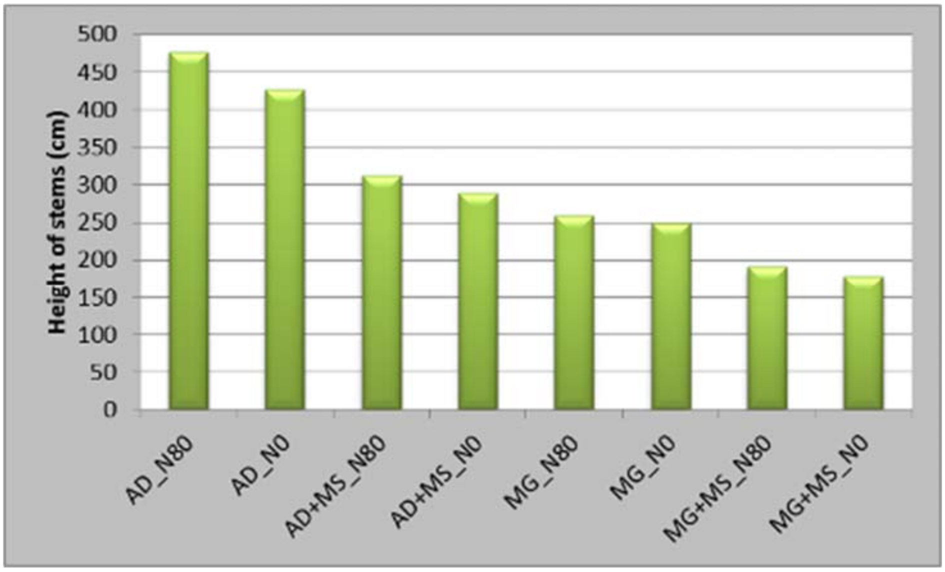


Figure 2 – CRES. Height of stems for Arundo donax (AD) and Miscanthus x Giganteus (MG) in pure stands and in mixtures with Medicago sativa (MS) in two nitrogen fertilisation rates (N0 and N80).

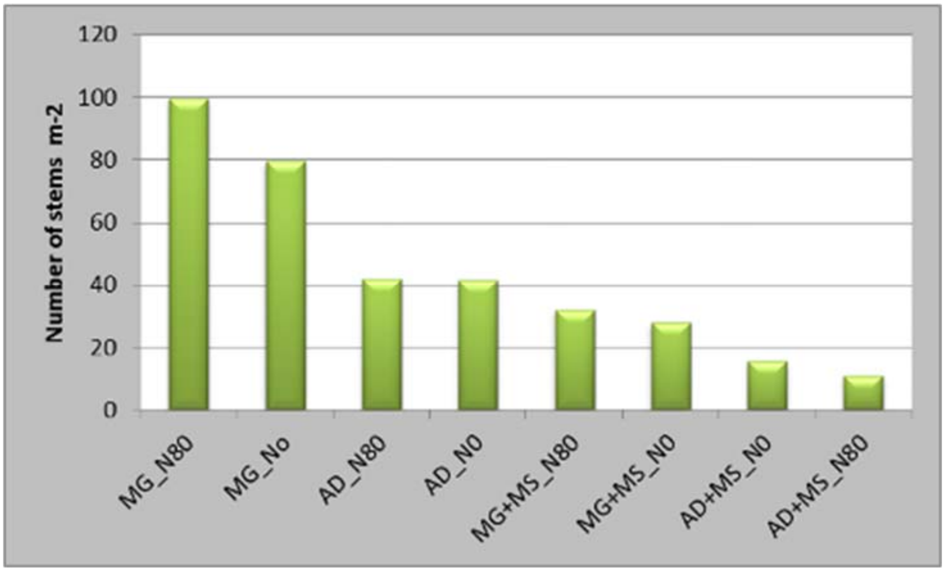


Figure 3 – CRES. Number of stems per square meter for Arundo donax (AD) and Miscanthus x Giganteus (MG) in pure stands and in mixtures with Medicago sativa (MS) in two nitrogen fertilisation rates (N0 and N80).

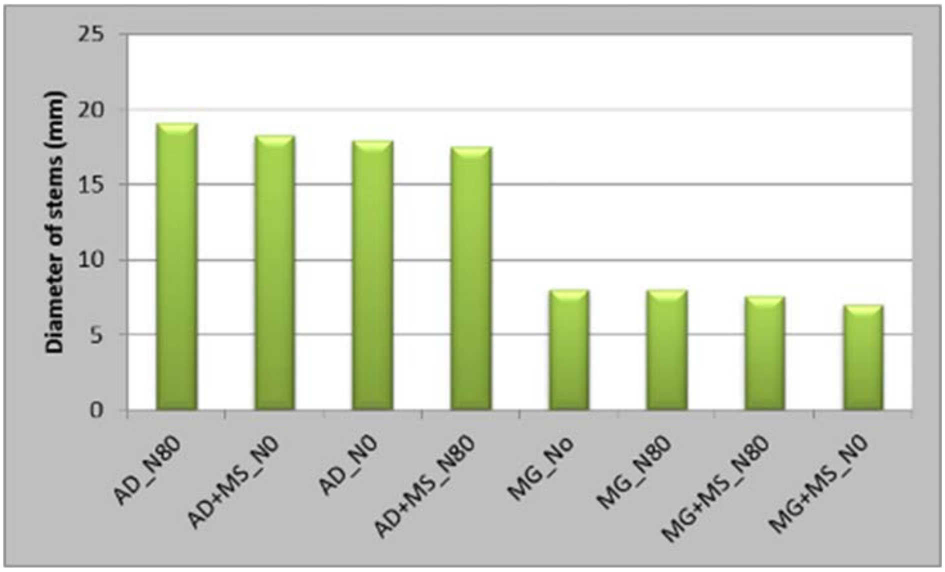


Figure 4 – CRES. Stem diameter for Arundo donax (AD) and Miscanthus x Giganteus (MG) in pure stands and in mixtures with Medicago sativa (MS) in two nitrogen fertilisation rates (N0 and N80).

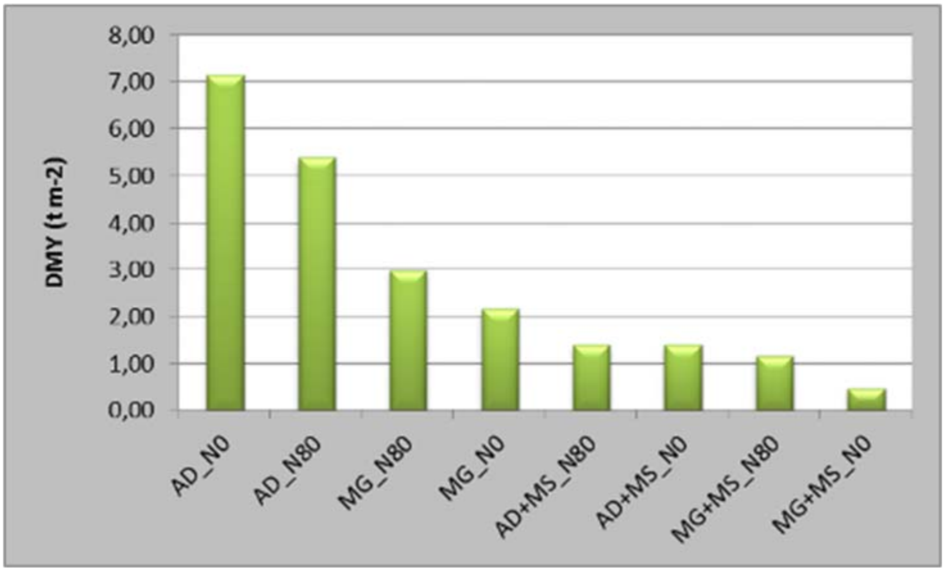


Figure 5 – CRES. Dry matter yields for Arundo donax (AD) and Miscanthus x Giganteus (MG) in pure stands and in mixtures with Medicago sativa (MS) in two nitrogen fertilisation rates (N0 and N80).

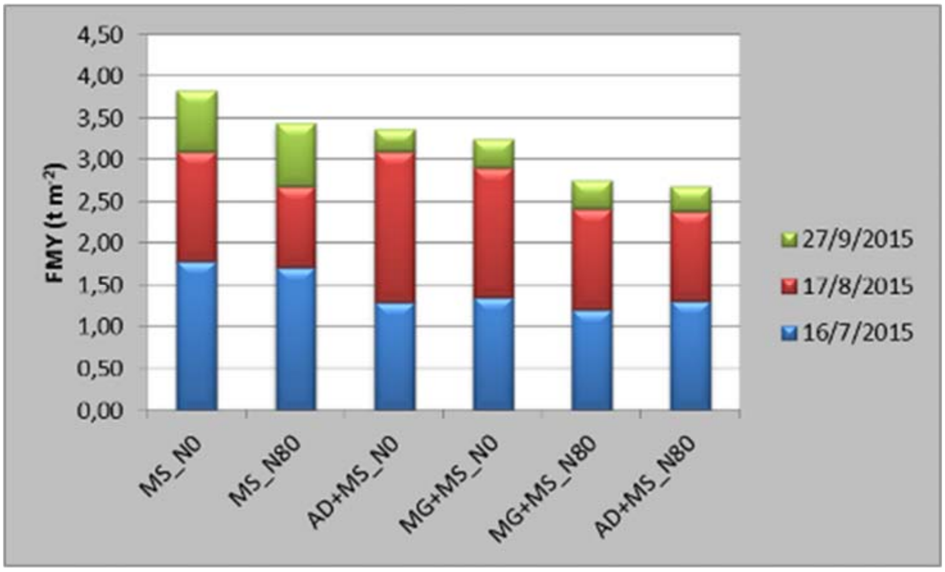


Figure 6 – CRES. Fresh matter yields for Medicago sativa (MS) harvested four times a year, in pure stands and in mixtures with Arundo donax (AD) and Miscanthus x Giganteus (MG), under two nitrogen fertilisation rates (N0 and N80).

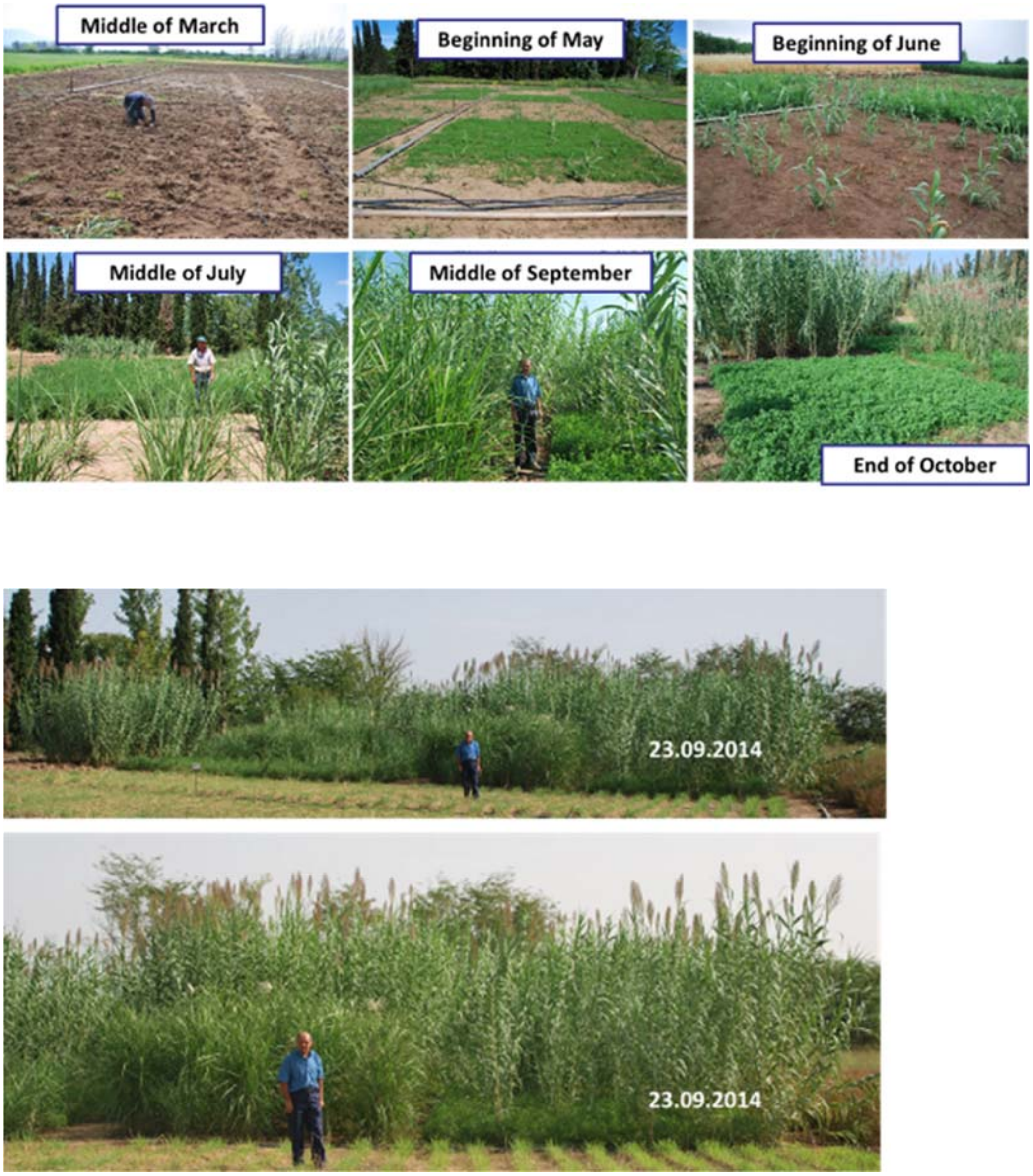


Figure 7 - CRES. Field view at different phonological stages

Università di Catania (n. 1)

Table 1 - UNICT. Number of intercropped species in spring intercropping trial

Number of intercropped species	Species
3	*Arundo+Saccharum+Sorghum*
2	*Arundo+Saccharum*
2	*Arundo+Sorghum*
2	*Saccharum+Sorghum*
1	*Arundo*
1	*Saccharum*
1	*Sorghum*

Picture 1 - UNICT. *Arundo+Saccharum* (sx), *Sorghum+Saccharum* (middle) and *Sorghum+Arundo+Saccharum* (dx)

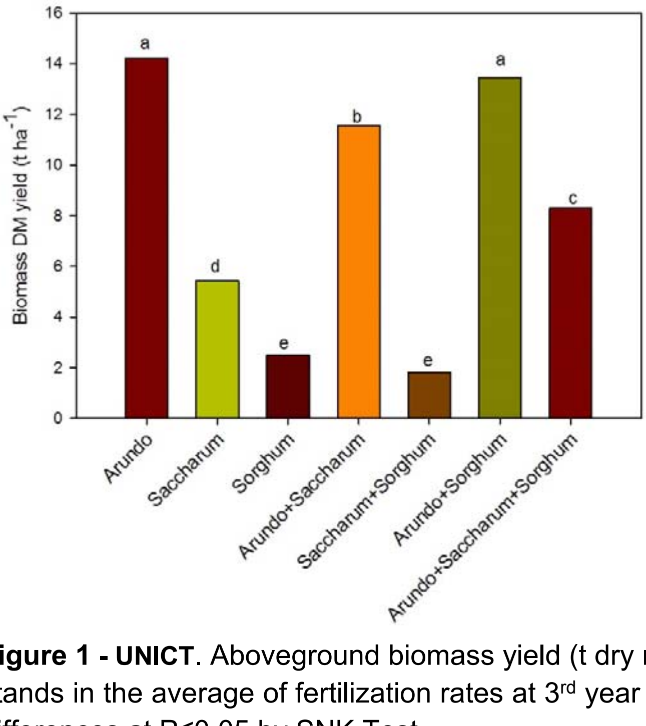


Figure 1 - UNICT. Aboveground biomass yield (t dry matter ha^{-1}) of intercropping levels and pure stands in the average of fertilization rates at 3rd year harvest. Different letters indicate significant differences at P≤0.05 by SNK Test.

Table 2 - UNICT. Nitrogen fertilization effect on aboveground biomass yield (t ha^{-1}) in the average of intercropping levels at 3rd year harvest (February 2015). Different letters indicate significant differences at P≤0.05 by SNK Test.

Nitrogen fertilization (kg ha^{-1})	Average biomass yield (t ha^{-1})
0	7.07c
40	8.27b
80	9.22a

Table 3 - UNICT. Number of intercropped species

Number of intercropped species	Species
2	*Miscanthus +T. alexandrinum*
2	*Arundo +T. alexandrinum*
1	*Arundo*
1	*Miscanthus*
1	*T. alexandrinum*



Picture 2 - UNICT. *Arundo* and *T. alexandrinum* in early-spring (left), middle of summer-time (center) and end-of summer after some irrigations (left)

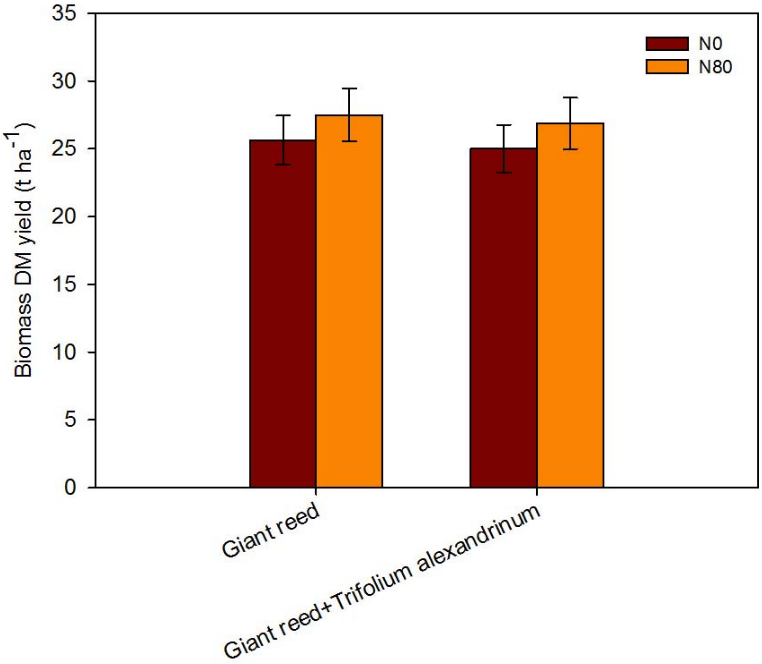


Figure 2 - UNICT. Aboveground biomass yield (t dry matter ha^{-1}) of intercropping levels and pure stands in the average of fertilization rates at the winter harvest (February 2015).

Table 4 - UNICT. Aboveground biomass yield (t ha^{-1}) in relation to the different studied treatments (mixture and fertilization rate).

Mixture	Fertilization rate	DM yield (tha-1)
Giant reed	N0	25.63±1.81
Giant reed+Trifolium alexandrinum	N0	25.00±1.76
Giant reed	N80	27.50±1.94
Giant reed+Trifolium alexandrinum	N80	26.88±1.90
Average		
N0		25.31±1.79
N80		27.19±1.92
Giant reed		26.56±1.88
Giant reed+Trifolium alexandrinum		25.94±1.83

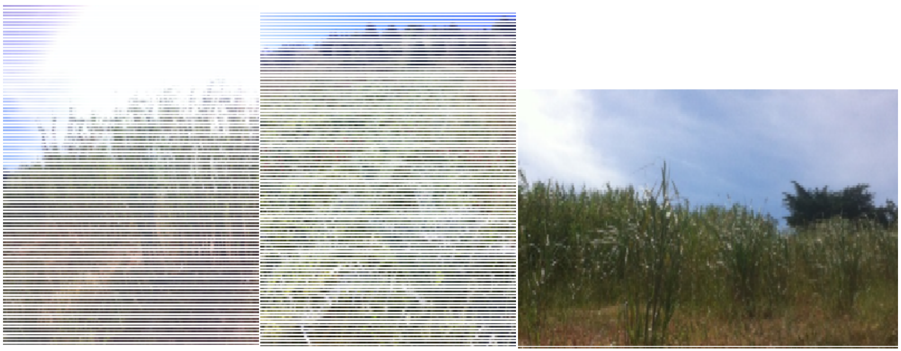
Table 5 – UNICT. Biometric and productive measurements of 5 ha giant reed plantation (harvest February 2015).

Measurement	**Unit**	**Value**
# of emerged plants	m^2	19.7±4.3
uniformity after transplant	visual score	Medium-high
height of stems	Cm	223.5±82.1
Dry stems	%	85.1±12.3
Dry leaves	%	13.1±8.7
Aboveground dry biomass yield	t ha^{-1}	12.1±2.9

Table 6 - UNICT. Morpho-biometric and productive characters of *Arundo donax*, *Saccharum spontaneum* and cardoon in the marginal slope field.

	Measurement unit	***Arundo donax***	***Saccharum spontaneum***	*Cynara cardunculus*
Plant height	Cm	223.2±38.2	94.1±26.4	98.6±11.4
Stems	%	87.1±4.0	79±5.1	36.8±3.2
Leaves	%	12.9±4.0	21±5.1	40.5±6.1
Heads	%			19.15±5.7
Hachenes	%			3.55±0.41
H_2O	%	45±2.7	53±3.2	9.3±1.3
Dry biomass yield	t ha^{-1}	8.1±1.5	4.3±1.1	5.7±0.9

± standard deviation of three determinations



Picture 3 - UNICT. Giant reed (left) cardoon (center) and saccharum (right) in the in a marginal area with 26-28% slope during last growing season.

Istituto per il Sistema Produzione Animale in Ambiente Mediterraneo – CNR-ISPAAM (n. 8)

Table 1 – CNR-ISPAAM. Seed rates and number of germinating seeds in legume crops intercropped in biomass crop (autumn sowing).

species	Accession	*n. of rhizomes m⁻²/sowing rate seed ha⁻¹*
A. donax	Local landrace	*2*
M. x giganteus	unknown	*2*
T. alexandrinum	Cv Laura	*42 kg*

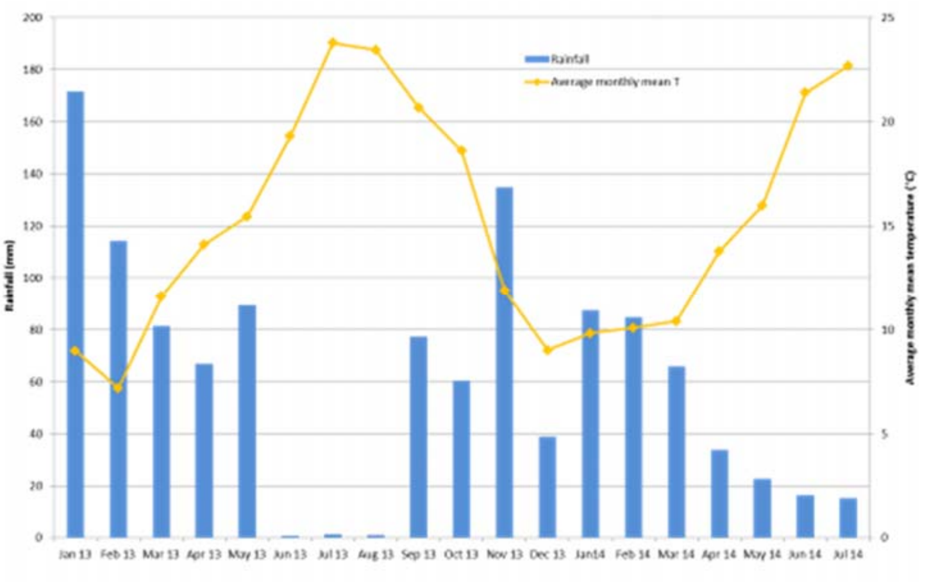


Figure 1 – CNR-ISPAAM. The weather pattern in the period January 2013 - August 2014.

Figure 2 - CNR-ISPAAM. Seedling establishment of *T. alexandrinum* (TA) intercropped with the conventional bioenergy species *A. donax* (AD) and *M. x giganteus* (MG) at two levels of nitrogen fertilization (N0= no fertilization and N80=80 kg of Nitrogen ha^{-1}).

Picture 1 – CNR-ISPAAM. Appearance of the pure stand of berseem clover, giant reed and giant silver reed intercropped with berseem clover at the end of summer 2014.

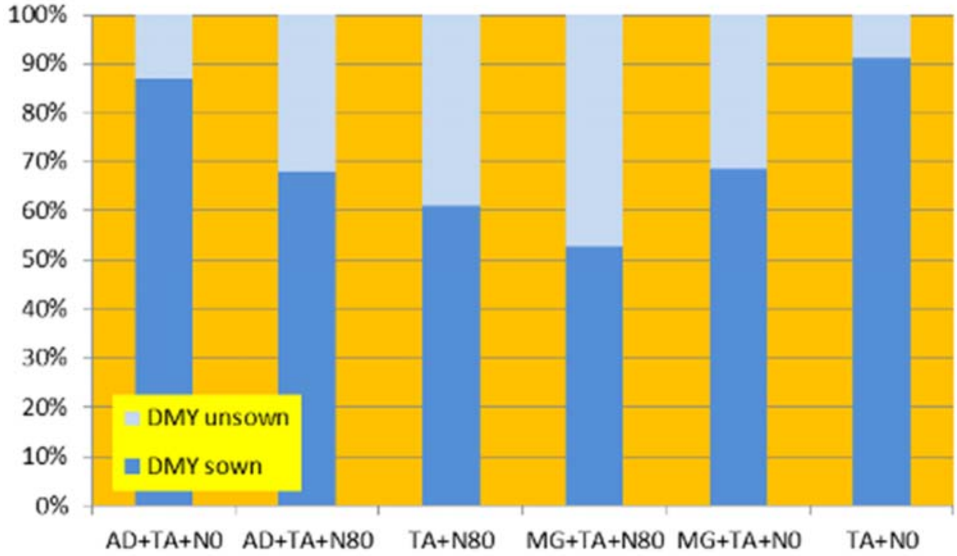


Figure 3 - CNR-ISPAAM. Rate of sown and unsown species in the DM for each treatment.

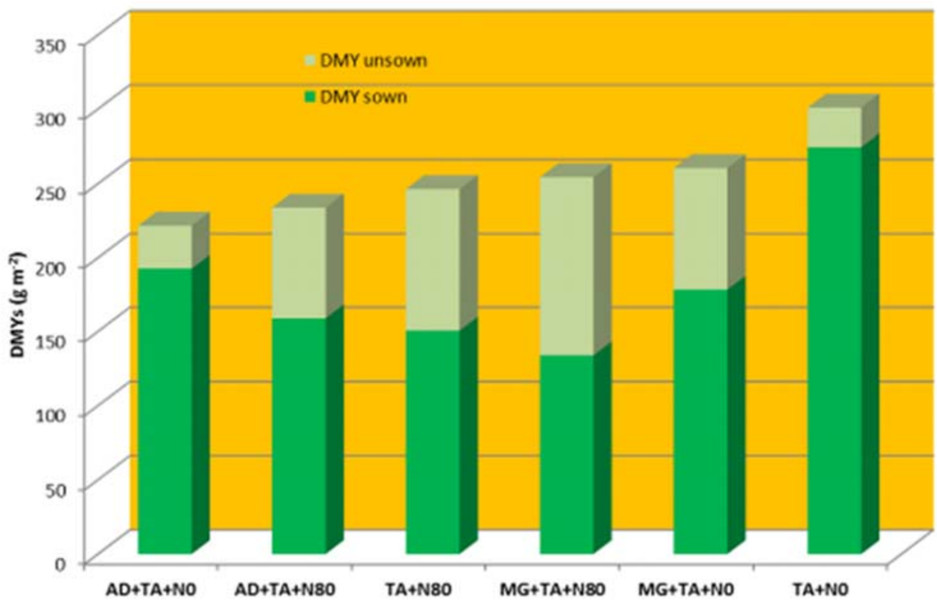


Figure 4 - CNR-ISPAAM. DMYs of *T. alexandrinum* and unsown species in different intercropped crops of bioenergy plants.

Indian Institute of Technology, Delhi – CRDT (n. 13)

(a)

(b)

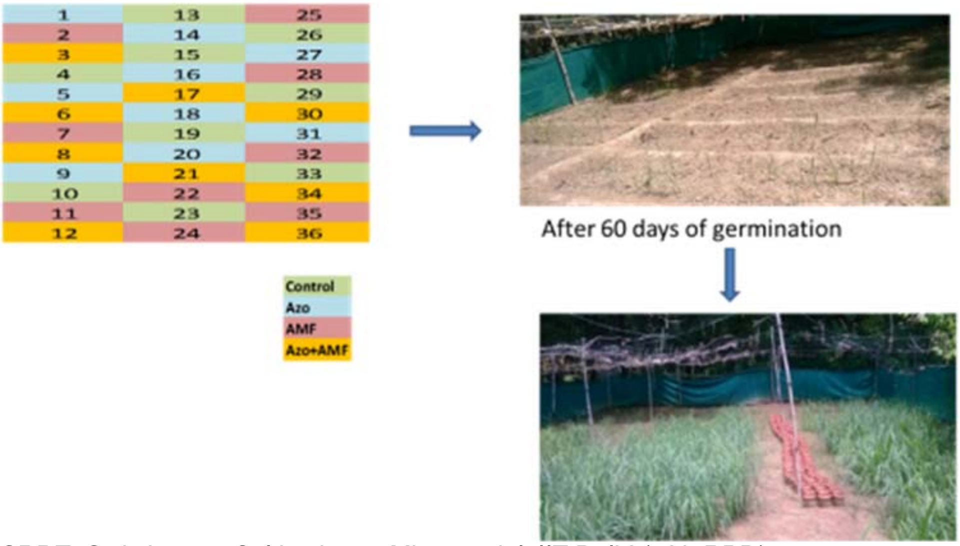
Picture 1 – CRDT. Germination of Switchgrass with a) Moist cotton treatment (after 12 days) b) with different seed treatment methods.

Table 1 - CRDT. Seed viability/germination (%)(at lab level in petri plates)

Methods Used	**No. of seeds germinated (No. of seeds tested = 25)**					
	1st Day	**4th day**	**8th Day**	**12th Day**	**15th Day**	**% Germination**
Moist blotting paper	0	0	0	1	9	**36**
Moist cotton	0	0	0	5	15	**60**
2% Water agar	0	0	0	2	7	**28**

Table 2 – CRDT. Germination % of seeds of *P. virgatum*

Treat-ments	**Hot water (80°C, 4 min)**	**Cold water (4min)**	**Cold water (over-night)**	**1% H_2SO_4 (5 min)**	**0.1% H_2SO_4 (5min)**	**10 ppm GA (5min)**	**Bioino-culants (*Azospirillum*)**	**Bioinocu-lants (AMF)**	**Bioinocu-lants (*Azospirillum*+AMF)**	**Control**
Germination %	10±0.5	6±0.7	36±0.7	9±0.5	15±1.0	54±0.5	58±1.0	59±1.1	61±0.9	60±1.0



Picture 2 – CRDT. Switchgrass Cultivation at Micromodel, IIT Delhi (with RBD)

Picture 3 – CRDT. Cultivation of Napier grass at Micromodel, IIT Delhi

Table 3 – CRDT. Fresh biomass yield (t/ha/year) of grasses and legume under silvipastoral models at Micromodel, IIT Delhi and Farmers land (Block Farrukhnagar)

Treatments	***C.setigerus (cc337)* (Dhaman grass)**		***C.setigerus (cc58)* (Dhaman grass)**		***P. pedicellatum* (Dinanath Grass)**		***P. maximum* (Guinae Grass)**	
	I Yr	**II Yr**	**I Yr**	**II Yr**	**I Yr**	**II Yr**	**I Yr**	**II Yr**
At Micromodel, IIT Delhi								
Control (T1)	28.96±1.1	28.5±0.9	25.63±1.1	25.1±1.5	23.7±0.16	20.1±0.7	27.54±1.1	27.1±1.0
Azospirillum (T2)	30.5±0.9	30.1±1.0	28.0±0.9	27.4±1.0	26.81±0.11	24.5±0.5	29.4±0.9	28.8±0.9
AMF (T3)	31.9±1.0	31.4±0.5	28.2±1.0	27.5±1.0	26.78±0.12	24.4±0.4	29.5±1.0	28.8±0.9
***Azospirillum*+AMF** (T4)	33.7± 1.1	33.3±1.0	32.0±1.5	31.6±1.0	28.35±0.07	26.1±1.0	33.1±2.0	32.9±1.0
At Vill. Farrukhnagar, Haryana								
Control (T1)	15.1±1.1	14.5±0.5	14.9±1.5	14.1±0.5	22.9.0±2.0	19.4±1.0	-	24.5±1.1
Azospirillum (T2)	16.1±1.5	15.7±0.5	15.93±0.5	15.5±0.3	25.11±1.25	23.1±1.1	-	26.2±1.0
AMF (T3)	15.8±0.7	15.1±0.4	15.4±0.5	14.9±0.4	25.18±1.1	23.3±0.9	-	26.3±1.0
***Azospirillum*+AMF** (T4)	18.2±1.7	17.8±0.4	17.7±0.8	17.2±0.6	27.20±1.18	25.4±1.0	-	30.0±1.0

***C. setigerus*:** 6 cuts in I year
I Year: Sowing - 14th April 2012; 1st Cut - 10th June 2012; 2nd Cut - 25th July 2012; 3rd cut - 17th August 2012; 4th cut – 25th September 2012; 5th cut – 10th November 2012; 6th cut – 13th March 2013
II year: 1st Cut - 28th May 2013; 2nd Cut – 3rd July 2013; 3rd cut - 10th August 2013; 4th cut – 12th September 2013; 5th cut – 31st Oct. 2013; 6th cut – 2nd March 2014

***P maximum*:** 4 cuts in I year
***I year*:** Sowing – 17th July 2012; 1st Cut - 10th Sept 2012; 2nd Cut – 10th Oct. 2012; 3rd cut – 13th Jan. 2013; 4th cut: 6th May 2013
II year: 1st Cut - 18th Aug. 2013; 2nd Cut – 28th Sept. 2013; 3rd cut – 26th Dec. 2013; 4th cut: 23rd Apr. 2014
-*P. maximum* seeds did not germinate at village Farrukhnagar in the first year. In II year, root slips of the grass were transplanted.

***P. pedicellatum*:** 2 cuts/year
I Year: Sowing – 17th July 2012; 1st Cut: 10th Sept. 2012; 2nd cut: 15th November 2012
II year: ; Sowing – 10th July 2013; 1st Cut: 14th Sept. 2013; 2nd cut: 20th November 2013

Table 4 – CRDT. Fresh biomass yield (t/ha/year) of legumes under silvipastoral models at Micromodel, IIT Delhi and at field level (Block Farrukhnagar, Haryana)

Treatments	***Trifolium alexandrinum* (Barseem)** **At Micromodel, IIT Delhi**		***Trifolium resupinatum* (Rijheka)** **On Farmer's field (Block Farrukhnagar)**
	I Year	***II Year***	***I Year***
Control	3.5±0.4	3.6±0.2	2.7±0.05
Rhizobium	4.1±0.2	4.5±0.4	3.1±0.2
AMF	4.3±0.2	4.8±0.4	3.2±0.3
***Rhizobium* +AMF**	4.9±0.09	5.1±0.5	3.7±0.1

Trifolium alexandrinum: I year: Sowing: 19th Jan.. 2013 (3 cuts till May 2013); ***II Year:*** Sowing: 25th Jan.. 2014 (3 cuts till May 2014)

Trifolium resupinatum: I year: Sowing: 24th Jan.. 2013 (3 cuts till May 2013);

Table 5 – CRDT. Effect of different biofertilizer treatments on survival % and growth parameters of tree sp. at Micromodel, IIT Delhi (after two years)

Treatments	Ber (*Z. mauritiana*)					Kinnow (*Citrus nobilis*)					Lemon (*C. limon*)				
	S %	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)		S%	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)		S %	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)	
		A	B	A	B		A	B	A	B		A	B	A	B
Control	62	19	73.4[a]	0.8	2.0[a]	54	17	65.7[a]	0.8	2.1[a]	50	19	68.3[a]	0.7	2.0[a]
AMF	73	18	96.7[b]	0.7	2.8[b]	69	16	90.4[b]	0.7	2.7[b]	57	17	85.4[b]	0.6	2.9[b]
Azotobacter	74	19	95.3[b]	0.7	2.7[b]	70	17	89.3[b]	0.7	2.7[b]	59	18	85.0[b]	0.7	2.8[b]
AMF + *Azotobacter*	76	18	109[c]	0.8	3.1[c]	73	17	103[c]	0.8	3.5[c]	60	18	99.5[c]	0.8	3.7[c]

same letter within each column indicates no significant difference among treatments ($p<0.05$) as determined by DMRT. value are means of $n = 4$. S: Survival; A: during transplantation (July, 2012); B: after two years, in July, 2014

Table 6 – CRDT. Effect of different biofertilizer treatments on survival % and growth parameters of tree sp. at Project site, Farrukhnagar, Haryana (after two years)

Treatments	**Ber (*Z. mauritiana*)**					**Kinnow (*Citrus nobilis*)**					**Lemon (*C. limon*)**				
	S %	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)		S %	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)		S %	Avg shoot length (cm)		Avg girth (cm) (30 cm above the ground)	
		A	B	A	B		A	B	A	B		A	B	A	B
Control	60	18	79.2^{a}	0.7	2.4^{a}	50	17	76.4^{a}	0.8	2.5^{a}	48	18	73.4^{a}	0.6	2.4^{a}
AMF	70	18	96.7^{b}	0.8	3.8^{b}	65	16	94.3^{b}	0.7	3.2^{b}	55	17	85.6^{b}	0.7	3.4^{b}
Azotobacter	72	19	96^{b}	0.8	3.6^{b}	70	16	93.1^{b}	0.7	3.0^{b}	57	17	85^{b}	0.8	3.2^{b}
AMF + *Azotobacter*	72	18	125^{c}	0.8	4.2^{c}	71	16	118^{c}	0.8	3.6^{c}	60	19	99.8^{c}	0.7	3.7^{c}

same letter within each column indicates no significant difference among treatments ($p<0.05$) as determined by DMRT. value are means of n = 4. S: Survival; A: during transplantation (July, 2012); B: after two years, in July, 2014

Table 7 – CRDT. Chlorophyll, fibre and mineral contents of *Cenchrus setigerus* (cc337) grass in response to biofertilizers in silvipastoral system (Micromodel, IIT Delhi and Farrukhnagar, Haryana) after two years (*I year: May 2012-May 2013; II Year: May 2013-May 2014*)

Parameters	Silvipastoral Model at Micromodel, IIT Delhi				Silvipastoral Model developed at Field (Vill. Farrukhnagar, Haryana)			
	Control	AMF	Az	AMF + Az	Control	AMF	Az	AMF + Az
Chlorophyll content								
Chl a (mg/g)	2.45±0.02	2.56±0.01	2.57±0.1	2.6±0.02	2.40±0.01	2.47±0.02	2.47±0.02	2.56±0.01
Total Chl (mg/g)	2.9±0.04	3.0±0.02	3.01±0.2	3.11±0.02	2.8±0.02	2.95±0.02	2.98±0.03	3.08±0.01
Fibre content								
Cellulose(%)	35.4±0.2	37.2±0.2	35.6±0.2	36.4±0.2	33.8±0.33	34.6±0.3	34.2±0.4	34.9±0.1
ADF (%)	46.3±0.3	44.3±0.2	43.9±0.3	42.9±0.2	49.8±0.19	48.3±0.3	48.2±0.3	47.3±0.2
NDF (%)	58.2±0.2	54.6±0.3	54.2±0.4	50.2±0.	61.1±0.25	60.1±0.5	60.0±0.3	59.3±0.2
Mineral content								
N (%)	1.28±0.01	1.27±0.02	1.26±0.03	1.49±0.01	0.91±0.01	1.18±0.01	1.19±0.01	1.47±0.01
P (%)	0.5±0.04	0.61±0.01	0.54±0.02	0.67±0.02	0.45±0.02	0.48±0.02	0.47±0.02	0.56±0.01
K (%)	1.35±0.02	1.42±0.01	1.43±0.02	1.48±0.02	1.29±0.02	1.37±0.01	1.38±0.01	1.41±0.02
Ca (mg/Kg)	3.18±0.03	3.21±0.02	3.2±0.01	3.27±0.01	3.1±0.01	3.18±0.01	3.17±0.02	3.21±0.02
Mg (mg/Kg)	3.35±0.03	3.4±0.02	3.39±0.01	3.45±0.01	3.29±0.02	3.37±0.02	3.38±0.02	3.41±0.02

Table 8 - CRDT Chlorophyll, fibre and mineral contents of *Cenchrus setigerus* (cc58) grass in response to biofertilizers in silvipastoral system (Micromodel, IIT Delhi and Farrukhnagar, Haryana) after two years (*I year: May 2012-May 2013; II Year: May 2013-May 2014*)

Parameters	Silvipastoral Model at Micromodel, IIT Delhi				Silvipastoral Model developed at Field (Vill. Farrukhnagar, Haryana)			
	Control	AMF	Az	AMF + Az	Control	AMF	Az	AMF + Az
Chlorophyll content								
Chl a (mg/g)	2.65±0.02	2.69±0.02	2.7±0.02	2.75±0.03	2.59±0.03	2.61±0.03	2.62±0.04	2.67±0.02
Total Chl (mg/g)	3.1±0.02	3.14±0.02	3.15±0.01	3.19±0.02	3.0±0.02	3.08±0.03	3.08±0.04	3.12±0.03
Fibre content								
Cellulose(%)	36.8±0.1	37.7±0.2	37.6±0.1	38.1±0.2	34.9±0.3	35.8±0.4	35.8±0.3	36.9±0.4
ADF (%)	47.1±0.2	46.4±0.2	46.1±0.3	45.0±0.1	50.1±0.4	49.1±0.5	49.7±0.2	48.0±0.5
NDF (%)	59.2±0.1	55.3±0.2	54.9±0.2	51.4±0.2	62.1±0.5	59.2±0.4	59.9±0.2	58.1±0.5
Mineral content								
N (%)	1.26±0.03	1.28±0.02	1.29±0.02	1.45±0.02	1.07±0.01	1.18±0.02	1.2±0.03	1.3±0.04
P (%)	0.5±0.02	0.62±0.01	0.62±0.02	0.69±0.03	0.47±0.02	0.52±0.02	0.52±0.03	0.58±0.03
K (%)	1.38±0.01	1.46±0.01	1.47±0.01	1.5±0.03	1.29±0.01	1.35±0.02	1.36±0.02	1.41±0.02
Ca	3.2±0.02	3.26±0.0	3.26±0.0	3.31±0.0	3.09±0.0	3.14±0.0	3.15±0.0	3.2±0.02

(mg/Kg)		3	1	2	2	3	2	
Mg (mg/Kg)	3.41±0.02	3.47±0.02	3.48±0.02	3.52±0.02	3.31±0.02	3.39±0.03	3.4±0.01	3.42±0.01

Table 9 – CRDT. Chlorophyll, fibre and mineral contents of *P. maximum* grass in response to biofertilizers in silvipastoral system (Micromodel, IIT Delhi and Farrukhnagar, Haryana) after two years (*I year: May 2012-May 2013; II Year: May 2013-May 2014*)

Parameters	Silvipastoral Model at Micromodel, IIT Delhi				Silvipastoral Model developed at Field (Vill. Farrukhnagar, Haryana)			
	Control	AMF	Az	AMF + Az	Control	AMF	Az	AMF + Az
Chlorophyll content								
Chl a (mg/g)	2.4±0.02	2.46±0.2	2.43±0.04	2.51±0.05	2.35±0.03	2.47±0.04	2.36±0.02	2.45±0.03
Total Chl (mg/g)	3.04±0.03	3.15±0.1	3.10±0.03	3.28±0.01	2.76±0.04	2.95±0.01	2.91±0.02	3.1±0.03
Fibre content								
Cellulose (%)	30.1±0.1	31.5±0.2	30.7±0.3	32.1±0.3	29.4±0.2	30.0±0.1	29.8±0.2	30.26±0.1
ADF (%)	34.3±0.1	33.6±0.1	33.3±0.3	32.7±0.1	35.3±0.3	34.6±0.3	34.6±0.3	34.2±0.2
NDF (%)	62.5±0.2	60.9±0.3	60.6±0.2	59.6±0.2	63.2±0.3	62.5±0.4	62.4±0.2	62.4±0.4
Mineral content								
N (%)	1.72±0.02	1.79±0.02	1.85±0.01	2.4±0.02	1.6±0.01	1.72±0.03	1.8±0.01	2.2±0.04
P (%)	0.57±0.03	0.67±0.03	0.62±0.01	0.71±0.02	0.49±0.02	0.54±0.02	0.52±0.03	0.61±0.03
K (%)	1.38±0.03	1.45±0.01	1.45±0.02	1.5±0.03	1.31±0.01	1.37±0.01	1.35±0.03	1.39±0.03
Ca (mg/Kg)	3.43±0.02	3.48±0.02	3.52±0.01	3.6±0.03	3.36±0.01	3.38±0.01	3.37±0.01	3.42±0.01
Mg (mg/Kg)	3.54±0.02	3.6±0.01	3.61±0.01	3.65±0.01	3.47±0.01	3.52±0.01	3.5±0.01	3.57±0.01

Table 10 – CRDT. Chlorophyll, fibre and mineral contents of *P. pedicillatum* grass in response to biofertilizers in silvipastoral system (Micromodel, IIT Delhi and Farrukhnagar, Haryana) after two years (*I year: May 2012-May 2013; II Year: May 2013-May 2014*)

Parameters	Silvipastoral Model at Micromodel, IIT Delhi				Silvipastoral Model developed at Field (Vill. Farrukhnagar, Haryana)			
	Control	AMF	Az	AMF + Az	Control	AMF	Az	AMF + Az
Chlorophyll content								
Chl a (mg/g)	2.7±0.03	2.78±0.01	2.72±0.04	2.85±0.03	2.55±0.03	2.62±0.01	2.61±0.02	2.71±0.03
Total Chl (mg/g)	3.18±0.02	3.31±0.02	3.26±0.02	3.38±0.01	3.08±0.03	3.11±0.01	3.1±0.02	3.17±0.03

Fibre content								
Cellulose(%)	32.15±0.3	32.9±0.1	32.56±0.2	33.2±0.1	31.2±0.2	32.12±0.3	31.89±0.3	32.7±0.2
ADF (%)	41.2±0.2	37.2±0.2	38.3±0.3	36.3±0.2	43.2±0.2	41.1±0.2	41.2±0.2	40.2±0.1
NDF (%)	55.7±0.3	54.2±0.3	54.2±0.1	52.2±0.2	56.3±0.1	55.9±0.25	56.2±0.2	55.2±0.1
Mineral content								
N (%)	0.8±0.01	1.11±0.01	1.28±0.02	1.57±0.03	0.74±0.04	1.02±0.02	1.18±0.04	1.49±0.03
P (%)	0.41±0.03	0.47±0.02	0.48±0.02	0.54±003	0.36±0.02	0.35±0.03	0.4±0.03	0.5±0.04
K (%)	1.09±0.04	1.1±0.02	1.11±0.01	1.17±0.02	0.97±0.01	1.08±002	1.1±0.03	1.16±0.03
Ca (mg/Kg)	3.08±0.01	3.11±0.01	3.1±0.01	3.18±0.02	2.98±0.02	3.08±0.02	3.07±0.01	3.16±0.02
Mg (mg/Kg)	3.21±0.01	3.27±0.01	3.26±0.02	3.3±0.01	3.1±0.02	3.19±0.02	3.19±0.01	3.22±0.02

Table 11 - CRDT. Chlorophyll, fibre and mineral contents of *P. virgatum* grass in response to biofertilizers at Micromodel, IIT Delhi

Parameters	**Silvipastoral Model at Micromodel, IIT Delhi**			
	Control	**AMF**	**Az**	**AMF + Az**
Chlorophyll content				
Chl a (mg/g)	2.8±0.4	2.95±0.3	2.97±0.25	3.01±0.2
Total Chl (mg/g)	3.32±0.35	3.4±0.2	3.43±0.4	3.5±0.1
Fibre content				
Cellulose(%)	36.5±0.29	37.9±0.15	37.56±0.21	38.1±0.1
ADF (%)	43.14±0.18	41.78±0.24	41.9±0.34	38.7±0.2
NDF (%)	76.7±0.35	72.3±0.31	73.5±0.11	68.6±0.1
Mineral Content				
N (%)	0.46±0.02	0.54±0.02	0.6±0.01	0.7±0.02
P (%)	0.57±0.04	0.67±0.01	0.61±0.02	0.74±003
K (%)	1.5±0.03	1.75±0.01	1.9±0.02	2.01±0.02
Ca (mg/Kg)	6922±0.02	7144±0.02	7168±0.01	8010±0.01
Mg (mg/Kg)	2626±0.02	2658±0.01	2670±0.01	2695±0.01

Table 12 – CRDT. Pre analysis of soil from project site (different villages) and Micromodel IIT Delhi

Sites (Villages)	**EC (mmhos/cm)**	**pH**	**N (Kg/ha)**	**P (Kg/ha)**	**K (Kg/ha)**	**C%**
Kheda	2.1±0.5	8.5±0.3	320±2.1	5.5±0.02	253±3.1	0.34±0.01
Bawda	1.9±0.6	8.7±0.3	318±1.6	6.1±0.01	256±2.4	0.41±0.01
Patli	1.9±0.5	8.3±0.2	310±2.0	6.0±0.01	241±2.0	0.36±0.02
Jodala	2.2±0.4	8.5±0.3	291±1.1	6.3±0.03	210±1.5	0.33±0.03
MicroModel, IITD	0.15±0.1	7.0±0.2	123±1.2	8.9±0.04	239±1.5	0.51±0.02

Table 13. CRDT. Comparative microbial analysis of soil of Micromodel, IIT Delhi and selected villages at project site, Block Farrukhnagar, Haryana (pre analysis)

Site (villages)	*Azotobacter* (CFU, log10)	*Azospirillum* (CFU, log10)	AMF (spores/g)
Kheda	3.1±0.2	3.0±0.1	14±0.4
Bawda	3.3±0.1	3.3±0.1	13±0.4
Patli	3.1±0.1	3.1±0.1	13±0.5
Jodala	2.9±0.2	3.4±0.2	12±0.3
Micromodel, IITD	11.0±1.1	9±0.2	35±1.1

Table 14 – CRDT. Post analysis of soil from project site (different villages) and Micromodel IIT Delhi

Sites (Villages)	EC (mmhos/cm)	pH	N (Kg/ha)	P (Kg/ha)	K (Kg/ha)	C%
Farrukhnagar**	2.24±0.02	8.4±0.1	326±2.1	6.57±0.5	269±1.5	0.43±0.01
Mubarikpur**	2.2±0.03	8.1±0.1	310±2.1	6.11±0.6	256±2.0	0.4±0.01
Mevka**	2.22±0.02	8.0±0.2	325±1.5	6.4±0.4	272±2.2	0.5±0.02
Dooma**	3.12±0.02	8.8±0.2	253±1.3	5.4±0.4	193± 2.5	0.37±0.02
Kheda*	2.0±0.6	8.4±0.3	326±1.6	6.2±0.01	259±2.4	0.43±0.01
Bawda*	2.0±0.5	8.0±0.2	318±2.0	6.09±0.01	245±2.0	0.38±0.02
Patli*	2.11±0.4	8.1±0.3	300±1.1	6.38±0.03	213±1.5	0.35±0.03
MicroModel, IITD**	0.67±0.01	7.0±0.1	142±1.5	9.0±0.7	248±2.1	0.57±0.02

***after one year**
****after two year**

Table 15 – CRDT. Comparative microbial analysis of soil of Micromodel, IIT Delhi and selected villages at project site, Block Farrukhnagar, Haryana (after one year)

Site (villages)	*Azotobacter* (CFU log10)	*Azospirillum* (CFU log10)	AMF (spores/g)
Farrukhnagar**	6.0±0.4	8.1±0.5	23±0.5
Mubarikpur**	4.9 ±0.5	7.9±0.5	27±0.6
Dooma**	3.0±0.2	3.1±0.2	16±0.5
Mevka**	7.0 ±0.2	8.2±0.5	29±1.5
Kheda*	5.5±0.4	7.7±0.5	19±0.5
Bawda*	4.4 ±0.5	7.2±0.5	20±0.6
Patli*	2.8±0.2	2.64±0.2	13±0.5
Micromodel, IITD**	11.5±0.8	10.4±0.6	45±1.7

***after one year**
****after two year**

Annexure I - CRDT

Training Programs Conducted this year

1	28th Oct 2013	Conducted a **Training Programme** on the benefits of High Yielding Fodder grasses and fodder conservation	40
2	16th Dec. 2013	**Motivation programme** for villagers (Vill. Jodala and Patli) to use biofertilizers and utilizing their marginal lands for fodder grass cultivation	20
3	28th Jan. 2014	**Taining programme** on fodder gass cultivation and use of biofertilizers (Vill. Patli)	30
4	10th March 2014	Meeting Sarpanch, MNREGA motivators and villagers to discuss about sustainability of the project activities and dissemination of the technology to the other villages.	-
5	10th July 2014	**Taining programme** on Hay and Silage formation at Farrukhnagar	15
6	24th July. 2014	**Taining programme** on Silage formation at Vill. Farrukhnagar	30
7	29th Aug. 2014	**Taining programme** on Silage formation at Vill. Jodala	50
8	9th Sept. 2014	**Taining programme** on Silage formation at Vill. Mubarikpur	10

Glimpses of some training and interaction programmes with farmers:

(A) **(B)**

(A) & (B) Visit to Farmer's Field at Vill. Mubarikpur

C) Silage Making Training Programme

D) Awareness generation cum training at Vill. Farrukhnagar programme on Hay and Silage

E) Meeting with Village Sarpanch and MNREGA Activators

Annexure II - CRDT

Quantity and Type of Grass provided to the Farmers this year (2013-2014)

S. No	Name of beneficiary	Village	Seeds provided	Quantity
1	Gopal	---- do----	*P. maximum* Napier grass	100 root slips each
2	Kudia Ram	---- do----	*P. maximum* Napier grass	100 root slips each
3	Lali Devi	---- do----	*P. maximum* Napier grass	100 root slips each
4	Tarachand Yadav	Joniawas	*P. maximum* Napier grass	100 root slips each
5	Dharmapal Singh	Musedpur	*P. maximum* Napier grass	100 root slips each
6	Roop Chand	Musedpur	*P. maximum* Napier grass	100 root slips each
7	Man Singh, Chairman, Kisan club	Dawoda	Para grass Karnal grass	100 root slips each
8	Santosh devi	---- do----	*P. maximum, P. pedicillatum*	0.2 Kg each
9	Mukesh	---- do----	*P. maximum, P. pedicillatum*	0.2 Kg each
10	Hans Raj	---- do----	*P. maximum, P. pedicillatum*	0.2 Kg each
11	Fatehsingh	---- do----	*P. maximum* Napier grass	100 root slips each

Annexure III - CRDT
Grass seeds distribution

S.No	Village	No. Of farmers involved	Types pf grass seed distributed	Yield obtained (ton/ha/year)	pH	
					A	B
1	**Mubarikpur**	7	Gunnia grass	24-28	8.7	8.1
			Cenchrus	12-20		
			Dinanath	15-24		
2	**Meoka**	5	Gunnia grass	25-30	8.5	8.0
			Cenchrus	17-20		
			Dinanath	22-27		
			Napier bajra	30-35		
3	**Dooma**	6	Gunnia grass	**Not established**	9.0	8.8
			Cenchrus	**---do---**		
			Dinanath	**---do---**		
			Napier bajra	**---do---**		
			Para grass	4-5		
			Karnal grass	**Not established**		
4	**Farrukhnagar**	5	Cenchrus	15-18	9.0	8.4
			Gunnia grass	24-29		
			Dinanath	18-25		
			Para grass	**Not established**		
			Karnal grass	**---do---**		
5	**Patli**	8	Gunnia grass	15-19	8.5	8.1
			Cenchrus	10-15		
			Dinanath	12-17		
			Napier bajra	20-30		
6	**Kheda**	3	Gunnia grass	16-20	9.0	8.4
			Dinanath	**Not established**		
			Para grass	**---do---**		
			Karnal grass	**---do---**		
			Napier grass	20-27		
7	**Dawoda**	1	Para grass	**Not established**	8.9	8.4
			Karnal grass	**---do--**		
			Napier grass	20-30		
8	**Bawda**	4	Gunnia grass	22-25	8.6	8.1
			Dinanath	**---do---**		
			Napier grass	19-24		
9	**Jadola**	5	Gunnia grass	18-25	8.6	
			Napier Grass	20-29		
10	**Musedpur**	2	Gunnia grass	19-24	8.4	
			Napier Grass	21-30		
11	**Joniawas**	1	Gunnia grass	18-25	8.3	
			Napier Grass	20-287		

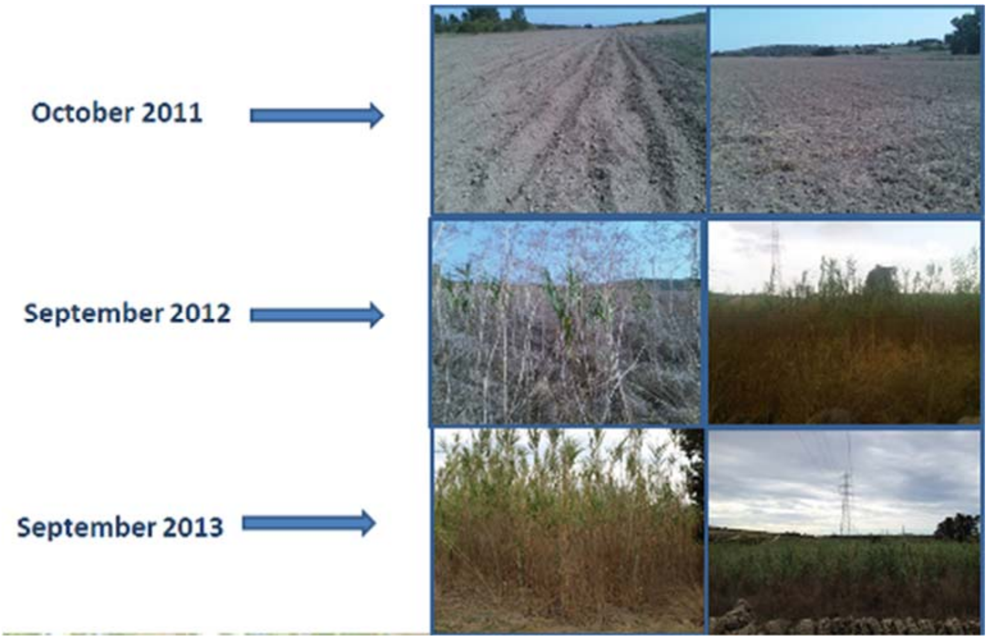
A: Before sowing the grass
B: After one year of grass establishment

- **pH of Vill. Jadola, Musedpur and Joniawas will be given after the completion of one year of grass establishment in these villages**

Task 4.2 Productivity in marginal large fields

University of Catania – UNICT (n. 1)

Picture 1 - UNICT. Experimental field location in Sicily, Italy. In the red marked circle in the middle of Sicily, 320 m^2 plot is shown, while in the South-East side the 5 ha field.



Picture 2 - UNICT. From field bed preparation (autumn 2011) up to last harvest time (February 2014).

Table 1 - UNICT. Biometric and productive measurements of 5 ha giant reed plantation (first harvest, February 2013)

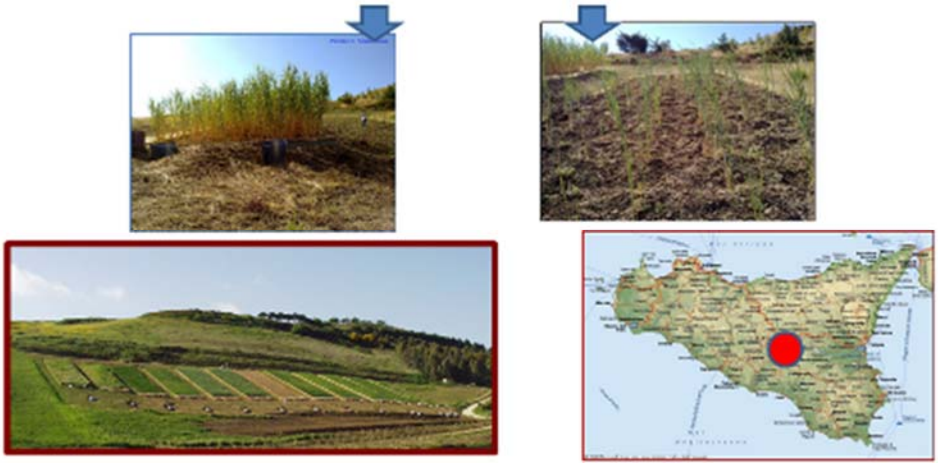
Measurement	Unit	value
# of emerged plants	m^2	4
uniformity after transplant	visual score	medium
height of stems	cm	173
Dry stems	%	68
Dry leaves	%	32
Aboveground dry biomass yield	t ha^{-1}	1.8

Table 2 - UNICT. Biometric and productive measurements of 5 ha giant reed plantation (second harvest, February 2014)

Measurement	Unit	value
# of emerged plants	m^2	15.3±4.1
uniformity after transplant	visual score	Medium-high
height of stems	cm	198.4±79.1
Dry stems	%	84.1±13.3
Dry leaves	%	12.1±9.1
Aboveground dry biomass yield	t ha^{-1}	8.4±2.1

Table 3 - UNICT. Biometric and productive measurements of 5 ha giant reed plantation (third harvest, February 2015).

Measurement	Unit	Value
# of emerged plants	m^2	19.7±4.3
uniformity after transplant	visual score	Medium-high
height of stems	Cm	223.5±82.1
Dry stems	%	85.1±12.3
Dry leaves	%	13.1±8.7
Aboveground dry biomass yield	t ha^{-1}	12.1±2.9



Picture 3 - UNICT. Plots of 320 m^2 each in the Center of Sicily (550 m a.s.l, 37° 21'N, 14°16'E). Up on the right giant reed (*Arundo donax*), up on the left *Saccharum spontaneum*.

Table 2 – UNICT. Biometric and productive characters of giant reed and *Saccharum spontaneum* after the harvest of 2013.

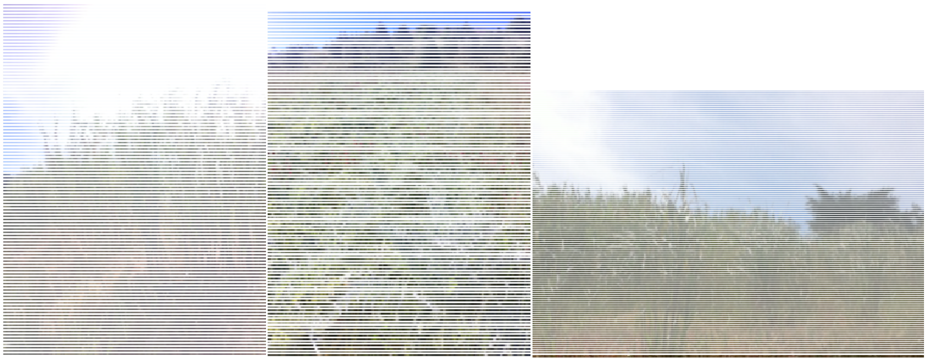
	Measurement unit	*Arundo*	*Saccharum*
Stem numbers	n.	7.2±1.0	1.9±1.1
Weigth of 1 stem	g	261.6±45.0	62.2±14.4
Basal stem diameter	mm	18.1±1.2	9.4±0.3
Plant height	cm	237.0±27.7	91.3±11.4
Stem fresh weigth	g	230.5±42.2	47.6±12.1
Leaf fresh weigth	g	31.1±2.8	14.6±2.4
Stem	%	87.7±1.5	74.9±2.4
Leaf	%	12.3±1.5	25.1±2.4
H2O stems	%	49.1±1.5	64.4±1.9
H2O leaves	%	18.8±0.9	42.3±6.1
Stems dry matter	%	50.9±1.5	35.6±1.9
Leaves dry matter	%	81.2±0.9	57.7±6.1
Fresh biomass yield	$t\ ha^{-1}$	16.3±1.6	0.8±0.4
Stems fresh biomas yield	$t\ ha^{-1}$	14.3±1.2	0.6±0.4
Leaves fresh biomas yield	$t\ ha^{-1}$	2.0±0.4	0.2±0.1
Stems dry biomass yield	$t\ ha^{-1}$	7.3±0.8	0.3±0.2
Leaves dry biomass yield	$t\ ha^{-1}$	1.6±0.3	0.1±0.1
Dry biomass yield	$t\ ha^{-1}$	8.9±1.0	0.4±0.2

Picture 4 - UNICT. *Miscanthus* establishment (left) and survived plant after drought stress (right).

Picture 5 - UNICT. Giant reed (left) cardoon (center) and saccharum (right) in the in a marginal area with 26-28% slope.

Table 3 – UNICT. Biometric and productive characters of giant reed and *Saccharum spontaneum* after the harvest of 2014.

	Measurement unit	*Arundo*	*Saccharum*
Stem numbers	n.	6.6±1.2	5.4±2.3
Weigth of 1 stem	g	201.8±89.8	65.0±31.6
Basal stem diameter	mm	18.7±3.6	8.2±2.3
Plant height	cm	223.2±38.2	94.1±26.4
Stem	%	87.1±4.0	79±5.1
Leaf	%	12.9±4.0	21±5.1
H2O stems	%	46.0±1.3	66.2±1.8
H2O leaves	%	26.6±14.2	45.7±3.6
Dry biomass yield	t ha^{-1}	7.6±1.3	1.3±0.3



Picture 6 - UNICT. Giant reed (left) cardoon (center) and saccharum (right) in the in a marginal area with 26-28% slope during last growing season.

Table 4 – UNICT. Morpho-biometric and productive characters of *Arundo donax*, *Saccharum spontaneum* and cardoon in the marginal slope field.

	Measurement unit	***Arundo donax***	***Saccharum spontaneum***	*Cynara cardunculus*
Plant height	Cm	223.2±38.2	94.1±26.4	98.6±11.4
Stems	%	87.1±4.0	79±5.1	36.8±3.2
Leaves	%	12.9±4.0	21±5.1	40.5±6.1
Heads	%			19.15±5.7
Hachenes	%			3.55±0.41
H_2O	%	45±2.7	53±3.2	9.3±1.3
Dry biomass yield	$t\ ha^{-1}$	8.1±1.5	4.3±1.1	5.7±0.9

± standard deviation of three determinations

Center for Renewable Energy Sources and Energy Saving – CRES (n. 3)

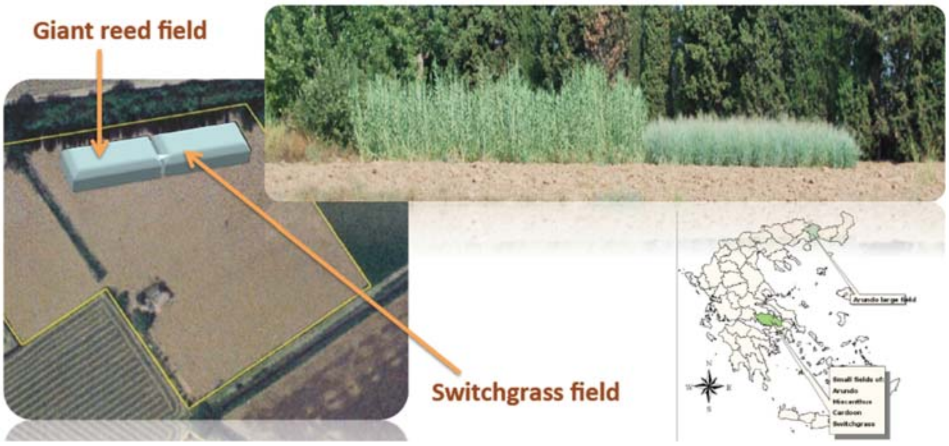


Figure 1 - CRES. Giant reed and switchgrass fields in Greece

Table 1 - CRES. Growth and productivity data of giant reed grown in non-irrigated and irrigated conditions for the first three growing periods

	Giant reed					
	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated
Harvesting date:	01.02.13	03.02.13	25.01.14	25.01.14	19.01.15	19.01.15
Plant height (cm)	391	414	400,00	506,00	540,00	616,00
Fresh matter (t ha^{-1})	15,4	17,4	45,00	60,00	40,50	45,50
Dry matter (t ha^{-1})	7,14	8,5	25,65	31,20	25,52	28,00
Moisture content (%)	53,64	51,15	43,00	48,00	36,99	38,46
Stem portion (% on f.m)	87,5	90	90,00	93,00	70,37	73,01
Stem portion (% on d.m)	80	84,8	86,0	90,0	59,6	61,4

Figure 2 – CRES. Giant reed grown in irrigated plots (on the left) and non-irrigated plots (on the right) (19.11.2013)

Table 2 - CRES. Growth and productivity data of switchgrass grown in non-irrigated and irrigated conditions for the first three growing periods.

	Switchgrass					
	Non-irrigated	**Irrigated**	**Non-irrigated**	**Irrigated**	**Non-irrigated**	**Irrigated**
Harvesting date:	**01.02.13**	**01.02.14**	**25.01.14**	**25.01.14**	**19.01.15**	**19.01.15**
Plant height (cm)	153	151	275	278	186,00	294,00
Fresh matter (t ha^{-1})	7,73	12,47	17,5	25	19,50	23,25
Dry matter (t ha^{-1})	4,95	7,63	12,95	20,25	15,19	17,90
Moisture content (%)	36,00	38,00	36,00	36,00	22,10	23,01
Stem portion (% on f.m)	68,7	70	68,7	68,7	72,87	82,37
Stem portion (% on d.m)	63,6	61	63,6	63,6	69,0	61,4

Figure 3 – CRES. Switchgrass grown in irrigated plots (on the left) and in marginal lands (on the right) (15.07.2013)

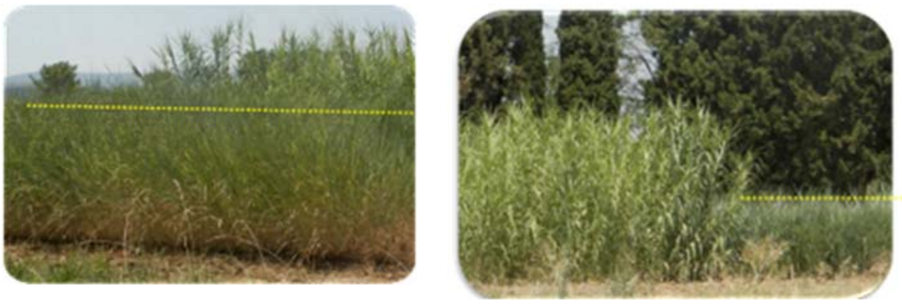


Figure 4 – CRES. Giant reed (on the left) and switchgrass (on the right) on marginal lands (15.07.2013)

Istituto per il Sistema Produzione Animale in Ambiente Mediterraneo – CNR-ISPAAM (n. 8)

Table 1 – CNR-ISPAAM. Plants, stalks and shoots m^{-2} and morphological traits. Plant height is the average height of main stalks. *=harvested in February 2014; **= harvested in August 2014.

Species	Initial No of plants (No m^{-2})	Plant height (cm)	No of stalks (No m^{-2})	No of nodes (No m^{-2})	Stalk diameter (mm)		
					Basal	Medium	Distal
*A. donax**	2	301	18	38.5	15.6	12.0	4.6
*M. x giganteus**	2	201	14	14.5	10.4	7.8	3.6

Table 2 – CNR-ISPAAM. Dry matter yield, dry matter partitioning among organs and dry matter content in giant reed, miscanthus and cardoon. *=harvested in February 2014; **= harvested in August 2014.

Species	Biomass yield		Biomass partitioning (% of plant DM)			Dry matter content (%)		
	DMY per plant (g)	DMY (t ha^{-1})	Leaves	Stems	Heads	Leaves	Stems	Heads
*A. donax**	142.7	24.6	21.5	78.5	-	66	42	-
*M. x giganteus**	-	8.9	31.5	68.4	0.1	73	43	76
*C. cardunculus***	2269.7	23.0	27.5	39.4	33.2	79.6	49.5	79.6

Picture 1 – CNR-ISPAAM. Appearance of *M. x giganteus* (dry plants) at the end of summer 2014 in comparison with *A. donax* and *C. cardunculus* var. *altilis*.

Table 3 – CNR-ISPAAM. Proximate and ultimate analysis of leaves, stalks and heads of *C. cardunculus* var. *altilis, A. donax and M. x giganteus*.

Plant component	Calorific value (MJ kg^{-1})	Volatile matter (%)	Fixed carbon (%)	Ash content (%)	C (%dw)	H (%dw)	N (%dw)	S (%dw)	O (%dw)
Leaves									
Cardoon	16.0	85.9	4.6	20.2	41.7	5.9	2.3	<0.3	48.4
Arundo	17.0	75.0	3.9	9.1	48.0	5.9	1.9	0.8	44.2
Miscanthus	16.0	73.0	1.7	9.5	49.0	6.3	2.7	<0.3	42.0
Stalks									
Cardoon	15.8	91.6	7.1	11.9	41.0	6.2	1.5	<0.3	49.2
Arundo	18.0	77.0	10.0	4.6	49.0	6.1	2.0	0.4	42.9
Miscanthus	17.0	77.0	3.6	6.0	50.0	6.3	1.7	<0.3	42.0
Heads									
Cardoon	17.8	93.5	12.0	9.2	44.5	6.7	2.5	<0.3	45.0

University of Bologna - UNIBO (n. 2)

Figure 1 - UNIBO. Switchgrass field in Ozzano dell'Emilia. (LEFT) November 2014, just after harvesting and bailing. (RIGHT) re-sprouting in April 2015.

Figure 2 - UNIBO. Spatial distribution of bales produced from the 2014 harvest of switchgrass in the Ozzano dell'Emilia field. (LEFT) Bailer tracking (lines) and bale positioning (violet points). (RIGHT) surface (m^2) from which each bail derived: the higher the surface the lower the productivity of switchgrass on that area.

Figure 3 - UNIBO. Pictures of hilly field in Ozzano during harvesting in October 2015.

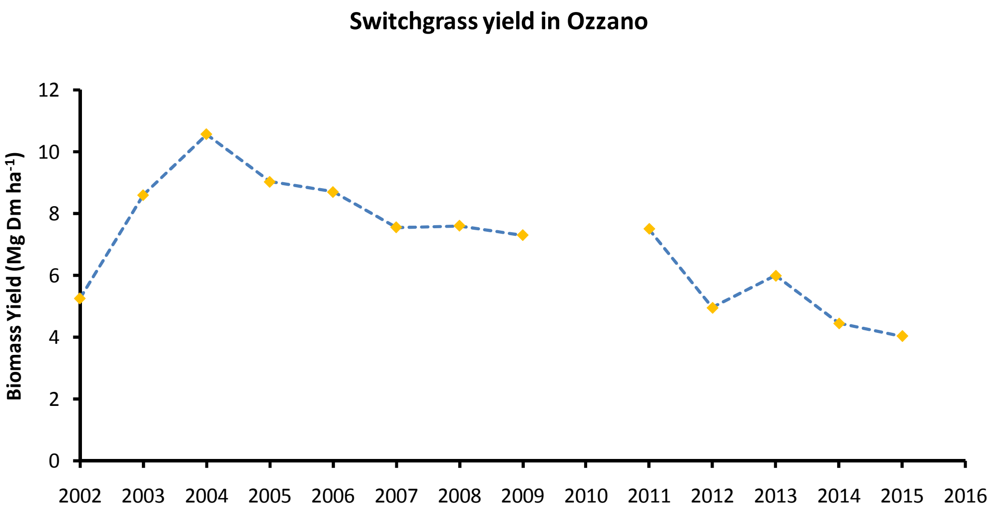


Figure 4 - UNIBO. Time course (2002-2015) of switchgrass biomass yield (Mg DM ha^{-1}) in the 5-ha field located in Ozzano dell'Emilia (Bologna). Data for 2010 are missing because adverse environmental conditions did not allow to harvest.

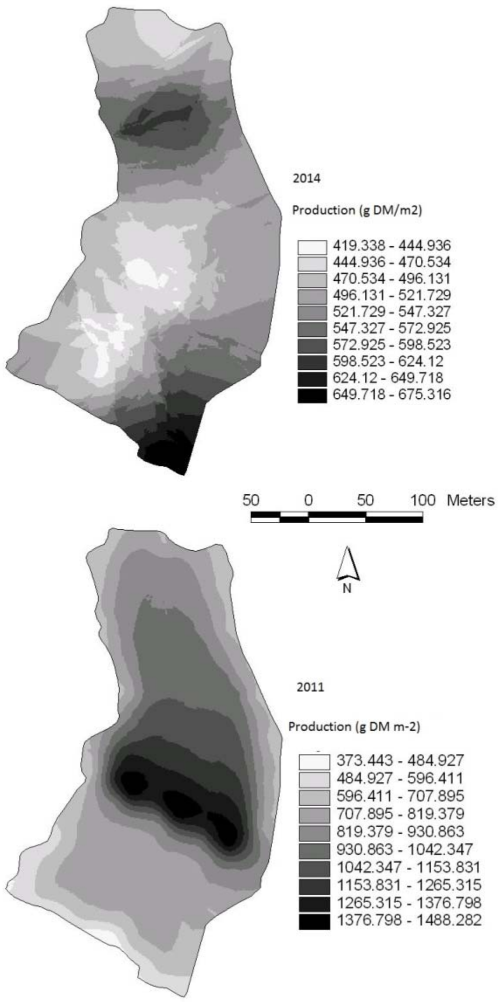


Figure 5 - UNIBO. Spatial distribution of switchgrass yield (g DM m^{-2}). Above map referred to 2014 harvest; bottom map referred to 2011 harvest.

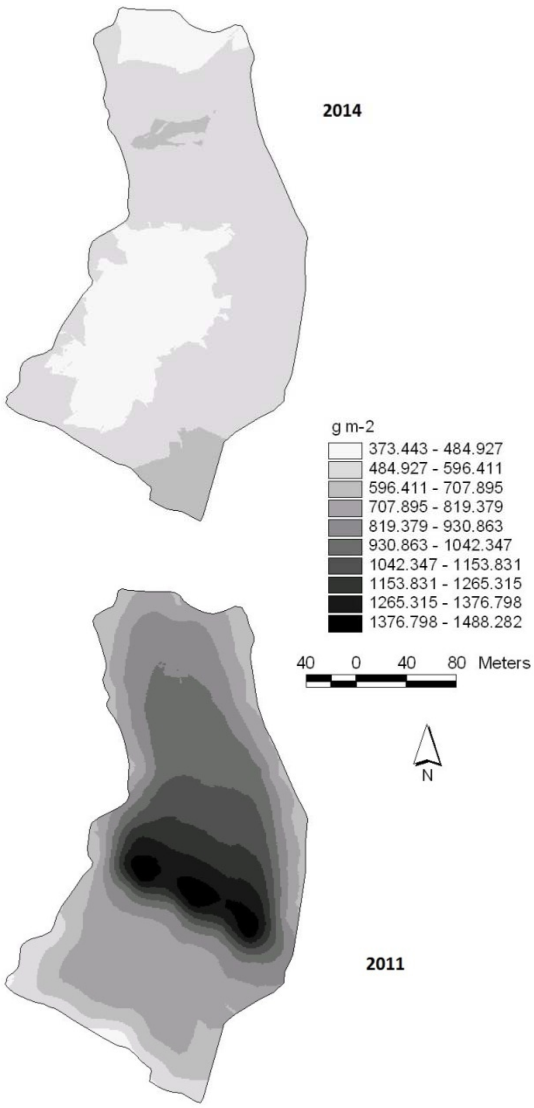
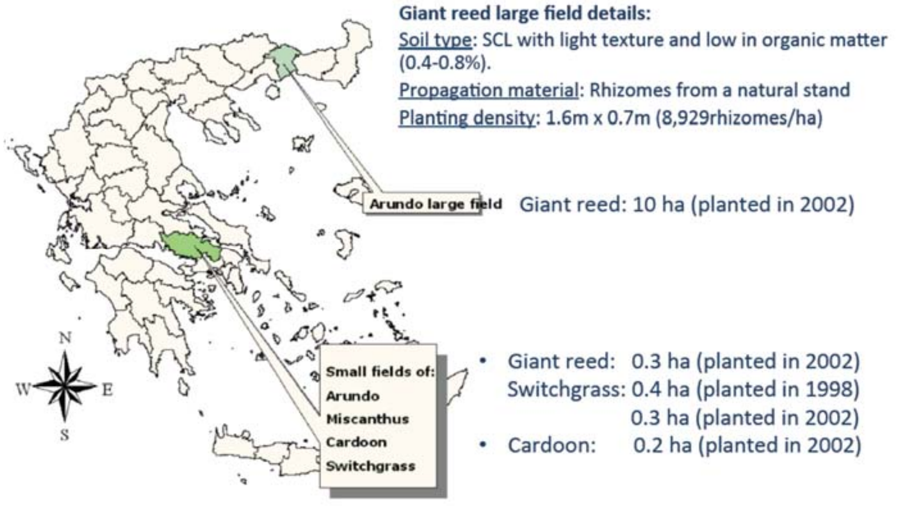


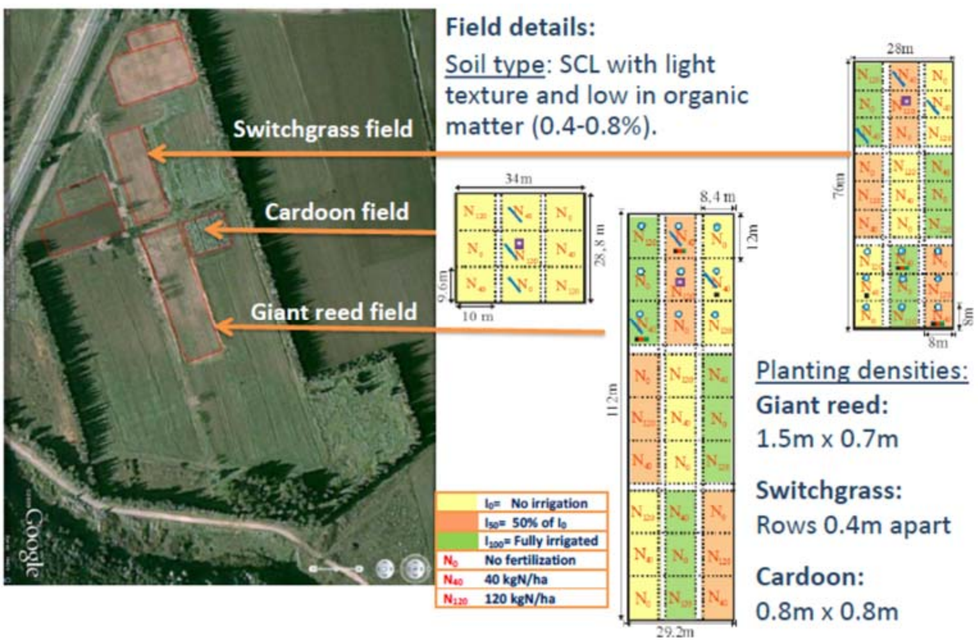
Figure 6 - UNIBO. Spatial distribution of switchgrass yield (g DM m^{-2}) derived from harvest of 2014 (top map) and 2011 (bottom map) adopting the same scale.

Task 4.3 Long term productivity of existing large-scale plantation

Center for Renewable Energy Sources and Energy Saving – CRES (n. 3)



Picture 1 - CRES. Large and small fields of perennial crops established in North and Central Greece.



Picture 2 - CRES. The experimental fields of cardoon, giant reed and switchgrass

Picture 3 - CRES. Panoramic view of the small fields

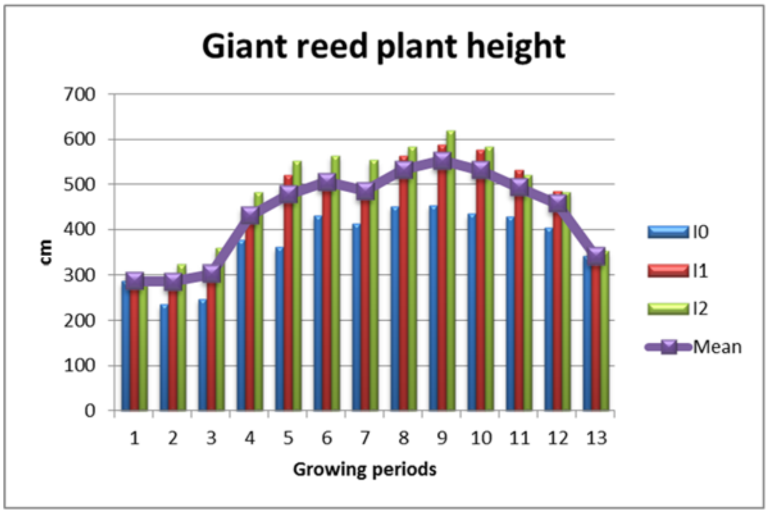


Figure 1 - CRES. Plant height for giant reed for three irrigation rates during 13 growing periods

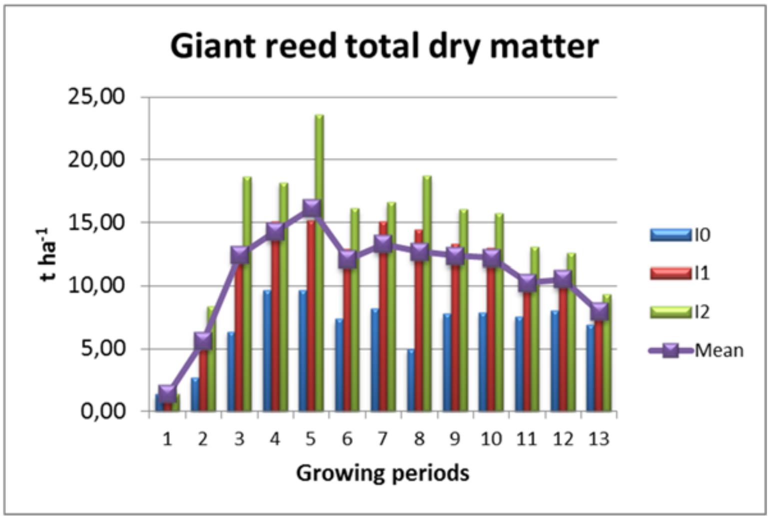


Figure 2 - CRES. Total dry matter yields for giant reed for three irrigation rates during 13 growing periods

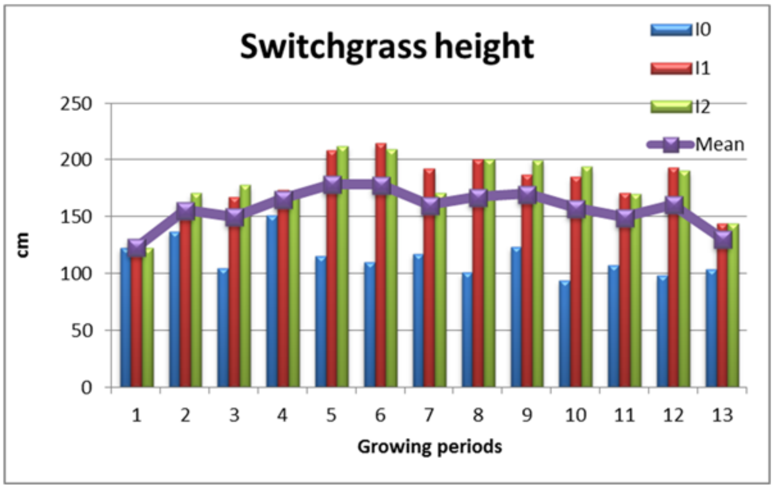


Figure 3 – CRES. Plant height for giant reed for three irrigation rates during 13 growing periods

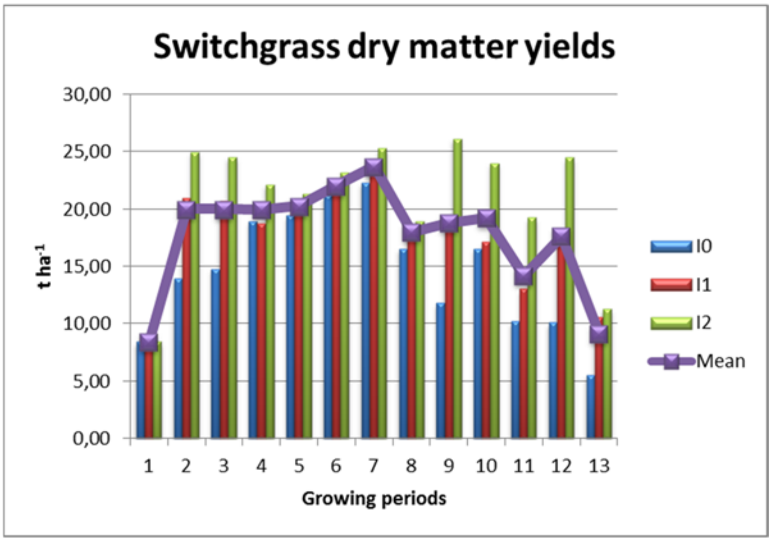


Figure 4 - CRES. Total dry matter yields for switchgrass for three irrigation rates during 12 growing periods

Università di Catania – UNICT (n. 1)

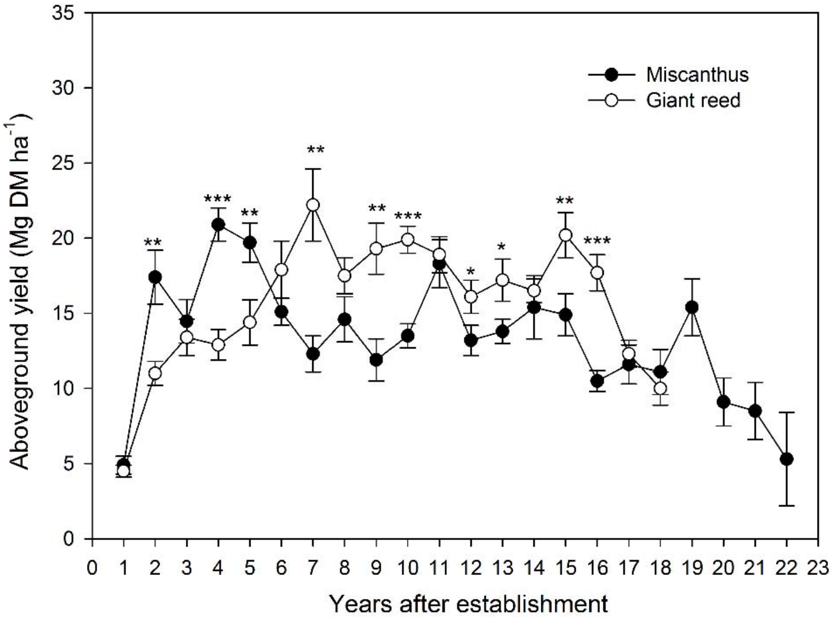


Figure 1 - UNICT. Long term side-by-side biomass yield of *Miscanthus* x *giganteus* and giant reed (*Arundo donax*) at Experimental farm of UNICT (Catania plain, 10 m a.s.l., 37°27' N, 15° 03' E).

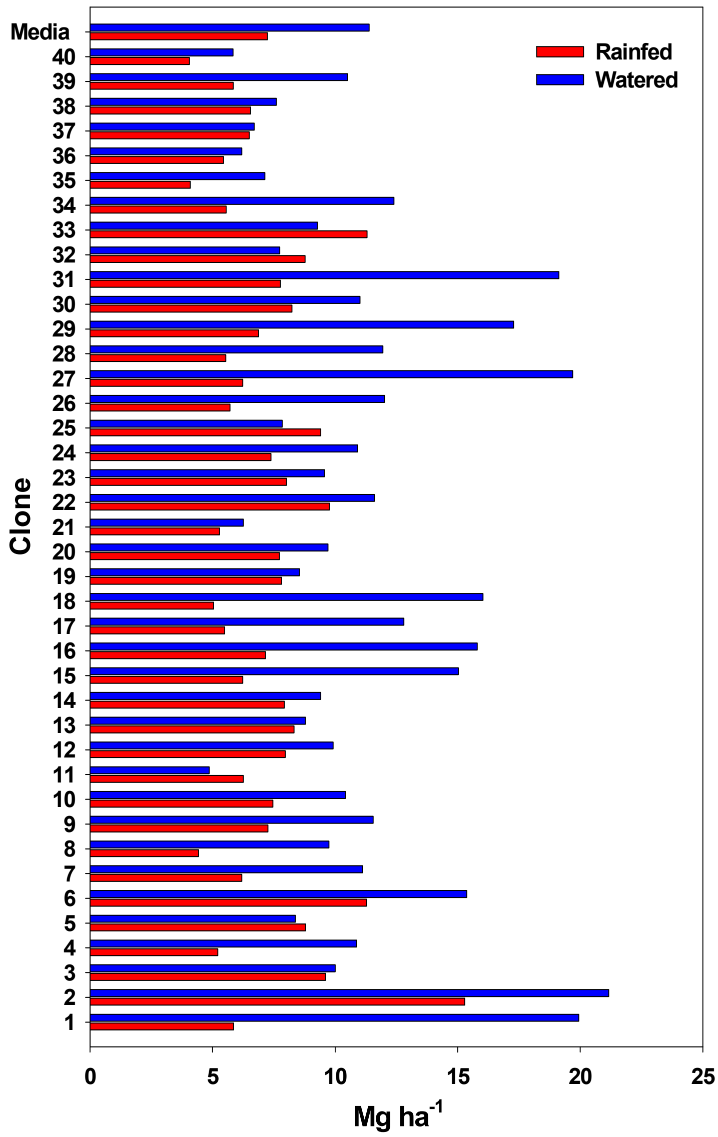


Figure 2 - UNICT. Aboveground biomass yield (Mg DM ha^{-1}) of Arundo donax clones in rainfed (I_0) and 100% ETm restitution conditions (I_{100}) in semi-arid Mediterranean environment.

University of Bologna - UNIBO (n. 2)

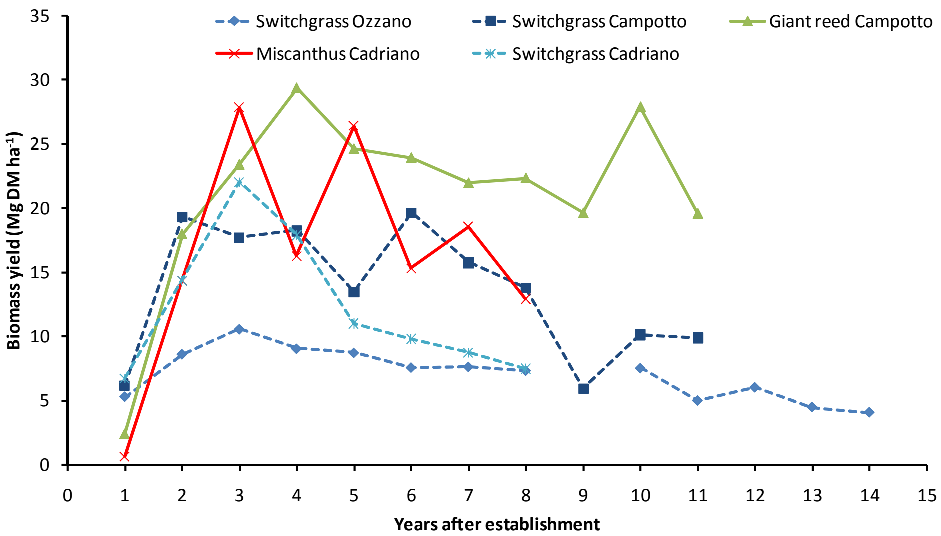


Figure 1 - UNIBO. Long term productivities of switchgrass, miscanthus and giant reed grown in different locations by UNIBO. Doted lines refer to switchgrass grown in different sites.

Universidad Politecnica De Madrid – UPM (n. 5)

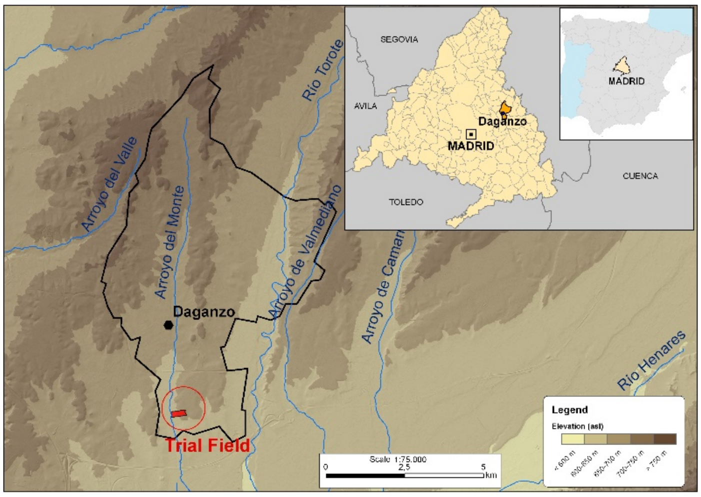


Figure 1 - UPM. Location map of the cynara crop under study (Daganzo, Spain).

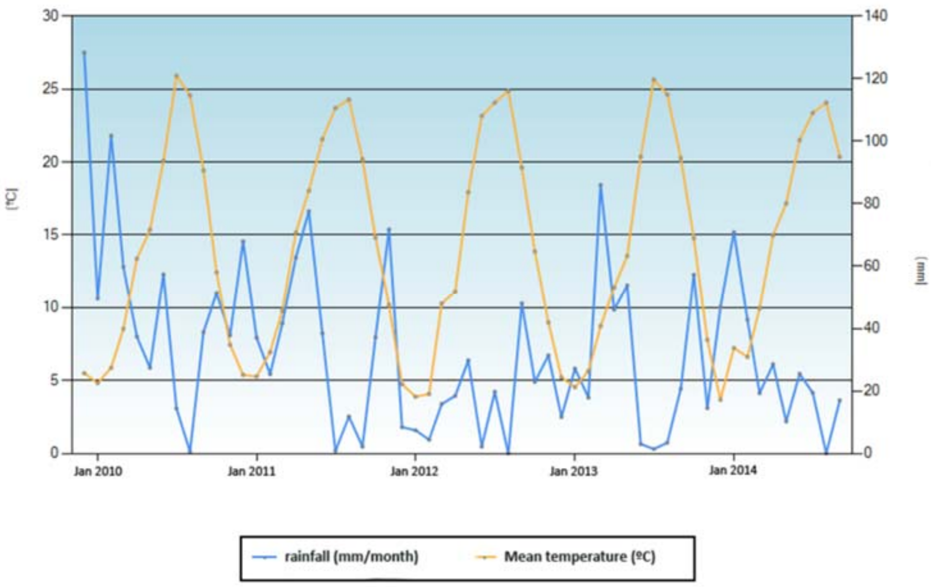


Figure 2 - UPM. Mean monthly temperature and monthy precipitation during the experiment. Records from the Meteorological Station located at (UTM) 30N 457867,4473610; 604 m a.s.l. Source: Ministry of Agriculture, Food and Environment of Spain.

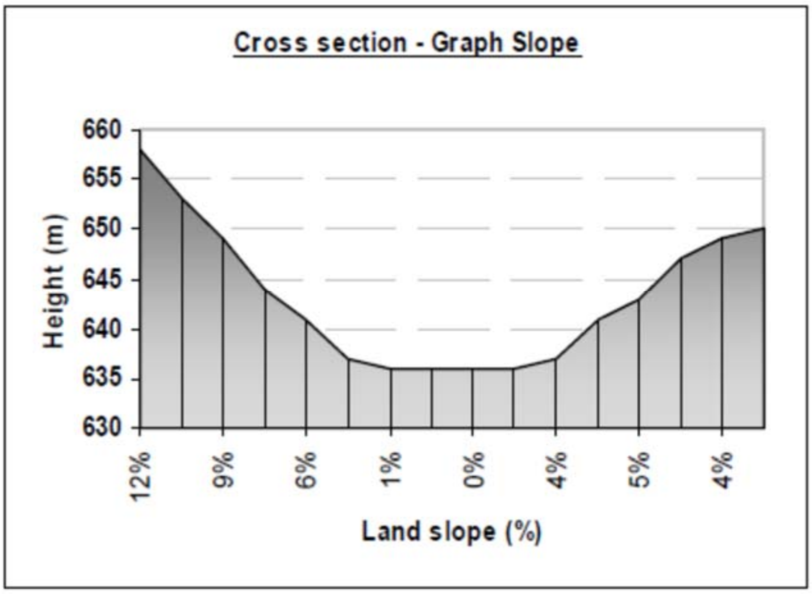


Figure 3 - UPM. Elevation profile and slope from one sampling spot to another.

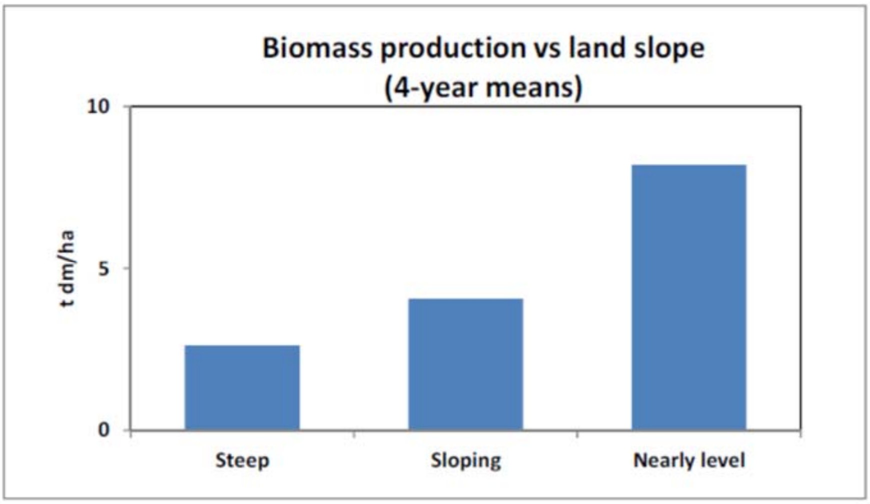


Figure 4 - UPM. Four-year means of biomass production of cynara grown in dry farming at the demostrative scale in Daganzo (Spain) (355 mm rainfall per year on average).

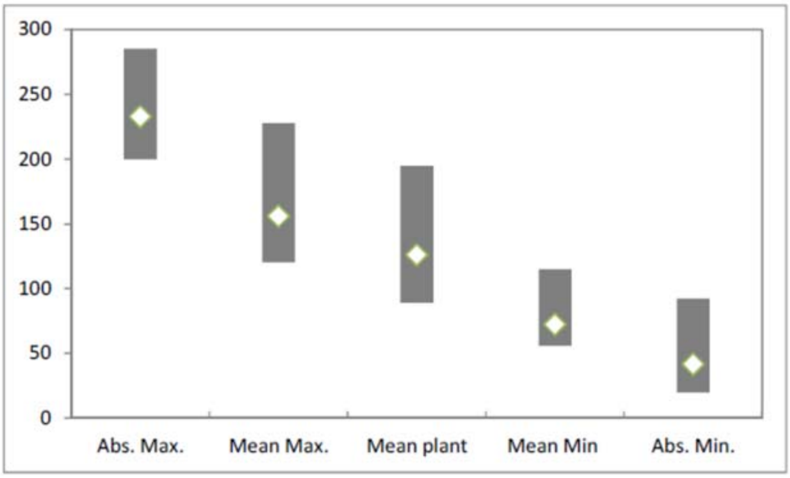


Figure 5 - UPM. Range of values for canopy height in the 5 years of cynara cultivation across 8-ha crop in Daganzo (Spain), in dry farming.

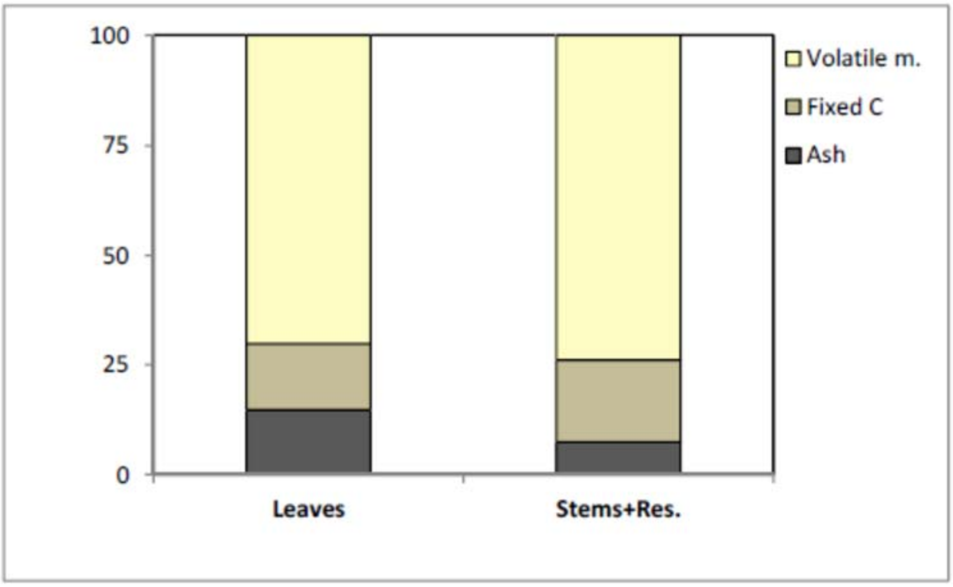


Figure 6 - UPM. Range of values for canopy height in the 5 years of cynara cultivation across 8-ha crop in Daganzo (Spain), in dry farming.

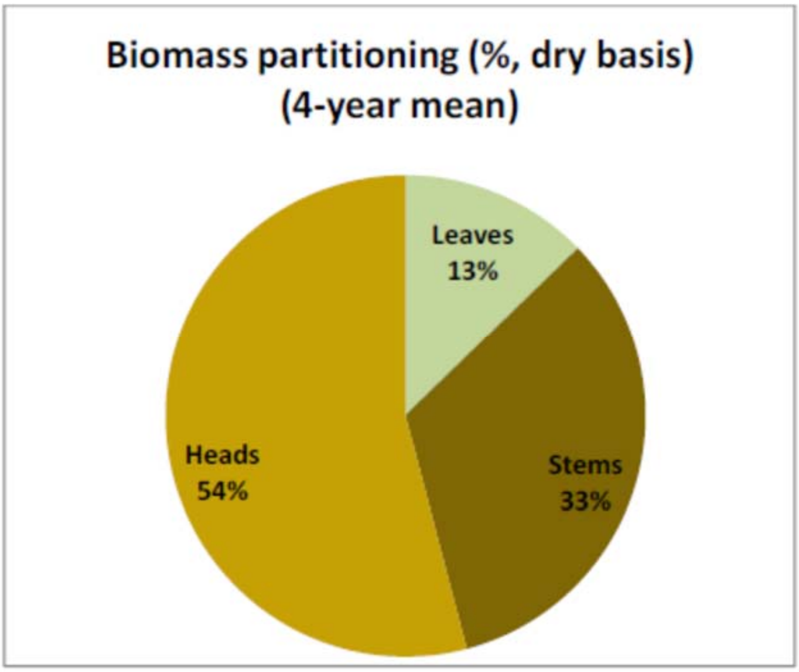


Figure 5 - UPM. Mean results of biomass partitioning (%w/w) (4 consecutive harvests) of cynara in dry farming at the demostrative scale in Daganzo (Spain).

Task 4.4 Reducing biomass losses during harvesting & storage (CRA-ING, SPAPPERI, UPM, SPAPPERI, CRDT)

Universidad Politecnica De Madrid – UPM (n. 5)

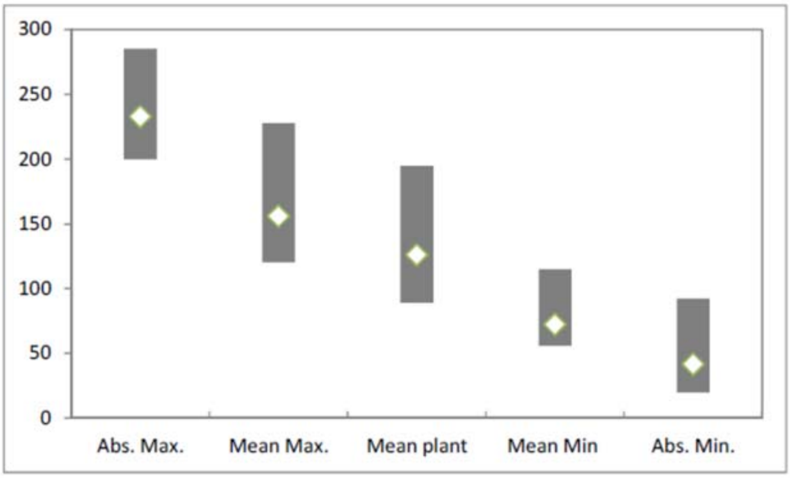


Figure 1 - UPM. Range of values for canopy height in the 5 years of cynara cultivation across 8-ha crop in Daganzo (Spain), in dry farming.

Picture 1 - UPM. Mechanical harvest of seeds of cynara by means of a conventional Jonh Deere W650 harvester with Kemper 206 header. September 2013..

SPAPPERI Srl

Figure 1 - SPAPPERI. Outer positioning of the counter-blades of the rotor.

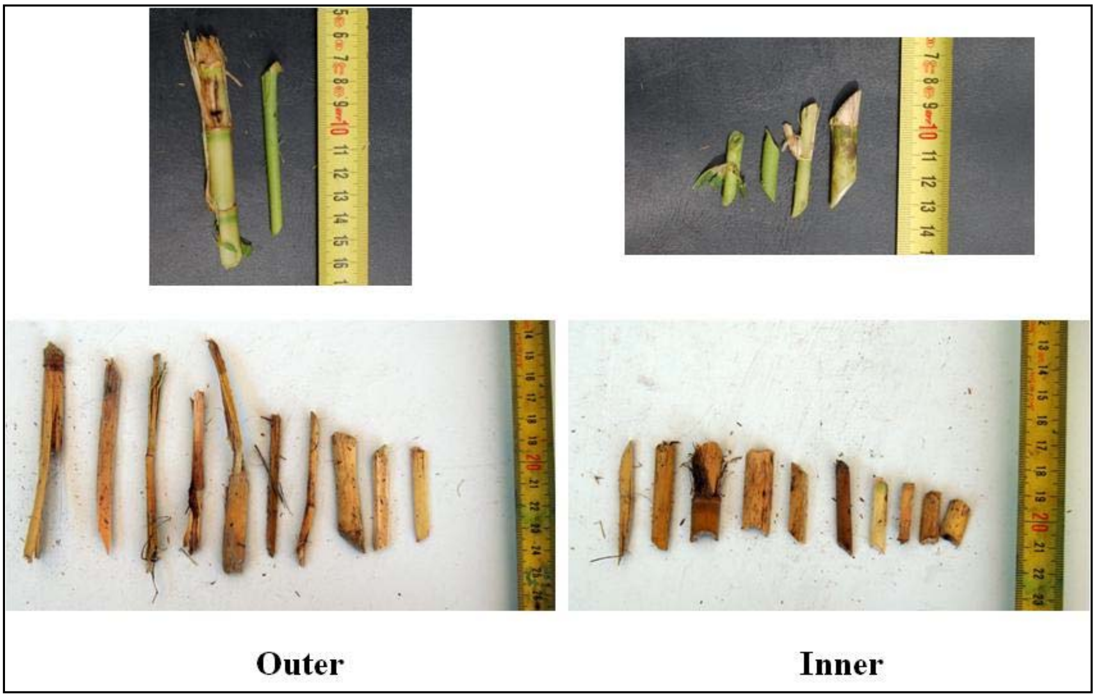


Figure 2 – SPAPPERI. Details of the product obtained keeping the counter-blades in the outer or inner position. The photograph shows the cut pieces at the time of harvesting (green portions, top) or previously sieving (dried portions, bottom).

Table 1 – SPAPPERI. Particle size distribution (%) obtained using inner or outer position of the counter-blades. The ANOVA was performed on the arcsine square root of the percentage values. Different letters next to the averages indicate statistically significant differences (Duncan test).

Size classes	Settings cut	
	Inner	Outer
100-125	0.00 I	0.00 I
75-100	0.00 I	0.43 I
50-75	1.18 I	0.90 I
25-50	2.44 I	2.59 I
12.5-25	10.97 G	13.28 G
6.3-12.5	39.11 A	37.75 A
3.15-6.3	26.83 D	24.88 DE
< 3.15	19.47 F	20.38 F

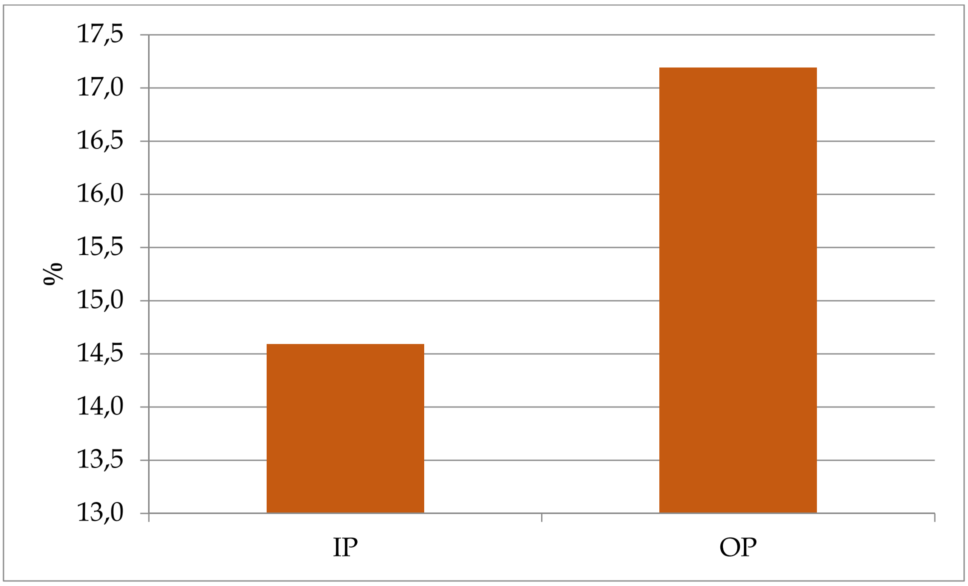


Figure 3 – SPAPPERI. Cumulative percentage of particles in the range 12.5-100 mm observed for the different position (inner or outer) of the counter-blades.

Figura 4 – SPAPPERI. Mowing and conditioning of Miscanthus
http://adlib.everysite.co.uk/resources/000/025/574/Miscanthusfig9.jpg

Figure 5 – SPAPPERI. Mowing and conditioning of Switchgrasshttps://passel.unl.edu/pages/printinformationmodule.php?idinformationmodule=1130447202&idcollectionmodule=1130274200

Figure 6 – SPAPPERI. Harvesting yard on Arundo donax L. composed by mulcher and baler; the biomass is collected only in one tractor passage. http://www.nobili.com/en/cat_serie.php?ID=411

Figure 7 – SPAPPERI. Claas jaguar and kemper head during harvesting operation in northern Italy. Photo by CREA-ING

Table 2 – SPAPPERI. Biobaler characteristics

<table>
<tr><td colspan="2">
</td><td>The BioBaler Harvesting System is a simple concept. In a single pass, with only one operator, the BioBaler cuts and compacts biomass into dense round bale. Bales can be collected on site at any time after harvest.</td></tr>
<tr><td>Manufacturer</td><td colspan="2">Anderson</td></tr>
<tr><td>Model</td><td colspan="2">Biobaler WB66</td></tr>
<tr><td>Drawbar lenght (m)</td><td>1.83</td><td>3.66</td></tr>
<tr><td>Overall Width (mm)</td><td colspan="2">2585</td></tr>
</table>

Working width (mm)		2250
Height (mm)*	Min 2460- Max 2970	
Length(mm)	5460	7290
PTO (rpm)	1000	
Weight (Kg)	6500	6820
Power requirements (Kw)	150	
Bale size (mm x mm)	1200 X 1200	
Bale weight (kg)	500-600	
Number of teeth of the mulcher	50	
Number of hammers of the feed rotor	38	
Productivity (t h^{-1})	8-20	

* Maximum and minimum height based upon the position of the lift system of the pneumatic axle

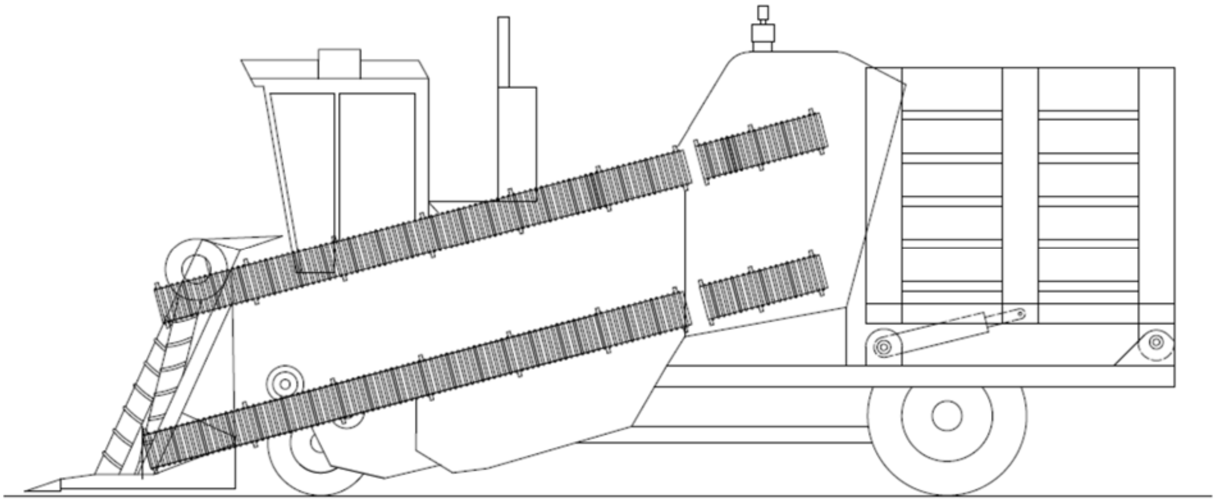


Figure 8 – SPAPPERI. Lateral view of the ideal prototype for mowing and baling perennial grasses for energy purposes

Unità di Ricerca per l'Ingegneria Agraria – CRA-ING (n. 15)

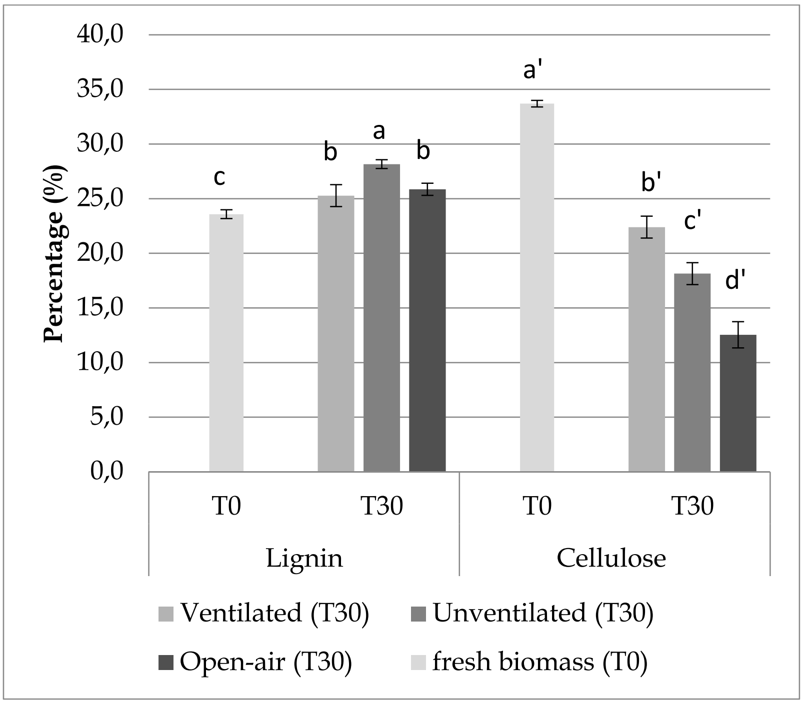


Figure 1 – CREA-ING. Lignin and cellulose contents (means ± SD) determined on fresh biomass (T_0) and after storage on the three treatments (T_{30}). Different letters indicate a significant difference at the level of $p<0.05$ after HSD Tukey's test.

Table 1 - Fuel quality parameters of fresh biomass (T_0) or after storage (T_{30}) under different storage conditions.

Parameter	U.M.	Ventilated		Unventilated		Open-air	
		T_0	T_{30}	T_0	T_{30}	T_0	T_{30}
MC[a]	%	58.65 ± 0.2	10.50 ± 0.6	58.80 ± 0.7	42.2 ± 1.15	59.50 ± 1.8	60.60 ± 0.9
HHV[b]	MJ kg^{-1}	17.85 ± 0.09	18.06 ± 0.26	17.89 ± 0.16	17.97 ± 0.39	17.95 ± 0.08	17.96 ± 0.36
LHV[c]	MJ kg^{-1}	16.64 ± 0.13	16.85 ± 0.22	16.65 ± 0.14	16.74 ± 0.38	16.69 ± 0.08	16.71 ± 0.34
Ash	%	7.4 ± 0.3	7.5 ± 0.3	7.85 ± 0.2	7.77 ± 0.2	7.9 ± 0.3	7.92 ± 0.2
C	%	46.70	46.53	46.53	46.44	46.34	45.42
H	%	5.38	5.38	5.82	5.76	5.58	5.53
N	%	1.40	1.42	1.58	1.52	1.58	1.51

[a] MC = moisture content.
[b] HHV = higher heating value.
[c] LHV = lower heating value.

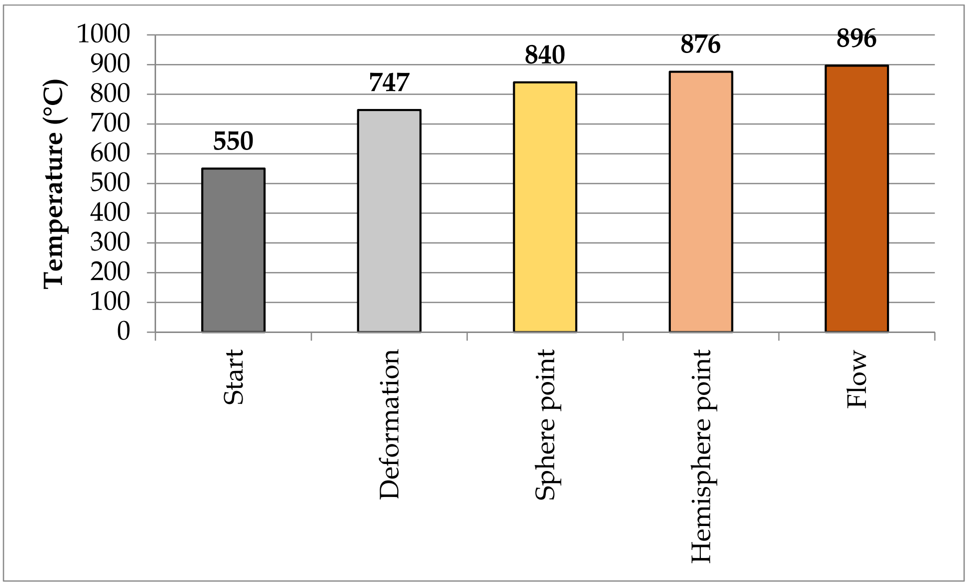


Figure 2 - CREA-ING. Ash fusion temperatures (°C)

Figure 3 – CREA-ING. *Arundo* harvesting in sloping degrade of riverbank

Table 2 – CREA-ING. Main characteristics of the chopping system compared

			Excavator-mounted	Self-propelled
Driving machine			Hitachi Zaxis 210 N	Energreen ILFS 1500
Mulcher			Berti ECF MD/SB	New Speed 150
	Motor		Hydraulic	Hydraulic
	Weight	kg	895	480
Rotor				
	Lenght	mm	1400	1416
	Diameter	mm	330	128
Hammers		n	24	
Knives		n		48 (16x3)

Figure 4 – CREA-ING. Hydraulic mulching head mounted on the tracked excavator

Figure 5 - CREA-ING. Shredder head with knives coupled with a self-propelled

Figure 6 - CREA-ING. River banks where the trial was carried out in February (a) and June (b)

Table 3 - CREA-ING. River banks analysed

		February	June
Lenght (m)	m	140	160
Width (m)	m	11,2	15,6
Area (ha)	ha	0,16	0,25
	km	1,14	1,6
Previous cut		one year	one year

Table 4 - CREA-ING. Main morpho-productive parameters.

			February	June
Plant traits	Density	n m^{-2}	37,4	29,3
	Height	cm	355,6	346,3
	Diameter	mm	14,2	20,6
	Weight	kg m^{-2}	8,31	17,3
Productive data	Yield $_{f.w.}$	t km^{-1}	93,3	270,0
		t ha^{-1}	83,3	172,6
	Moisture	%	47,9	65,8
	Yield $_{d.w.}$	t km^{-1}	48,6	92,3
		t ha^{-1}	43,4	59,0

Table 5 - CREA-ING. Average bulk density observed for month, implement and their interaction (month x implement).

Month	Implement		Mean
	Hammer	Knife	
February	77.9 B	107.2 A	92.6 B
June	116.3 A	110.0 A	113.2 A
Mean	97.1 B	108.6 A	

Different letters indicate statistical significance at the 1% (capital) level

Table 6 - CREA-ING. Working time (%) calculated in February and June for the mulcher with hammers and in June for the knives.

	Hammers		Knives
	February	June	June
TE - Effective operative time	86,45	78,41	92,67
TA - Time for turning	13,55	21,59	7,33
TO - Operative time	100,00	100,00	100,00

Table 7 - CREA-ING. Performance of the machines observed in February and June for the heading with hammers and in June for the knives

		Hammers		Knives
		February	June	June
Field efficiency	%	86,45	78,41	92,67
Effective speed	$m\ s^{-1}$	0,64	0,67	0,62
Operative speed	$m\ s^{-1}$	0,55	0,52	0,58
Theoretical field capacity (TFC)	$ha\ h^{-1}$	0,09	0,11	0,15
Effective field capacity (EFC)	$ha\ h^{-1}$	0,07	0,09	0,14
Work productivity (WP)	$t\ h^{-1}$	6,70	15,05	25,16

Figure 1 – BTG. photograph of the Arundo (left) and Miscanthus (right) biomass before and after size reduction.

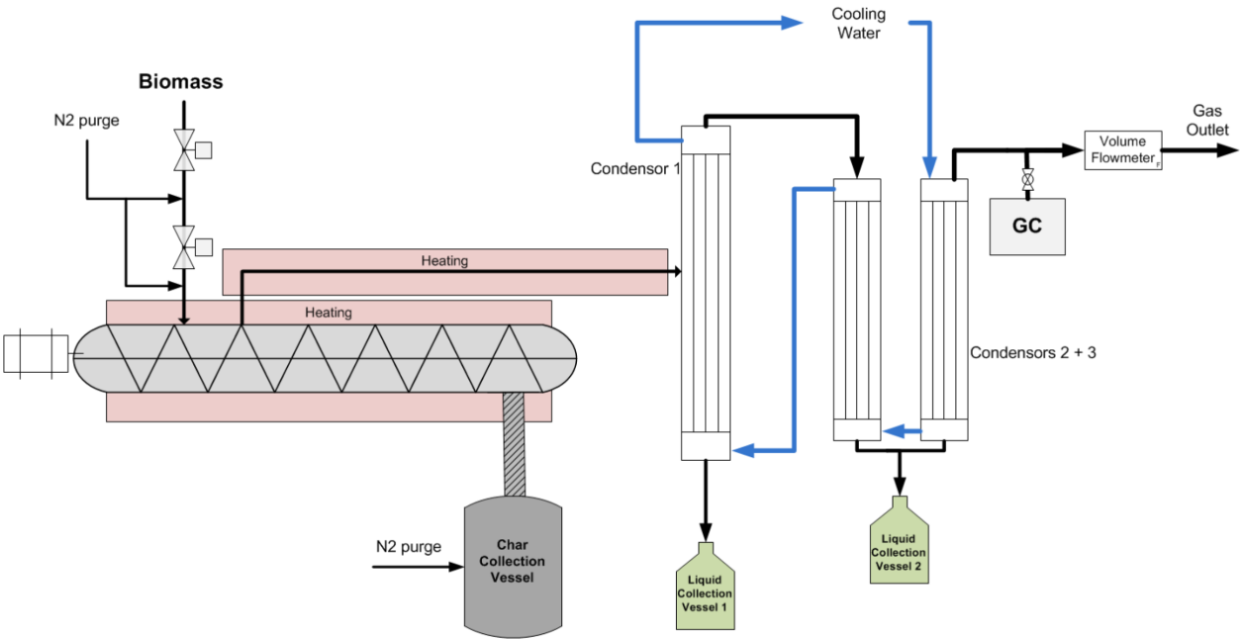


Figure 2 – BTG. Schematic representation of the torrefaction setup

Table 2 – BTG. Torrefaction operating conditions

Parameter	Arundo test	Miscanthus test	Unit
Temperature	283	282	[°C]
Feed capacity	0.35	0.32	[kg/h]
Runtime	1.90	1.85	[h]

Figure 3 – BTG. Photograph of the torrefaction setup

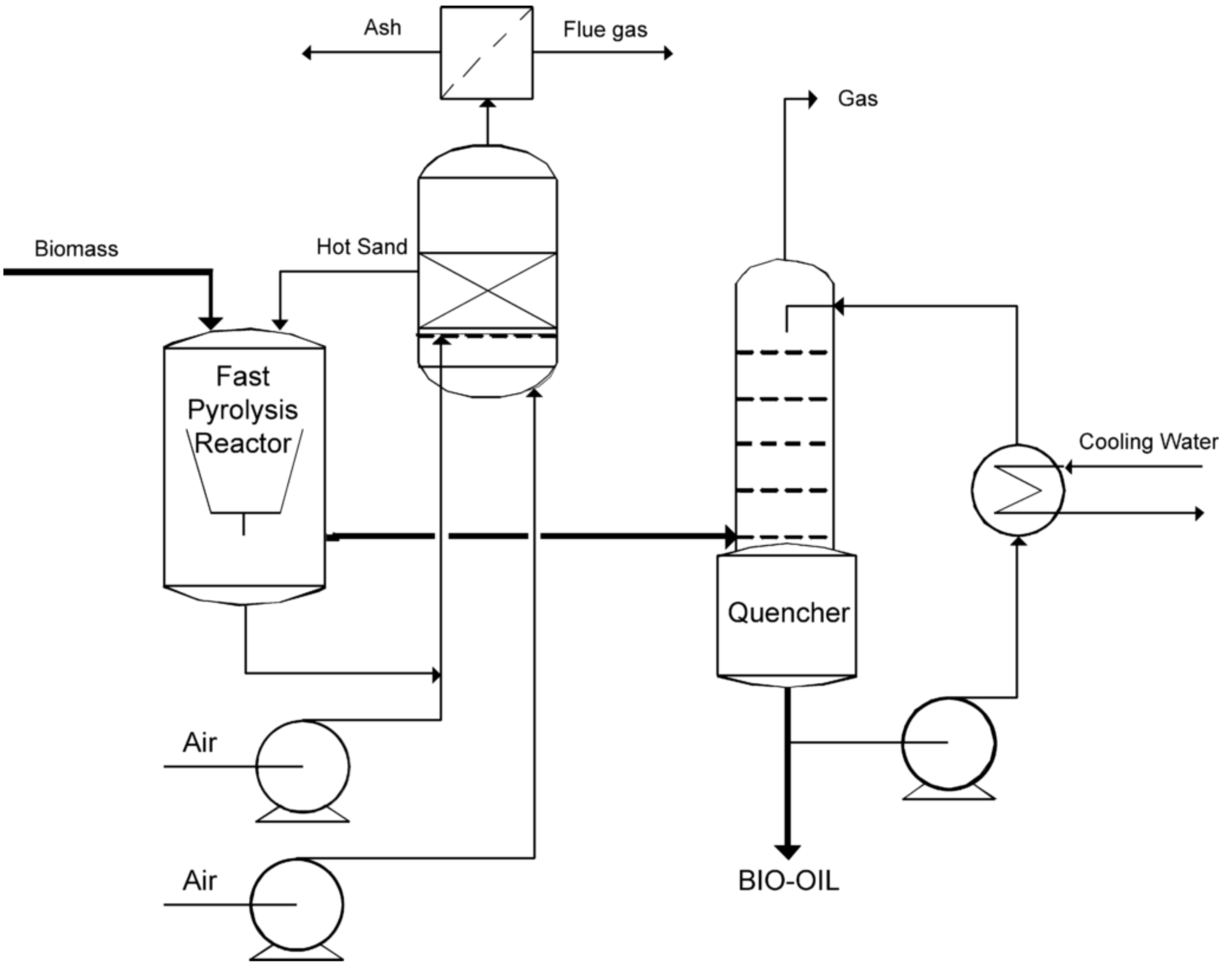


Figure 4 – BTG. Schematic representation of the fast pyrolysis setup

Figure 5 – BTG. Photograph of the fast pyrolysis setup

Table 3 – BTG. Pyrolysis operating conditions.

Parameter	Arundo test	Miscanthus test	Unit
Temperature	529	520	[°C]
Feed capacity	3.42	3.57	[kg/h]
Runtime	1.7	1.6	[h]

Table 4 – BTG. Mass, energy and carbon balance for the torrefaction tests

	Mass yield		**Energy yield**		**Carbon yield**	
	Arundo	Miscanthus	Arundo	Miscanthus	Arundo	Miscanthus
Char	69%	74%	90%	87%	87%	87%
Liquid	18%	15%	5%	4%	7%	6%
Gas	6%	4%	3%	2%	5%	3%
Total	94%	93%	98%	93%	99%	95%

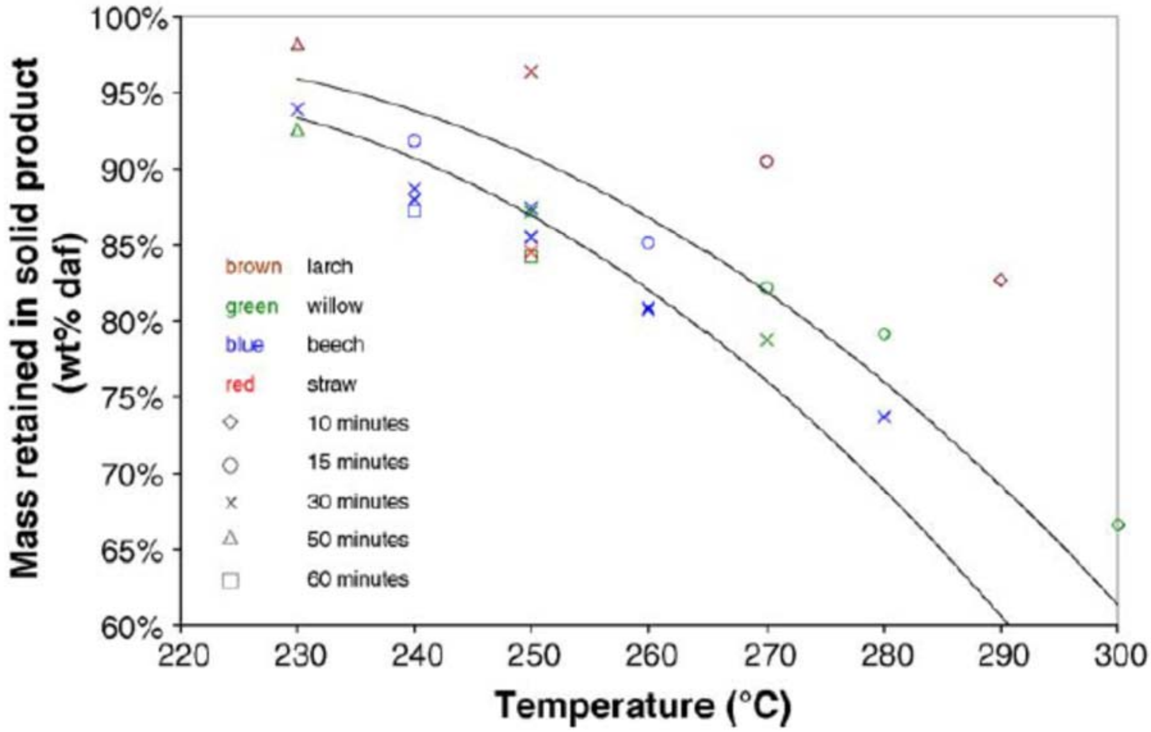


Figure 6 – BTG. Percentage char from product as result of the torrefaction temperature (Prins, 2006).

Table 5 – BTG. Mass, energy and carbon balance for the pyrolysis tests

	Mass yield		**Energy yield**		**Carbon yield**	
	Arundo	Miscanthus	Arundo	Miscanthus	Arundo	Miscanthus
Liquid	55%	63%	55%	58%	55%	60%
Gas	21%	19%	8%	6%	19%	17%
Char	19%	15%	22%	18%	22%	18%
Ash	6%	3%	-	-	-	-
Total	100%	100%	86%	82%	95%	95%

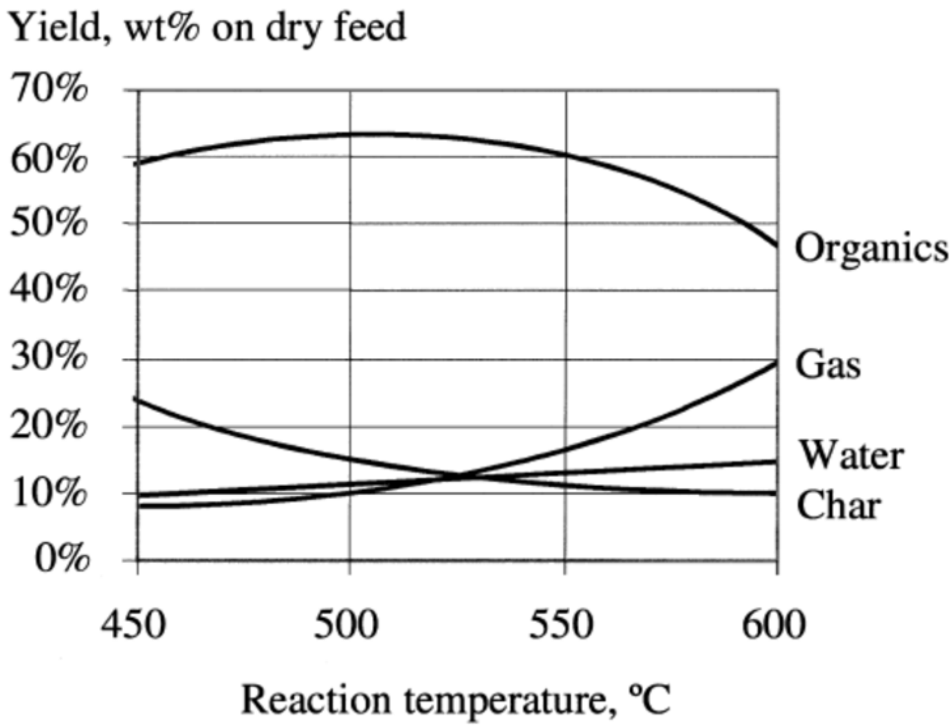


Figure 7 – BTG. Yields pyrolysis dependent on temperature (Bridgewater, 1999).

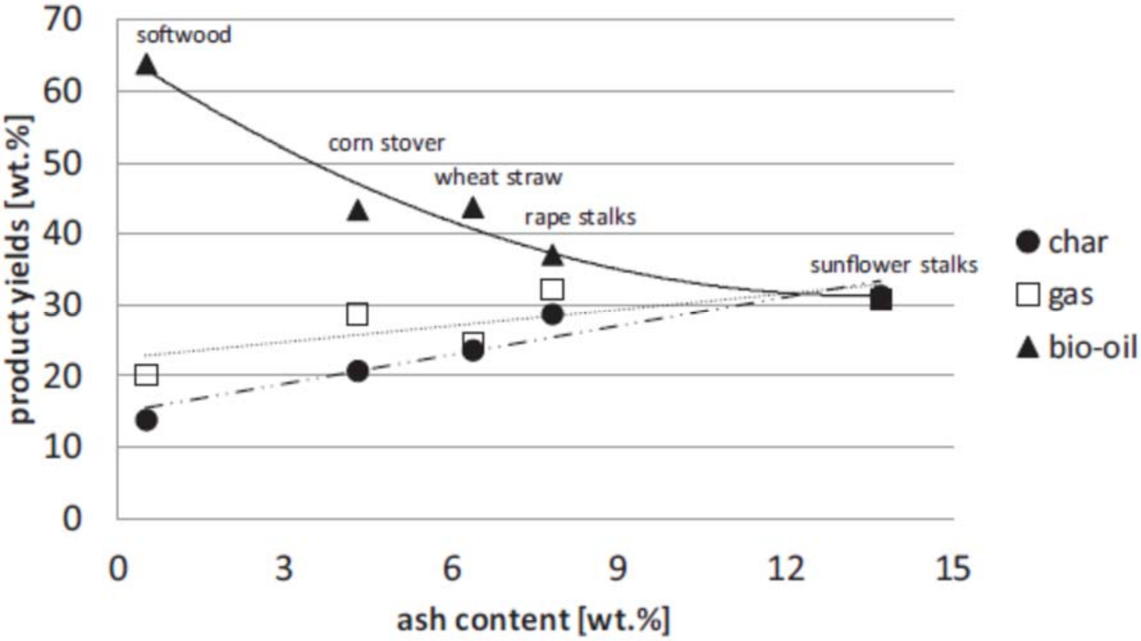


Figure 8 – BTG. Pyrolysis yields mass based of several feedstock Troger (2013).

Table 6 – BTG. Proximate and Elemental Analysis Miscanthus and Arundo from BTG laboratory. The green cells are measured, grey cells are calculated from the measurements.

	As received basis						Dry basis					Calculated (Milne)		
Feedstock	Moisture [wt.%]	Ash [wt.%]	C [wt.%]	H [wt.%]	N [wt.%]	O (diff) [wt.%]	Ash [wt.%]	C [wt.%]	H [wt.%]	N [wt.%]	O (diff) [wt.%]	HHV dry [MJ/kg]	LHV dry [MJ/kg]	LHV ar [MJ/kg]
Miscanthus feedstock (torr)	3.4%	3.48%	43.6%	5.9%	0.5%	43.1%	3.60%	45.09%	6.16%	0.53%	44.6%	18.0	16.7	16.0
Miscanthus feedstock (pyro)	4.6%	3.43%	43.0%	5.9%	0.5%	42.6%	3.60%	45.09%	6.16%	0.53%	44.6%	18.0	16.7	15.8
Arundo feedstock (torr)	2.7%	5.53%	42.4%	5.7%	1.2%	42.5%	5.68%	43.54%	5.90%	1.25%	43.6%	17.2	15.9	15.4
Arundo feedstock (pyro)	2.4%	5.55%	42.5%	5.8%	1.2%	42.6%	5.68%	43.54%	5.90%	1.25%	43.6%	17.2	15.9	15.5

Table 7 – BTG. Proximate and Elemental Analysis Miscanthus and Arundo from Literature.

	As received basis						Dry basis					Calculated (Milne)		
	Moisture	Ash	C	H	N	O (diff)	Ash	C	H	N	O (diff)	HHV dry	LHV dry	LHV ar
Feedstock	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[wt.%]	[MJ/kg]	[MJ/kg]	[MJ/kg]
Miscanthus feedstock (Guanxing, 1999)	3.40%	2.70%	46.27%	6.09%	0.68%	42.31%	2.8%	47.90%	6.30%	0.70%	43.80%	16.52	15.15	14.55
Miscanthus feedstock (Van Ree, 1997)	3.40%	1.45%	47.29%	5.84%	0.67%	41.30%	1.50%	48.95%	6.05%	0.69%	42.75%	19.68	18.36	17.65
Arundo feedstock (Miles, 1995)	3.4%	3.34%	45.79%	5.68%	0.58%	41.60%	3.43%	45.79%	5.84%	0.6%	42.75%	18.85	17.58	17.04
Arundo feedstock (Hallgren, 1999)	3.4%	3.48%	42.60%	5.02%	0.29%	45.79%	3.60%	44.10%	5.20%	0.29%	47.40%	18.30	17.17	16.50

Table 8 – BTG. Analysis results of the feedstocks and various products. The green cells are measured, grey cells are calculated from the measurements.

	As received basis						Dry basis					Calculated (Milne)		
	Moisture	Ash	C	H	N	O (diff)	Ash	C	H	N	O (diff)	HHV dry	LHV dry	LHV ar
Torrefaction products														
Miscanthus liquid	65.1%	0.0%	17.0%	2.0%	0.0%	81.0%	0.00%	48.50%	5.81%	0.00%	45.7%	18.7	17.5	4.5
Miscanthus char	0%	5.3%	51.2%	5.6%	0.5%	37.4%	5.26%	51.19%	5.60%	0.53%	37.4%	20.2	19.0	19.0
Arundo liquid	61.7%	0.0%	16.4%	2.5%	0.0%	81.1%	0.00%	42.85%	6.42%	0.00%	50.7%	17.0	15.6	4.5
Arundo char	0%	8.5%	53.3%	5.4%	1.2%	31.6%	8.49%	53.30%	5.43%	1.19%	31.6%	21.3	20.1	20.1
Pyrolysis products														
Miscanthus liquid	22.9%	0%	41.4%	6.96%	0.44%	51.2%	0%	54%	6%	0.6%	40%	21.0	19.8	14.7
Miscanthus char	0%	33.2%	50.9%	3.2%	0.6%	12.1%	33%	51%	3%	0.61%	12.1%	19.5	18.8	18.8
Arundo liquid	28.0%	0%	41.9%	7.50%	1.08%	49.5%	0%	58%	6%	1.5%	34%	23.6	22.3	15.4
Arundo char	0%	39.3%	48.4%	3.0%	1.2%	8.1%	39.3%	48.4%	3.0%	1.2%	8.1%	18.8	18.1	18.1

Gas composition	CO2 [kg/h]	CO [kg/h]	HC [kg/h]	LHV [MJ/kg]	Carbon [wt.%]
Miscanthus Torrefaction	0.010	0.002	0.001	7.2	32%
Arundo Torrefaction	0.018	0.004	0.001	6.6	32%
Miscanthus Pyrolysis	0.319	0.261	0.054	5.2	38%
Arundo Pyrolysis	0.366	0.252	0.072	6.0	38%

Table 1 – 2ZK. The market volumes and price levels for different applications were defined and assessed by the market players.

	Market volume	**Product value (€/ton)**	**Enabling market introduction**
Pulp& paper (cellulose Properties requested (market value/market volume)	+200 million tons	500-1000	Price - performance
PVAc/cellulose	+ 100 kt	700-1500	Renewable - performance
Phenol	+ 9 million tons	~1400	Price – renewable - quality
Cresols	+ 100 kt	~2500	Price - quality
Antioxidants	+ 200 kt	1500-7000	Price – renewable - performance
Phenol resins	+ million ton	1000-4000	Price – renewable – performance, SHE
Bi(o)tumen	95 millions	300-400, but rising	Price - performance
Woody Plastic Composite	+260 kT	Broad range	Price - performance
Fuel additives	Million tons	~1000	Price - performance
Ethanol	+ 70 million tons	~ 500	Price – renewable -

Task 6.1 Assessment of CO_2 and water exchange between canopy and atmosphere through micrometeorological "eddy covariance" measurement

University of Bologna - UNIBO (n. 2) / Istituto per il Sistema Produzione Animale in Ambiente Mediterraneo – CNR-ISPAAM (n. 8)

Table 1. Monthly value of NEE, GPP and Re (Mg C ha^{-1})during the growing seasons 2014 (left table) and 2015 (right table).

2014	NEE (t C ha^{-1})	GPP (t C ha^{-1})	ER (t C ha^{-1})	T air (°C)
January	0.17	-0.29	0.46	5.3
February	0.03	-0.52	0.55	7.3
March	-0.21	-0.98	0.77	9.7
April	-0.73	-1.84	1.10	12.6
May	-1.84	-3.11	1.27	16.0
June	-2.13	-3.43	1.29	20.7
July	-1.94	-2.98	1.04	21.1
August	-1.56	-2.66	1.10	21.4
September	-0.49	-1.31	0.82	19.1
October	0.45	-0.57	1.02	16.2
November	0.34	-0.25	0.59	11.7
December	0.08	-0.20	0.28	6.3
Total	**-7.82**	**-18.14**	**10.28**	**14.0**

2015	NEE (t C ha^{-1})	GPP (t C ha^{-1})	ER (t C ha-1)	T air (°C)
January	0.09	-0.23	0.32	3.8
February	0.02	-0.31	0.32	4.4
March	-0.11	-0.70	0.59	9.0
April	-0.48	-1.17	0.69	13.7
May	-1.06	-2.10	1.04	18.5
June	-2.05	-3.26	1.21	22.7
July	-1.75	-2.81	1.06	27.6
August	-1.13	-2.20	1.07	25.0
September	-0.64	-1.24	0.60	20.1
October	0.26	-0.58	0.84	13.8
Total	**-6.85**	**-14.59**	**7.74**	**15.9**

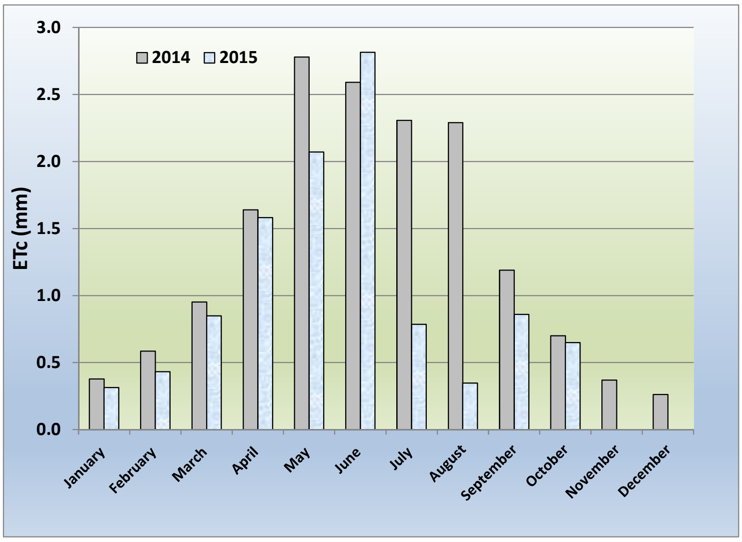


Figure 1. Monthly crop evapotranspiration (ETc) during 2014 (grey histograms) and 2015 (blue histograms) seasons.

Task 6.2 - Root development and carbon storage in the soil

University of Bologna - UNIBO (n. 2) / Faculdade de Ciências e Tecnologia- Universidade Nova de Lisboa (n. 4)

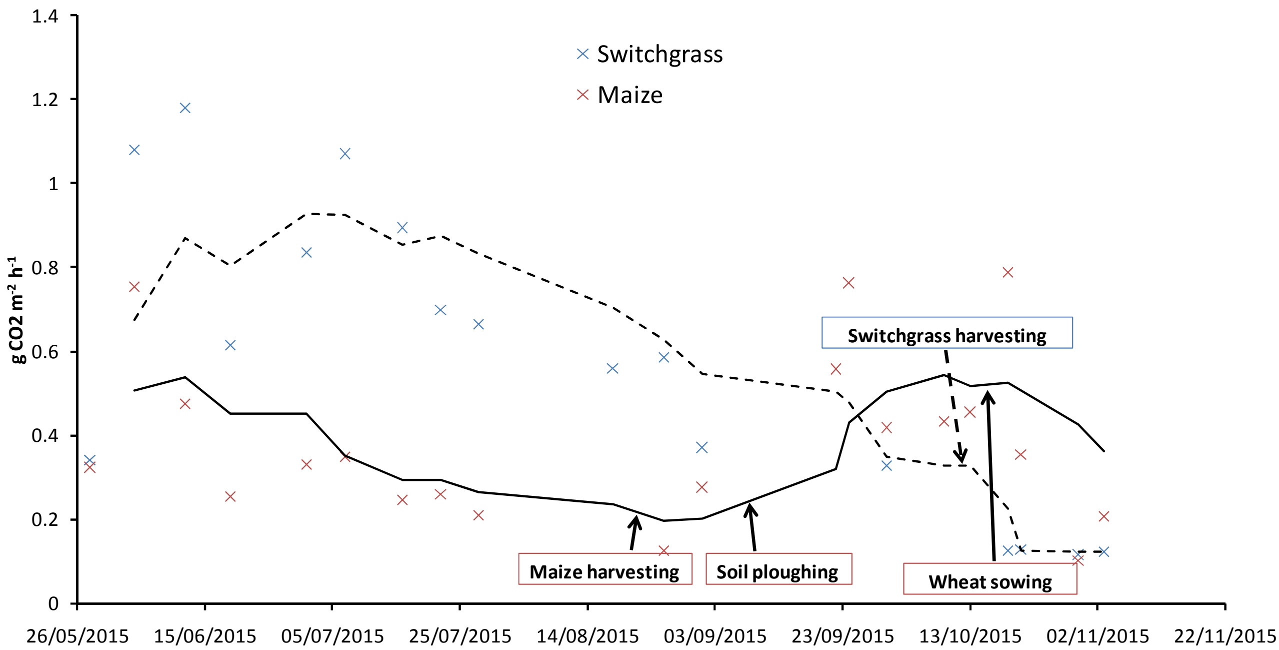


Figure 2. Soil respiration in the period May-October 2015 for switchgrass (dashed line) and a maize (continuous line) at the experimental farm of UNIBO. Remarkable phases of the two crop cycles are highlighted: blue squares for switchgrass, red squares for maize-wheat rotation.

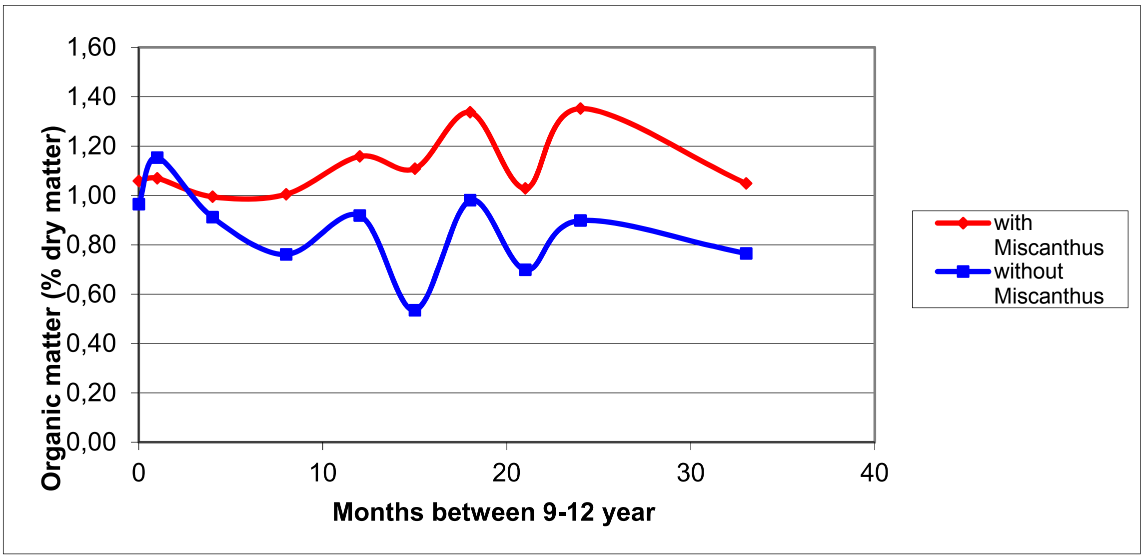


Figure 3. Organic matter content in the soil in *Miscanthus* (red line) and fallow fields (blue line). Average results from 33 months, between 9-12 year of *Miscanthus* plantations in FCT-UNL.

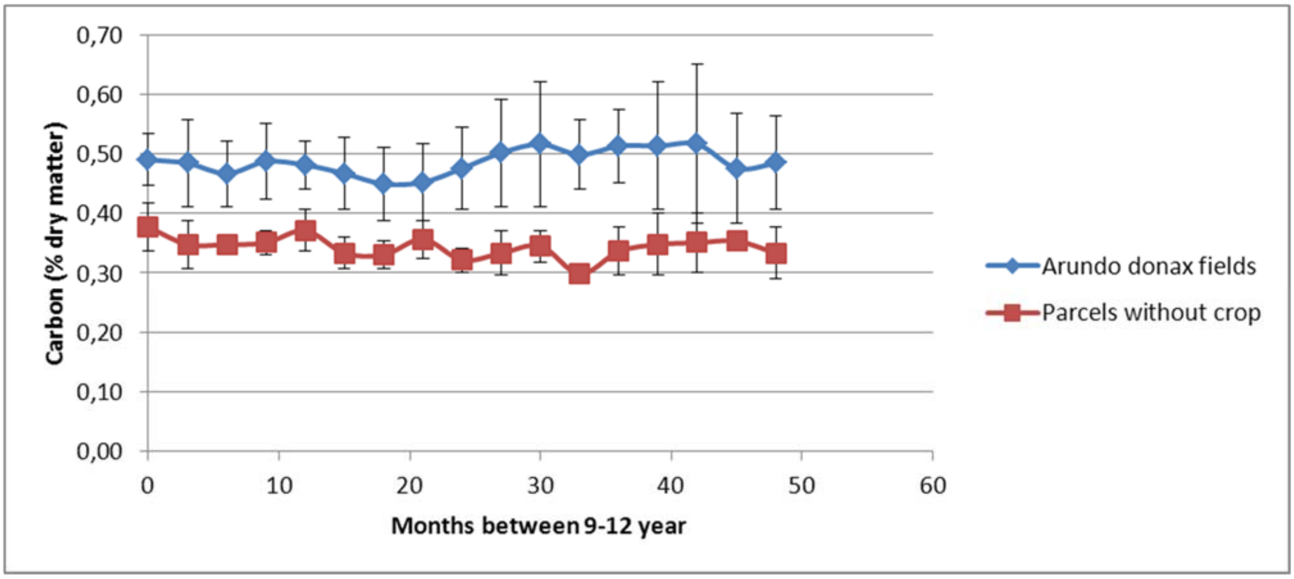


Figure 4. Carbon organic matter content in the soil of *A. donax* plots (blue line) and fallow ones (red line) at the experimental farm of FCT-UNL.

Task 6.3 - Energy balance

Faculdade de Ciências e Tecnologia-Universidade Nova de Lisboa (n. 4) / University of Bologna - UNIBO (n. 2)

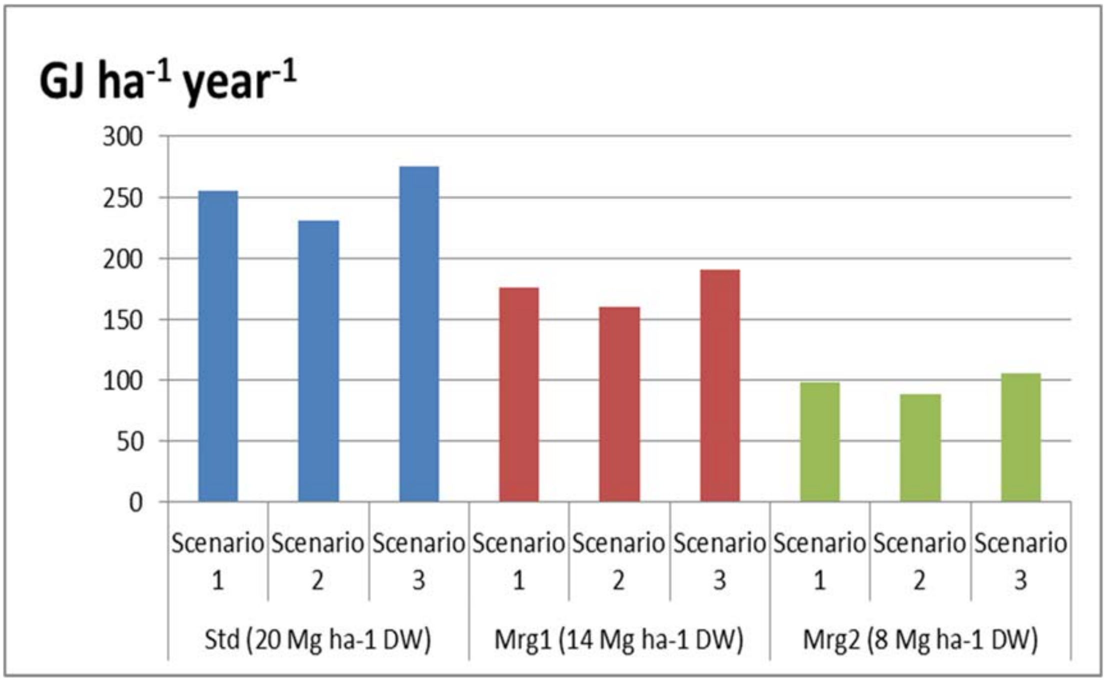


Figure 5. Influence of combustion scenarios in the energy balance of the use of *Miscanthus* for energy production, in Portugal (FCT-UNL). Results are from the standard and marginal soils, considering that the crop was harvested in January

Task 6.4 – Phytoremediation issue

Faculdade de Ciências e Tecnologia-Universidade Nova de Lisboa (n. 4), Indian Institute of Technology, Delhi – CRDT (n. 13), Primus Ltd. – PRIMUS (n. 20)

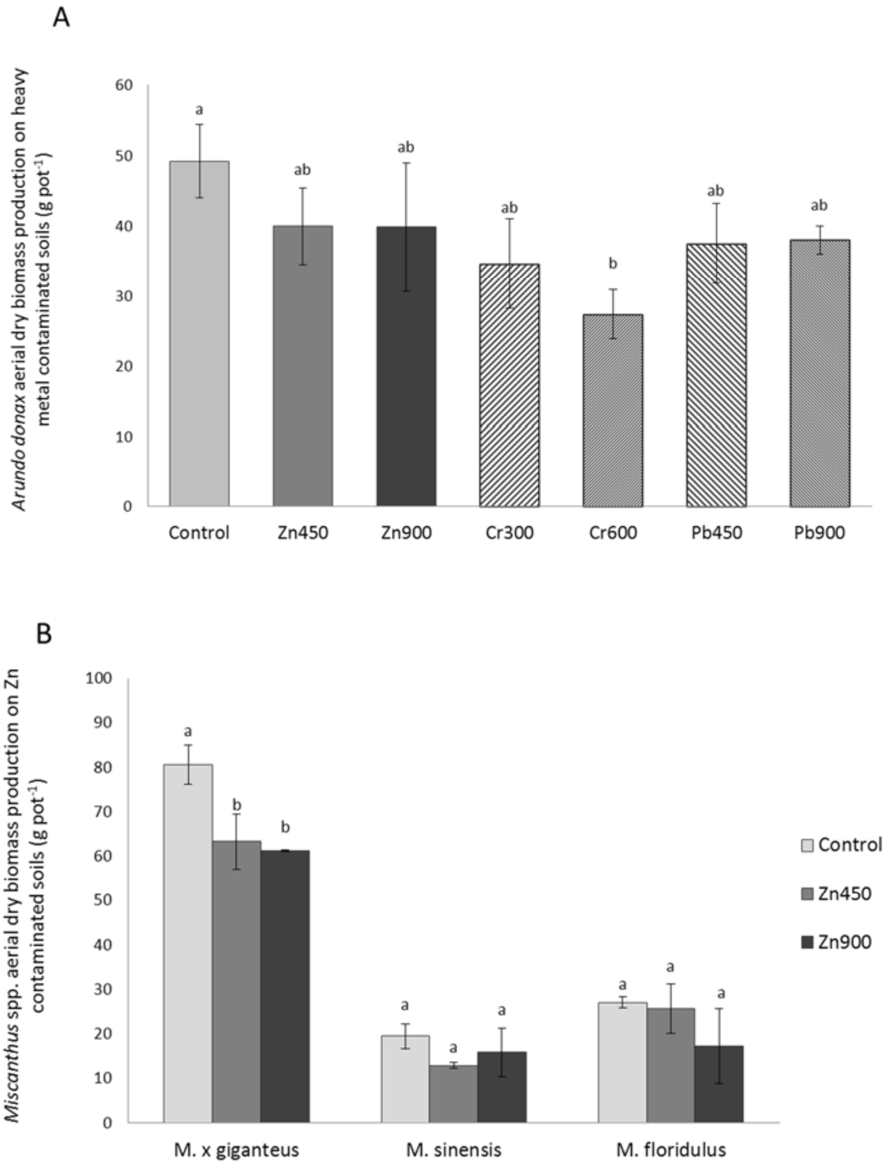


Figure 6. Aerial biomass production of *Arundo donax* L. in Zn, Cr and Pb contaminated soils (A) and aerial biomass production of *Miscanthus* spp. under Zn contaminated soils (B) grown in pots by FCT-UNL. For each species, different lower-case letters indicate statistical significance ($p<0.05$) among treatments.

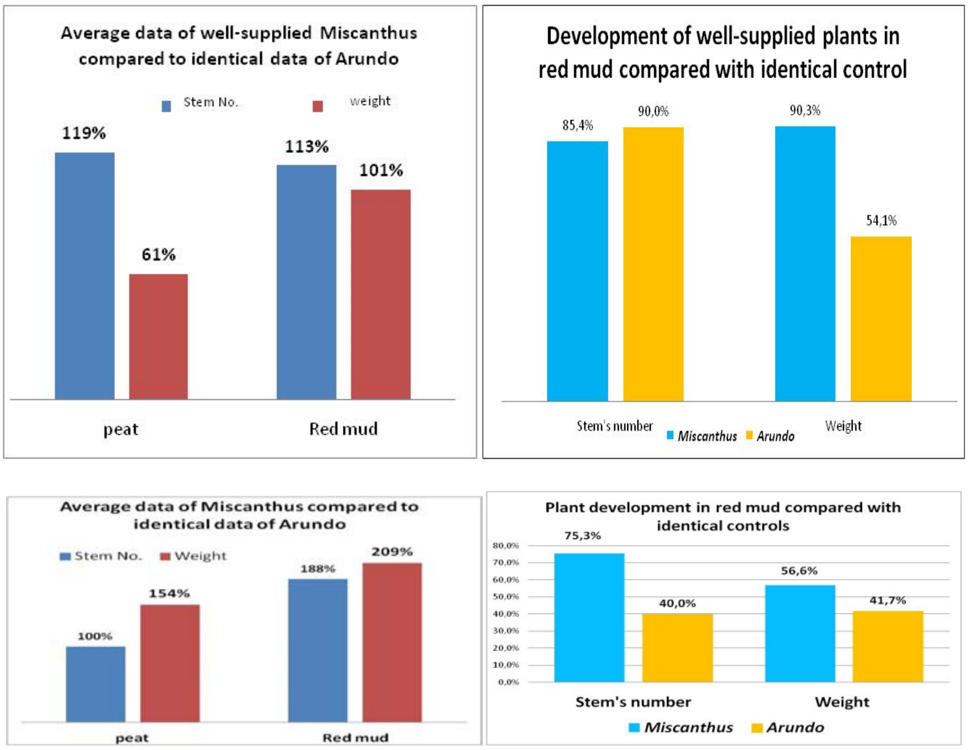


Figure 7. Results from arundo and miscanthus grown in red mud and peat (control) filled pots at PRIMUS experimental station. **Left:** Average stem number (per pot) and average weight of stems of *Miscanthus* and *Arundo* plants grown in peat and red-mud. Values of miscanthus have been standardized over values of arundo grown in the same conditions. Above graph referred to plants grown in well nourished condition, bottom graph to poorly nourished condition. **Right:** Average stem number and average weight of stems of red-mud-grown *Miscanthus* and *Arundo* plants were compared with the identical controls (same plants grown in peat). Values are presented as standardized over peat grown miscanthus (100%). Above graph in well nourished condition, bottom graph in poorly nourished condition

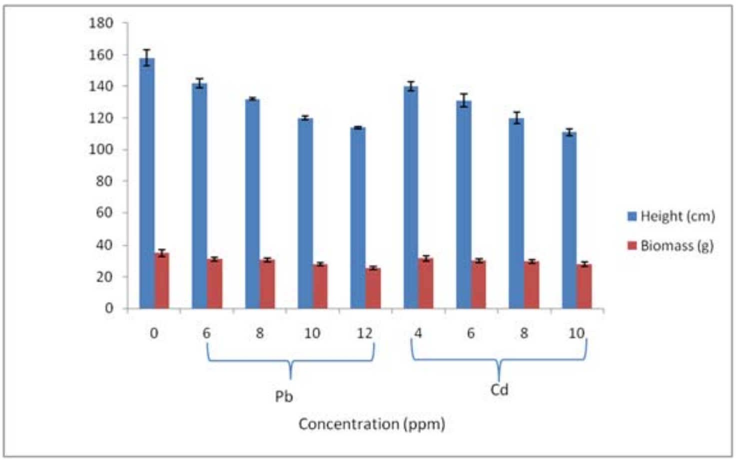


Figure 8. Height and biomass of switchgrass subjected to various concentrations of heavy metals (Pb and Cd) in plot experiment at CRDT- IITD.

Table 2. Bioconcentration factor (BCF) and translocation index (□□) of switchgrass treated with Pb and Cd at different concentration at CRDT- IITD experimental farm.

Treatment	**Heavy metal concentration(ppm)**									
	4		**6**		**8**		**10**		**12**	
	BCF	**Ti %**	**BCF**	**Ti %**	**BCF**	**Ti %**	**BCF**	**Ti %**	**BCF**	**Ti %**
Pb	-	-	0.19±0.03	11.6	0.16±0.03	10.5	0.16±0.02	9.9	0.09±0.02	8.7
Cd	0.15±0.02	11.7	0.13±0.04	9.9	0.11±0.02	9.3	0.08±0.02	9.0	-	-

Task 6.5 - Soil Erosion mitigation by perennial grasses

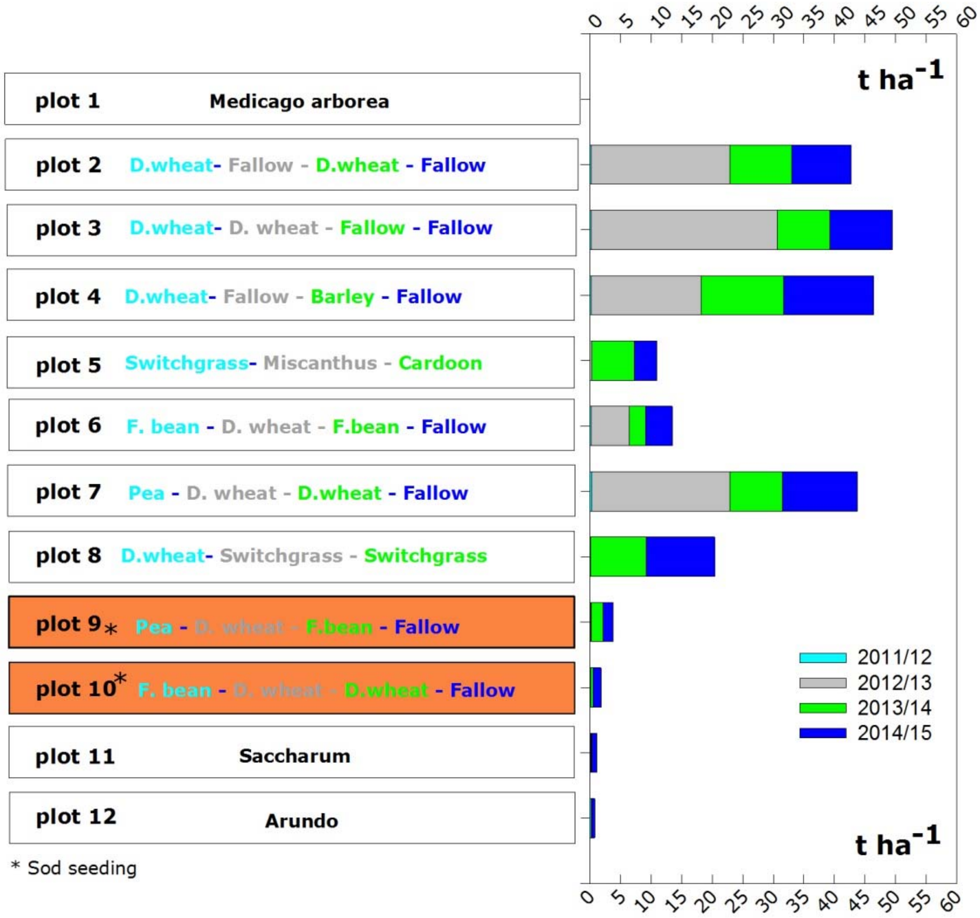


Figure 9. Soil losses (t ha^{-1}) in the twelve plots established at UNICT experimental farm with perennial grasses, perennial legumes and annual species managed both with conventional and no tillage cropping systems.

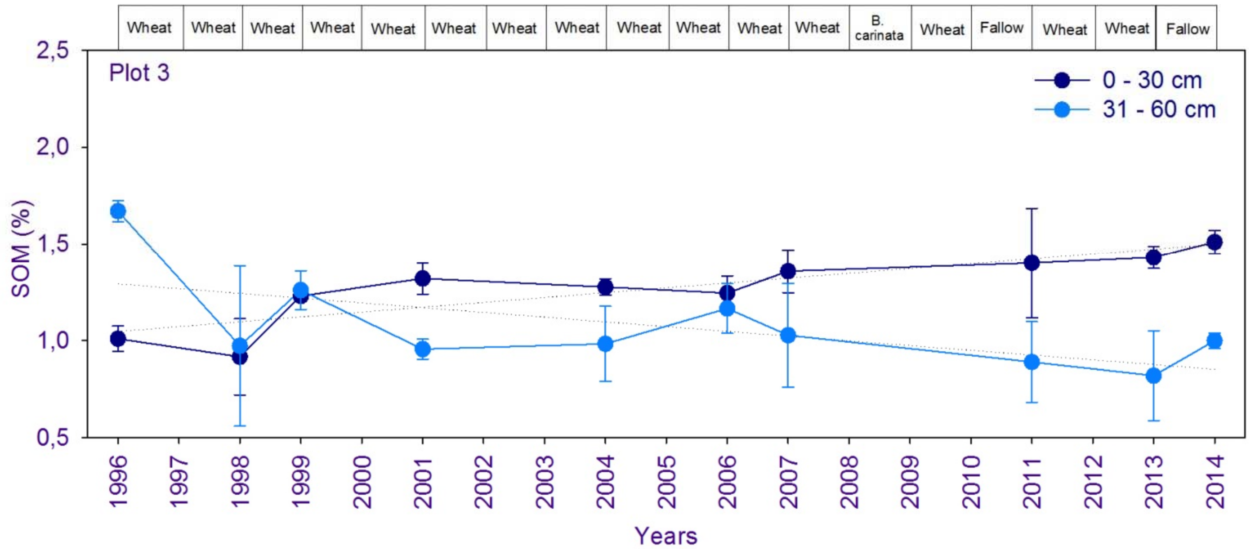


Figure 10. Soil organic matter (SOM) content (%) in a plot managed with a typical Mediterranean cropping system (wheat-wheat-fallow) by UNICT.

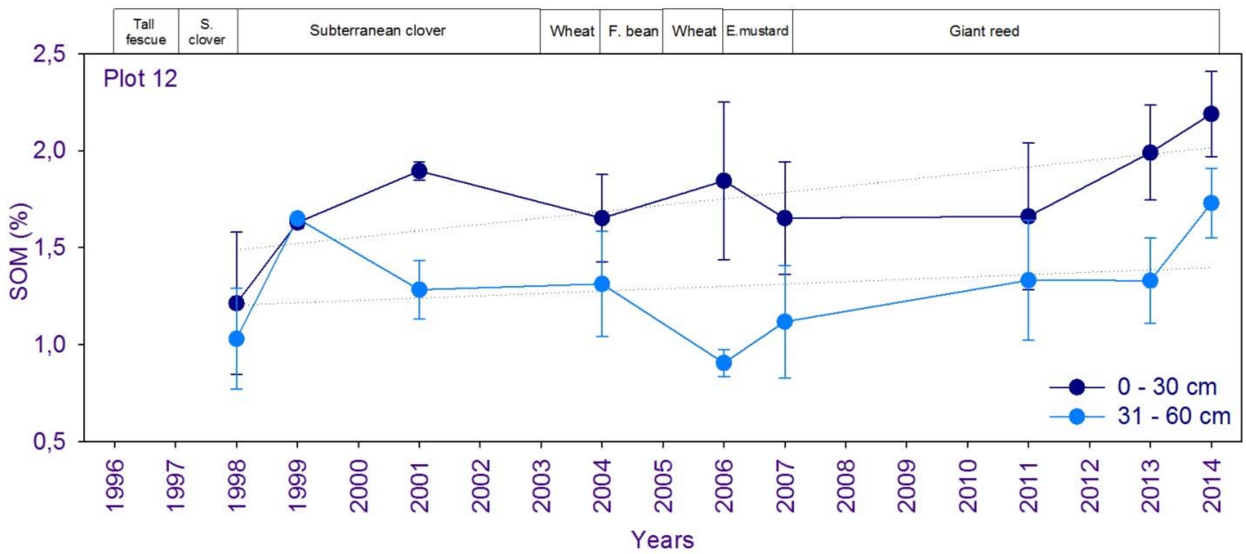


Figure 11. Soil organic matter (SOM) content (%) in a plot managed with a typical Mediterranean cropping system (s.clover-D.wheat-F.bean-D.wheat-B.carinata) and a new perennial crops (*Arundo donax*) at the experimental farm of UNICT.