Titre du Projet

Coopération transfrontalière
ITALIE TUNISIE
2007-2013

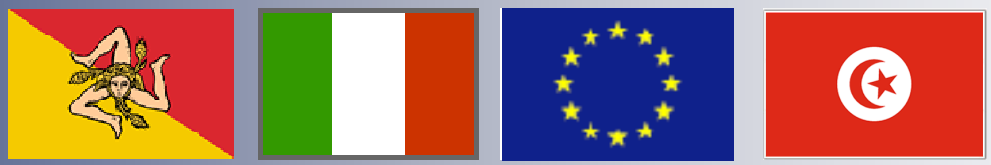
Evaluation technico-économique des systèmes de culture pour la production d'huile végétale dans un but énergétique en Tunisie

www.prohuve.eu

Marrakech, 15/11/2013

Dott. Fulvio Pernice, *Ph.D.*

PRO.HU.V.E.



PRO.HU.VE partnership

S.E.A.R.C.H. ONG	***Organizzazione per lo sviluppo delle energie alternative, rinnovabili cooperazione e health S.E.A.R.C.H. ONG*** *(Organizzazione Capofila)*	www.searchong.it
Ecopark Borj-Cedria CONSORZIO DI RICERCA GIAN PIETRO BALLATORE	**Borj Cedria Ecopark** (Partner 1) **Consorzio di Ricerca "Giampietro Ballatore"** (Partner 2)	www.ecopark.rnrt.tn www.ilgranoduro.it
UNIVERSITÀ DEGLI STUDI DI PALERMO	**Università degli Studi di Palermo – Dipartimento DEMETRA** (Partner 3)	www.unipa.it

Activities

- Activity 1: Technical and economic evaluation of two crop systems for the production of energy oil: herbaceous crop (*Brassica carinata* A. Braun) and tree crop (*Jatropha curcas* L.);
- Activity 2: assessment of the environmental impact of crops in the northern part of Tunisia;
- Activity 3: Analytical assessment of the world market of energy oils aimed to identify the current flow of energy oils;
- Activity 4: dissemination of results;
- Activity 5: project management.

Why to compare woody trees and herbaceous crops?

Jatropha curca field

Brassica carinata (in Sicily)

Intrercropping Jatropha/onions

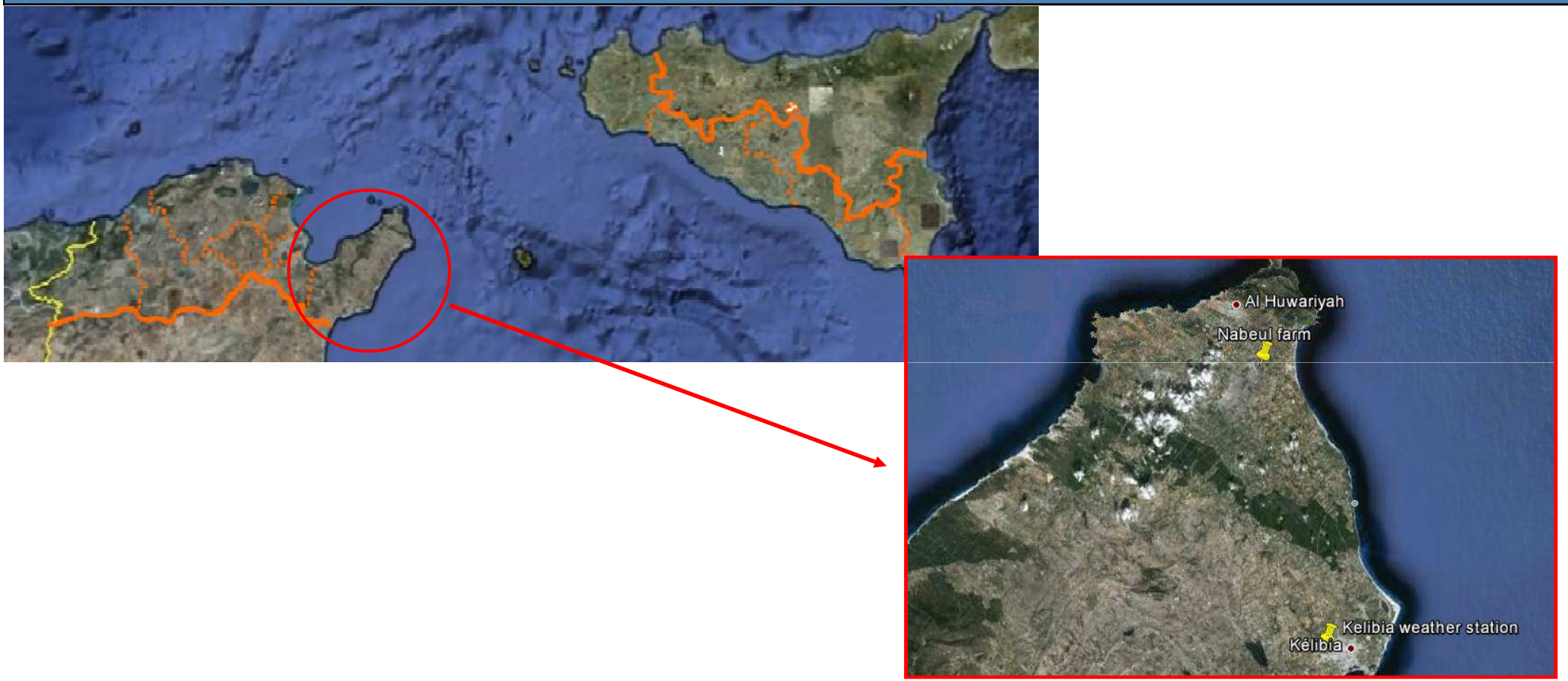
- different growth habit and different permanence period of the plants in the soil (1 year against "50" years): this can significantly affects the crop capacity to act as sink of atmospheric CO2 (carbon credits);
- Perennial crops have deeper roots, which allow a greater accumulation of dry matter and a more efficient management of nutrients and water: generally, perennial crops, are considered more suitable to grow in marginal lands (Cox et al., 2006; Glover et al., 2007);
- To explore the possibility of performing the intercropping (separation between food and energy crops-FAO)!!

-Cox TS, Glover JD, van Tassel DL, Cox CM, DeHaan LR. 2006. Prospects for developing perennial grain crops. Bioscience 56, 649-659;

-Glover JD, Cox CM, Reganold JP. 2007. Future farming: a return to roots? Scientific American 297, 82-89;

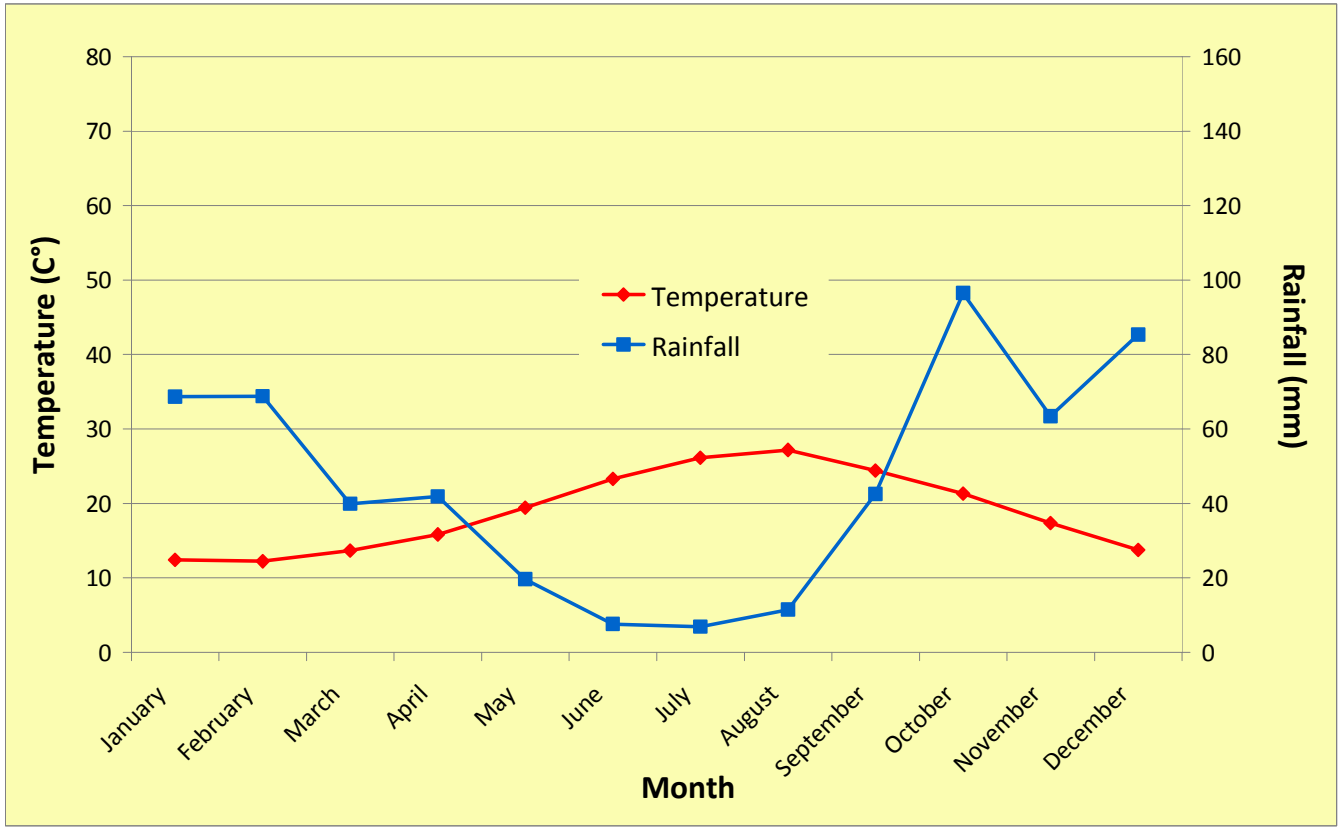
-Intercropping Jatropha/onion photo. Source: Jatropha Assessment Agronomy, socio-economic issues, and ecology. Copernicus Institute, Utrecht University Technical University, Eindhoven - Plant Research International, Wageningen UR

Eligible territories of the ENPI projects (Italy-Tunisia)



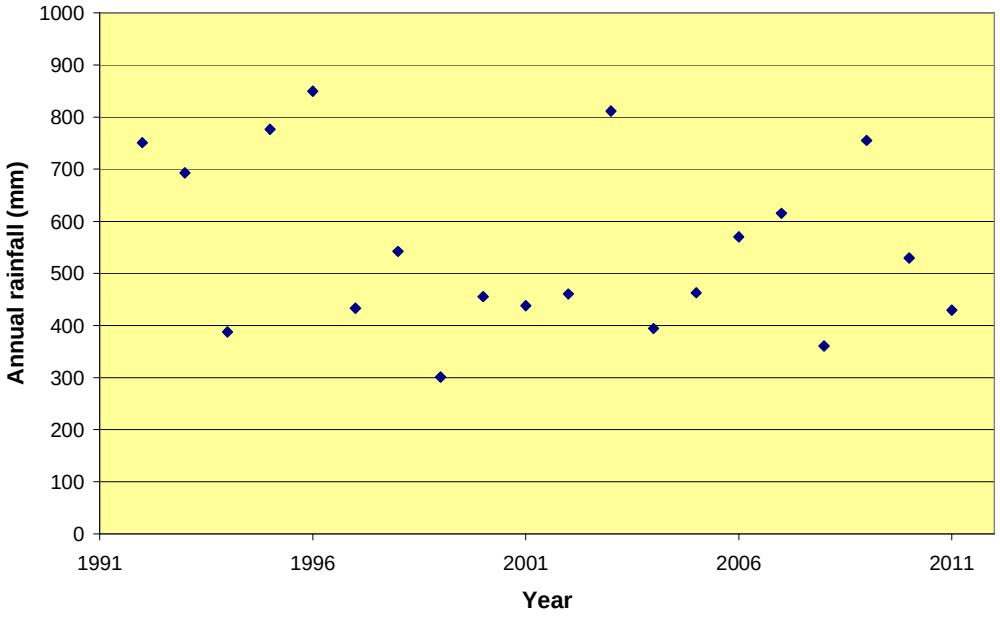
- The experimental activity of the PRO.HU.V.E project was carried out in the Governorate of Nabeul (Tunisia);
- Local climate characterization was performed on the basis of historical data (20 years) recorded in the meteorological station of Kelibia.

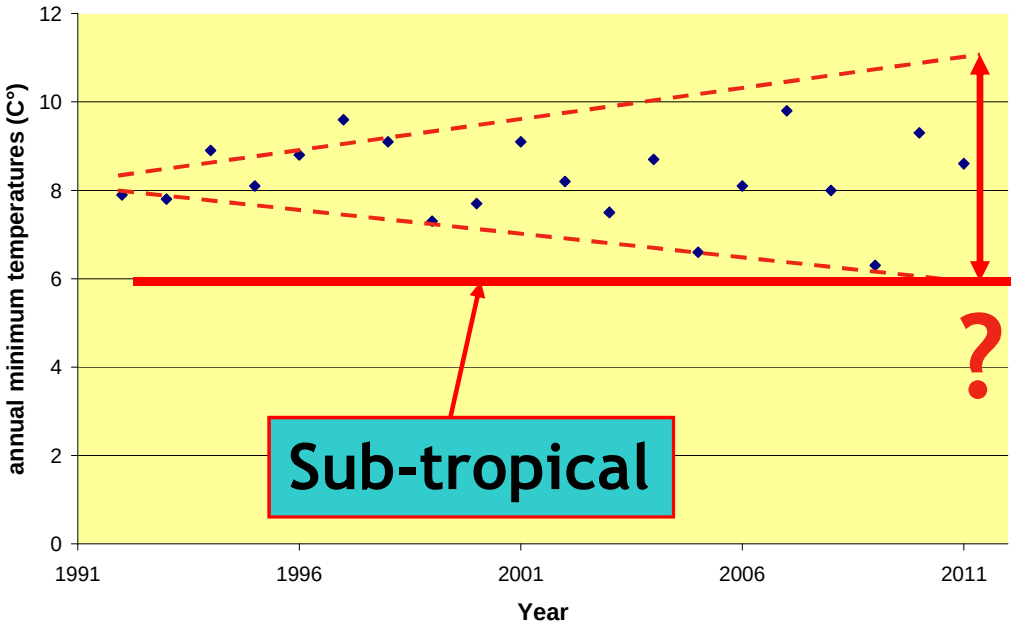
Local climate characterization



- The Bagnouls – Gaussen graph was carried out by processing the Kelibia weather station data of the two decades 1992-2011;
- Climate classification: Sub-tropical. For Trewartha, it is an intermediate climate (between the tropical and the tempered one), including the areas with at least eight months of average temperature above 10° C, while for John F. Griffiths, it is characterized by an average temperature of the coldest month greater than 6 ° .

Local climate characterization





- Global climate change is increasing the variability of **minimum annual temperatures**;
- This may imply (for the future in Tunisia) the use of genotypes (energy crops) more resistant to cold than those chosen in the PRO.HU.V.E project.

Cold resistance of selected crops

Ecology

	Optimal		Absolute	
	Min	Max	Min	Max
Temperat. requir.	11	28	7	36
Rainfall (annual)	500	1500	300	2000
Latitude	-	-	28	30

Jatropha curcas L.

Ecology

	Optimal		Absolute	
	Min	Max	Min	Max
Temperat. requir.	20	35	7	48
Rainfall (annual)	700	2200	400	2600
Latitude	10	10	20	30

Moringa oleifera Lam.

Ecology

	Optimal		Absolute	
	Min	Max	Min	Max
Temperat. requir.	10	25	5	35
Rainfall (annual)	1000	1500	800	1700
Latitude	-	-	30	35
Altitude	---	---	50	2600

Brassica carinata A.Braun

Source: http://ecocrop.fao.org/ecocrop/srv/en/home

Experimental fields in the PRO.HU.V.E project

PROHUVE activity 1

- **Activity 1: Technical and economic evaluation of two crop systems for the production of energy oil: herbaceous crop (*Brassica carinata* A. Braun) and tree crop (*Jatropha curcas* L.):**

- Technical evaluation: all field operations (such as sowing, transplanting, watering, fertilizing, plant protection treatments) were evaluated by identifying the critical factors linked to the territory;

- Economical evaluation: for both crops, the cost of each agricultural operation were detected and used to determine (as a function of crop) the cost per hectare (compared to the yield).

Brassica carinata in the PRO.HU.V.E project: field operations

- In Tunisia, *Brassica carinata* was sown for the first time within the PRO.HU.V.E. project in 2012;
- Annual crop: in Sicily, it is sown between October/November and harvested in June;
- In Sicily it is normally sown in rotation with cereals (such as wheat): separation between food and energy crops (FAO)!!

A

B

C

D

E

F

A: regulation of the sowing machine for *Brassica carinata*; B: sowing operation of *Brassica carinata*; C: germination of *Brassica carinata*; D: *Brassica carinata* plants (Defen variety) at the 4th month; E: *Brassica carinata* (Sincron variety) at the 4th month; F: mechanization of the *Brassica carinata* harvesting

Brassica carinata in PRO.HU.V.E project: field operations

Brassica carinata in the Haouaria field (February 2013)

Brassica carinata in PRO.HU.V.E project: field operations

Brassica carinata in the Haouaria field (April 2013).

Yield (qli/ha):

1. Haouaria field:

(sandy soil)

Sincron: 16,44

Defen: 19,1 (1,91 ton/ha)

2. Mornag field:

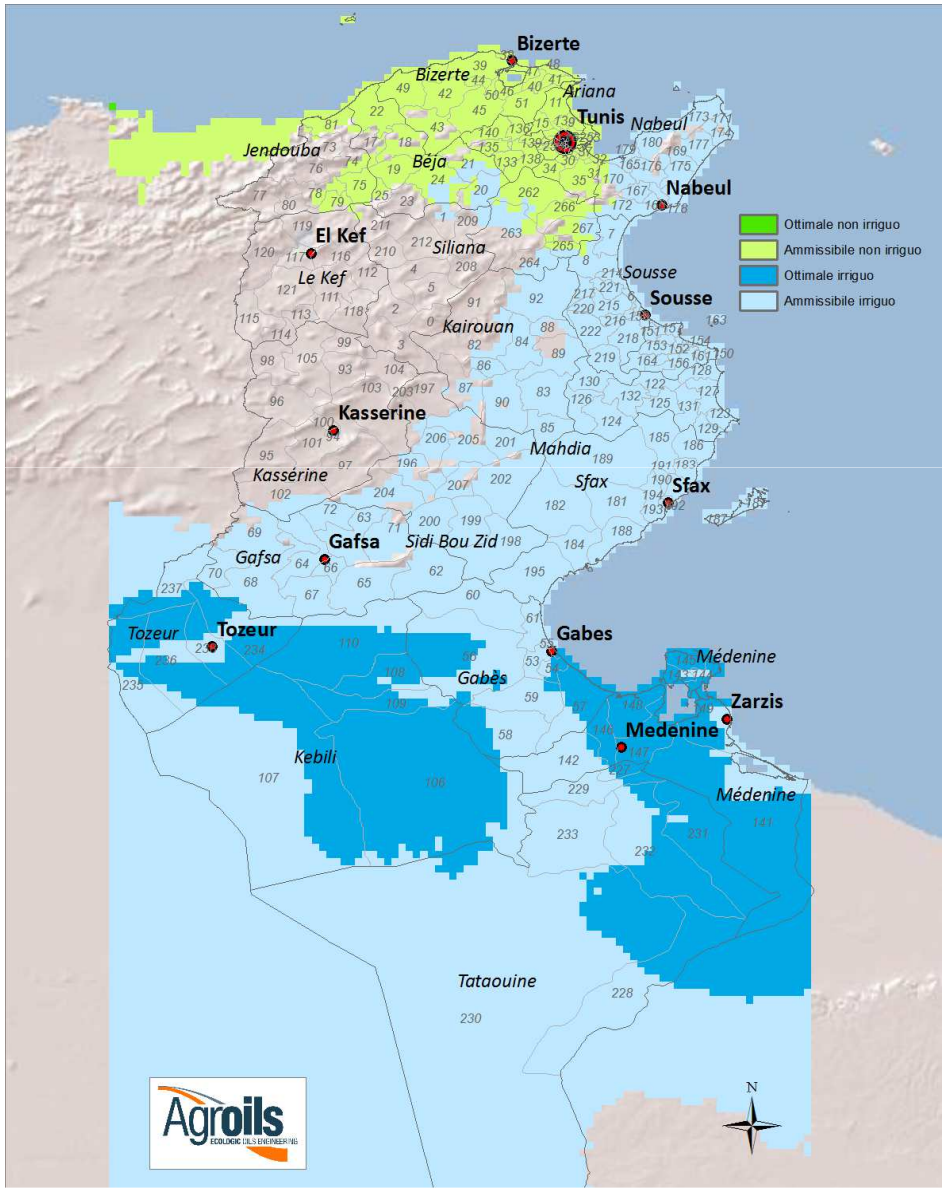
(clay soil: water logging!)

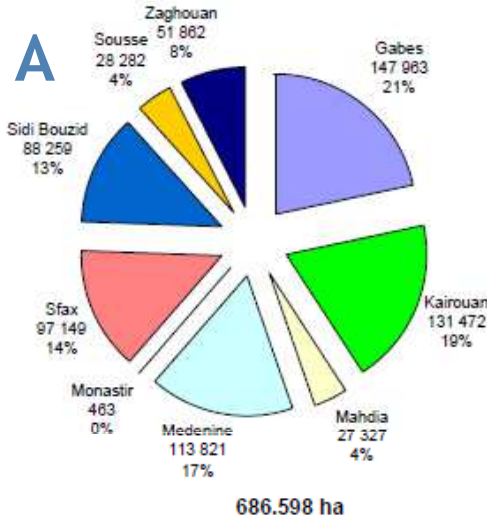
Sincron: 6,05

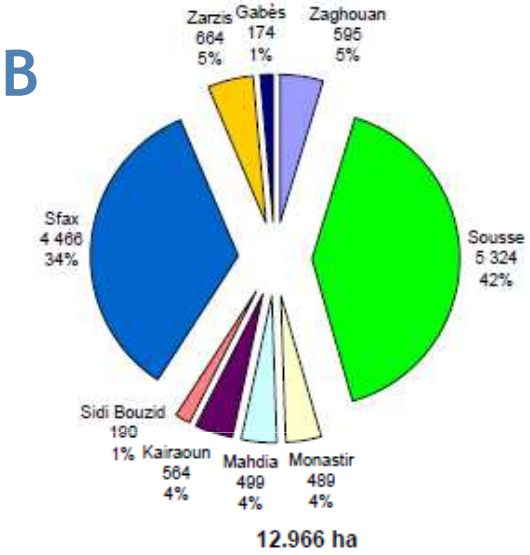
Defen: 7,8

Sicily (2007/08): 1,74 tons/ha (average)

Jatropha curcas in Tunisia: studies already carried out







A: Tunisian lands suitable for *Jatropha curcas* cultivation;

B: Irrigated Tunisian lands suitable for *Jatropha curcas* cultivation.

Source: Etude de l'opportunité de développement d'une filiière de biocarburant à partir du jatropha en Tunisie" by ALCOR (ALCOR-GTZ. 2008).

Jatropha curcas and Moringa oleifera in PRO.HU.V.E project: nursery operations.

Indian genotype

A

B

C

D

(A) e (B): CBBC nursery in Borj Cedria (Centre de Biotechnologie Technopole Borj Cédria); (C) preparation of the soil; (D): preparation of pots for Jatropha curcas e Moringa oleifera.

Jatropha curcas and Moringa oleifera in PRO.HU.V.E project: nursery operations.

Plants of Jatropha c. during the first month

Plants of Jatropha c. during the third month

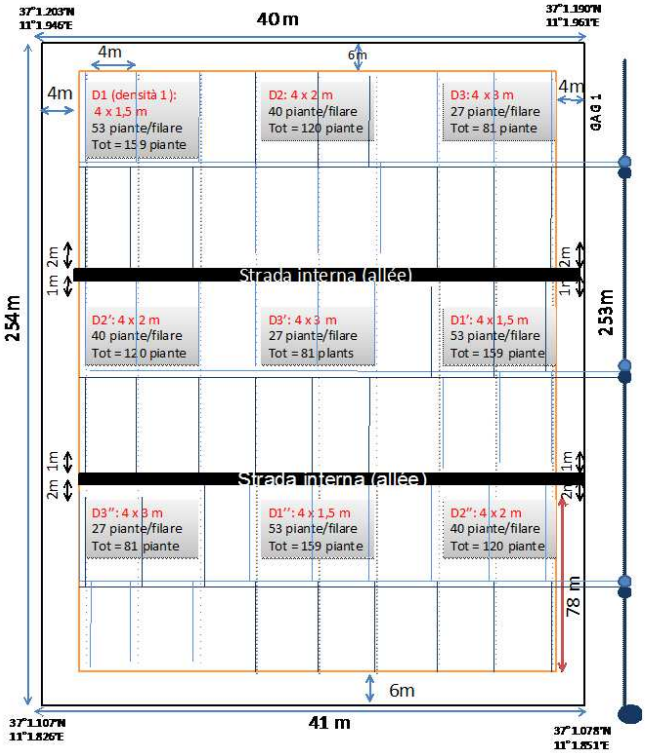
Plants of Moringa oleifera during the first month

Plants of Moringa oleifera during the third month

Jatropha curcas and Moringa oleifera in PRO.HU.V.E project: field operations (Haouaria, first year: 2012).

Inoculation of *Jatropha curcas* plants with mycorrhization

Transplanting of *Jatropha curcas* plants in the field



- Split-split plot randomized blocks design;
- 3 replications;
- 3 treatments:

A - 3 densities;

B - 2 irrigation levels (50 and 80% of ETc);

C - mycorrhization

Jatropha curcas and Moringa oleifera in PRO.HU.V.E project: field operations (Haouaria second year: 2013)

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After winter time (*Jatropha curcas*):

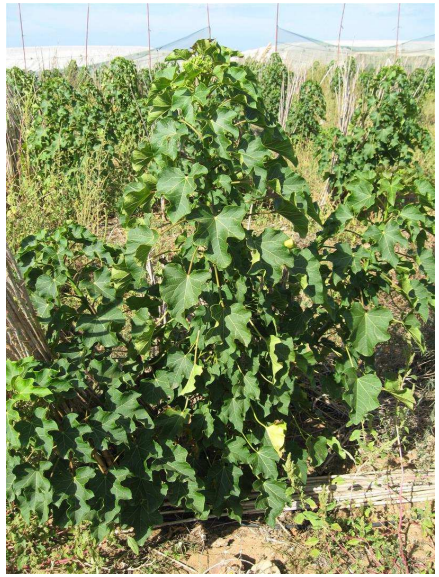
- Mortality due mainly to water logging (*Jatropha curcas*) in the soil and winter cold (*Jatropha curcas and Moringa oleifera*);

-Observed mortality:

***Jatropha curcas*:12%**

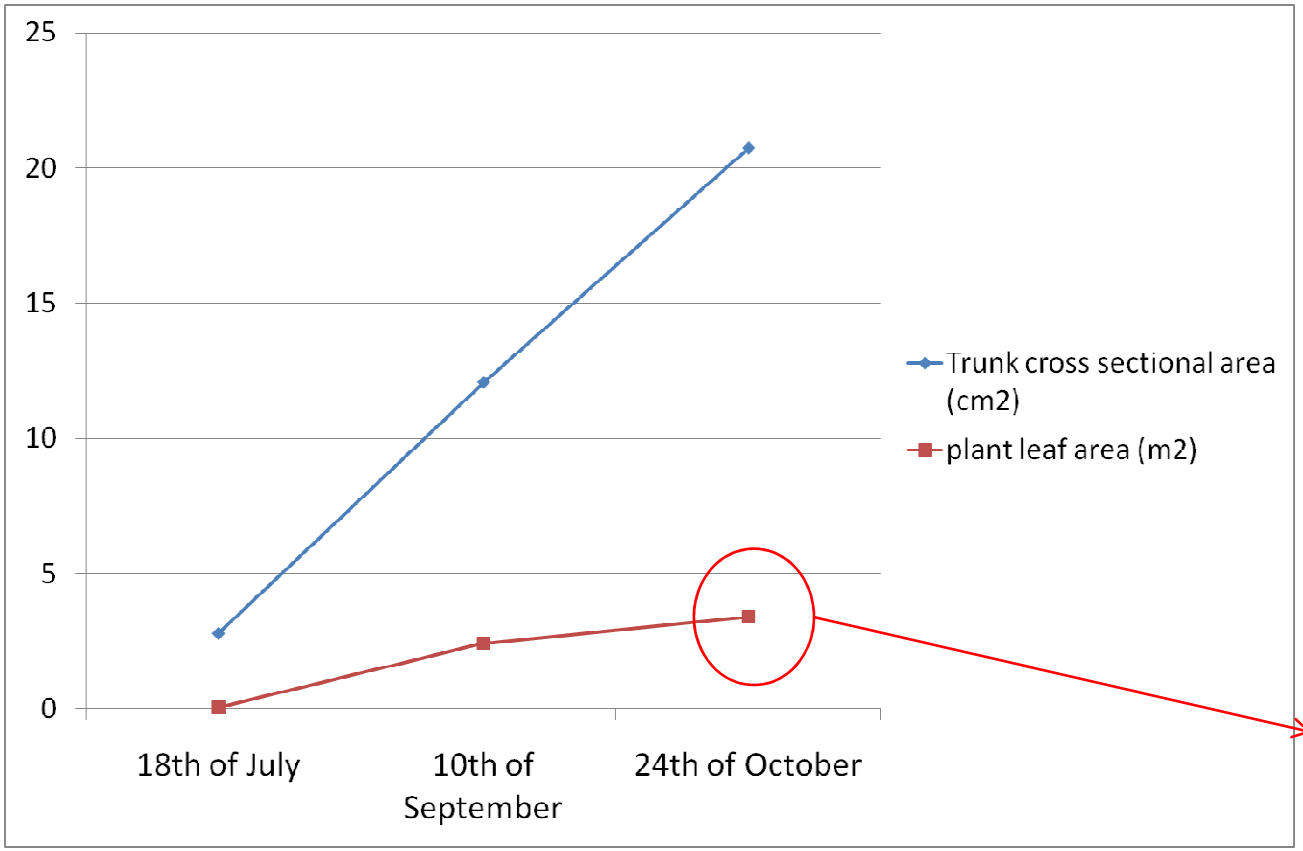
***Moringa oleifera*: 100%**

October 2013 (*Jatropha curcas*):



Jatropha curcas in PRO.HU.V.E project: field operations (second year).

During the growing season, in 3 different time, main vegetative parameters (plant height, trunk cross sectional area and plant leaf area, were measured)



Average among all treatments

Orchard LAI: 0,42

Jatropha curcas in PRO.HU.V.E project: field operations (second year).

Increase of trunk cross sectional area (cm2) observed during last observation (24th of October):

Treatment	Mean ± Standard Error	Treatment	Mean ± Standard Error	Treatment	Mean ± Standard Error
Mycorrhization	0,64 ± 0,034	**Full Irrigation**	0,68 ± 0,04	**Density 1: 1,5x4**	0,64 ± 0,05 **ab**
No-Mycorrhization	0,70 ± 0,004	**Half irrigation**	0,66 ± 0,03	**Density 2: 2x4**	0,76 ± 0,04 **a**
	No significant differences		**No significant differences**	**Density 3: 3x4**	0,61 ± 0,004 **b**

- The highest increase (significant difference) of trunk cross sectional area was observed in trees planted at 2 x 4 meters;
- Significant interactions between mycorrhization and density and between irrigation and density were observed.

Increase of tree leaf area (m2) observed during last observation (24th of October):

Treatment	Mean ± Standard Error	Treatment	Mean ± Standard Error	Treatment	Mean ± Standard Error
Mycorrhization	0,5 ± 0,08	Full Irrigation	0,53 ± 0,09	Density 1: 1,5x4	0,37 ± 0,08
No- Mycorrhization	0,56 ± 0,09	Half irrigation	0,52 ± 0,08	Density 2: 2x4	0,64 ± 0,11
	No significant differences		**No significant differences**	Density 3: 3x4	0,58 ± 0,11
					No significant differences

- The highest increase of tree leaf area was observed in trees planted at 2 x 4 meters (differences were not significant due to the high values of standard error);
- Significant interaction between mycorrhization and irrigation was observed.

PROHUVE activity 1

- **Activity 1: Technical and economic evaluation of two crop systems for the production of energy oil: herbaceous crop (*Brassica carinata* A. Braun) and tree crop (*Jatropha curcas* L.):**

- Technical evaluation: all field operations (such as sowing, transplanting, watering, fertilizing, plant protection treatments) were evaluated by identifying the critical factors linked to the territory;

- Economical evaluation: for both crops, the cost of each agricultural operation were detected and used to determine (as a function of crop) the cost per hectare (compared to the yield).

Specific data collection sheets were prepared in order to detect and monitor the costs in the field

PROHUVE activity 1: data collection sheets

CHAMP EXPERIMENTAL - BRASSICA CARENATA
ANNEE' 2011/2012

PREPARATION DU SOL

Charrure

PERIODE
MACHINE (marque, type, puissance en CH)
OUTIL
PROFONDEUR
TEMPS PAR HECTARE
LOCATION OUI NON COUT PAR HECTARE
AVEC CARBURANT OUI NON COUT CARBURANT PAR LITRE

Ouvrages préparéurs PERIODE ET NOMBRE DES INTERVENTIONES

MACHINE (marque, type, puissance en CH)
OUTIL
TEMPS PAR HECTARE
LOCATION OUI NON COUT PAR HECTARE
AVEC CARBURANT OUI NON COUT CARBURANT PAR LITRE

NOTES:

FUMURE

Avant ensemencement

PERIODE
OUTIL
LOCATION OUI NON
GENRE DU FUMIER
DOSE PAR HECTARE
MACHINE (marque, type, puissance en CH)
TEMPS PAR HECTARE
COUT PAR HECTARE
COUT dt/q

Après ensemencement

PERIODE
OUTIL
LOCATION OUI NON
GENRE DU FUMIER
DOSE PAR HECTARE
MACHINE (marque, type, puissance en CH)
TEMPS PAR HECTARE
COUT PAR HECTARE
COUT dt/q

EN CAS DE LOCATION IL Y A DES OUVRIERS?
OUI NON HEURES PAR HECTARE
NOTES:

ENSEMENCEMENT

CULTIVARS ENSEMENCEES
QUANTITE' PAR HECTARE (Kg/Ha)
COUT dt/q
DOSE PAR HECTARE
PERIODE
MACHINE (marque, type, puissance

PROHUVE activity 1: economic evaluation of two crop systems

	Brassica c.	Jatropha c.	
rental cost (machines)	€ 219,20	€ 27,50	
cost of materials (fertilization, irrigation....)	€ 196,30	€ 75,00	
labor cost	€ 7,81	€ 198,00	
depreciation cost (Inizial investment)	€ -	€ 98,12	
Total costs/Ha	€ 423,31	€ 398,62	
Yeld ton./Ha	1,6	0,7	(*)
cost €/kg seed	0,26	0,57	
vegetable oil %	40	40	
oil production ton./Ha	0,64	0,28	
cost €/ton. Oil	€ 661,42	€ 1.423,64	(**)

(*) With a Jatropha production of 3,75 ton/ha, the "*cost €/kg seed*" could be equal to 0,21;

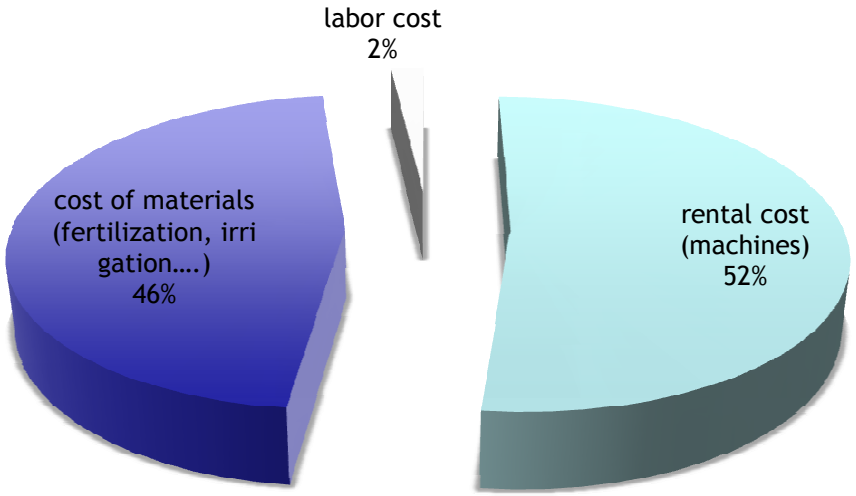
(**) Brassica carinata is a biennial crop: we obtain one oil production in every 2 years!

Cost per year

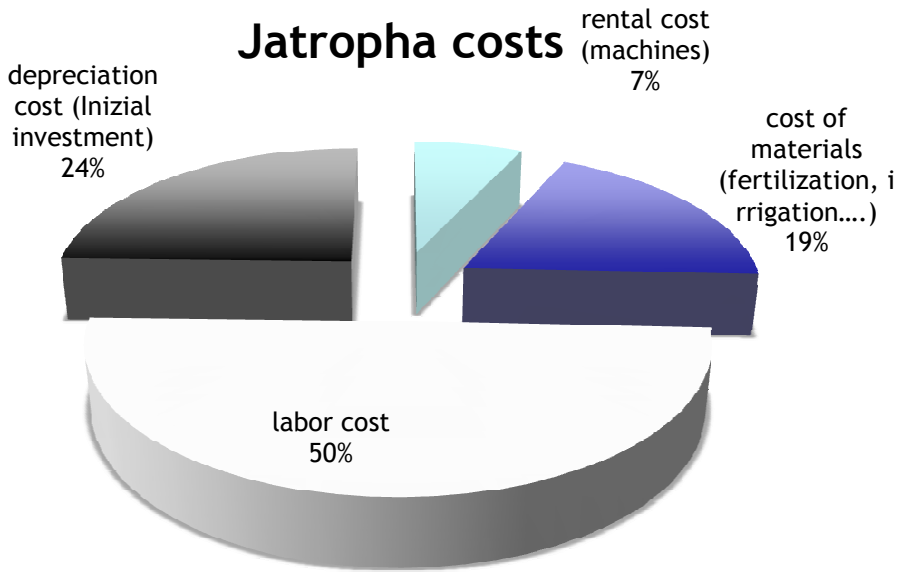
The most productive variety in Nabeul was the "*Brazil - region of Norte de Minas*", with an average yield of 0.7 tons per hectare

PROHUVE activity 1: economic evaluation of two crop systems

Brassica costs



Jatropha costs



PROHUVE sub-activities in activity 2

- Activity 1: Technical and economic evaluation of two crop systems for the production of energy oil: herbaceous crop (*Brassica carinata* A. Braun) and tree crop (*Jatropha curcas* L.);
- Activity 2: assessment of the environmental impact of crops in the northern part of Tunisia:
- *Sub-activity 2.1. Individuation of main water and nutritional requirements;*
- *Sub-activity 2.2 Evaluation of atmospheric CO2 accumulation capacity and carbon credit determination;*
- *Sub-activity 2.3 Possible uses of seed by-products (due to oil extraction, such as press cake); (NO YET!!)*
- *Sub-activity 2.4 Physical-energetic characterization of oil. (NO YET!!)*

Sub-activity 2.1. Individuation of main water and nutritional requirements

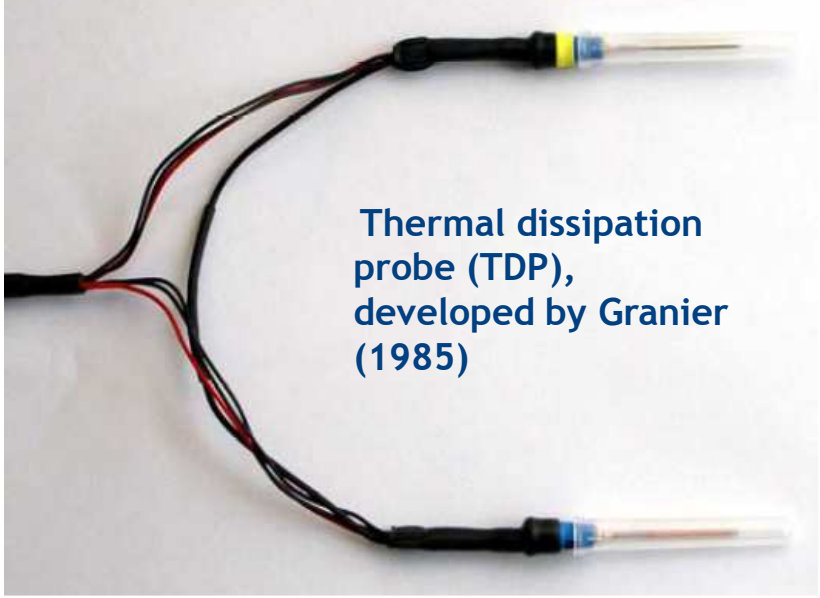
- Referring to the nutritional parameters, we identified (also on the basis of the existing literature) an effective fertilization plan for *Jatropha curcas* and *Moringa oleifera* suitable to our soils (in Tunisia), which can ensure a good balance between vegetative and reproductive plant activity;

- Referring to the water parameters, we are evaluating the plant water consumption (***and so the Kc and W.U.E.***), through the following approaches (*):

- micro-meteorological approach for *Jatropha curcas*: use of sap flow sensors;
- Application of a "soil water balance" for *Brassica carinata*.

(*) In the FAO Irrigation and Drainage Paper n° 56 (and in other scientific papers), Kc for *Brassica carinata e Jatropha curcas* are not contemplated/calculated.

Use of sap flow sensors in *Jatropha curcas*



Thermal dissipation probe (TDP), developed by Granier (1985)

- *Jatropha curcas* field in Nabeul of INRGREF (Institut National de Recherche en Génie Rural Eaux et Forêts). Scientific responsable: Dr Khouja Mohamed Larbi Laboratoire d'Ecolgie Forestière;
- water consumption experiment on *Jatropha curcas* will be carried out in partnership with INRGREF

Use of sap flow sensors in *Jatropha curcas*

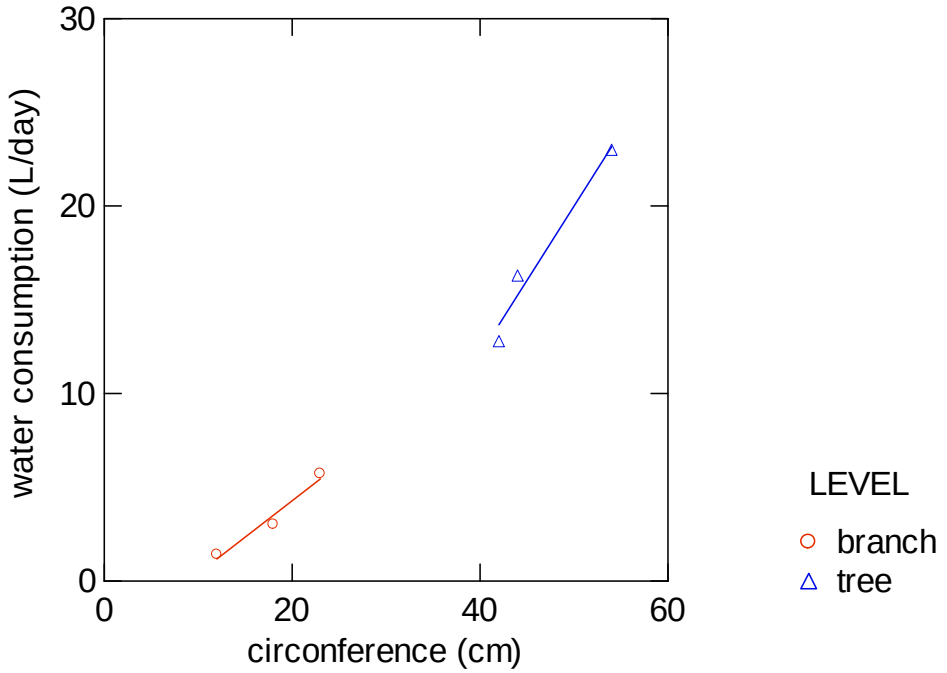
BRANCHING OF JATROPHA CURCAS STARTS VERY CLOSE TO THE GROUND: THE INSTALLATION OF SENSOR ON THE MAIN TRUNK WAS NOT POSSIBLE!

- Trial was carried out in 6 Jatropha curcas plants: 3 irrigated with normal water and 3 with treated water;
- One sap flow sensor was installed on each tree: for each level of treatment (normal or treated water), sensors were installed on 3 different main branches (characterized by different diameter) in order to correlate the branch diameter with the daily branch water consumption;
- through the canopy architecture analysis of the 6 trees, and by using the before obtained correlations, it was possible to obtain the daily tree water consumption;
- Correlating the daily tree water consumption with the plant trunk cross sectional area (measured at 10 cm from the ground), it was possible to determine the variation of tree water consumption as function of the tree vigor;
- For each water typology, an evaluation of the mean trunk cross sectional area was carried out: this allowed to evaluate the daily orchard water consumption.

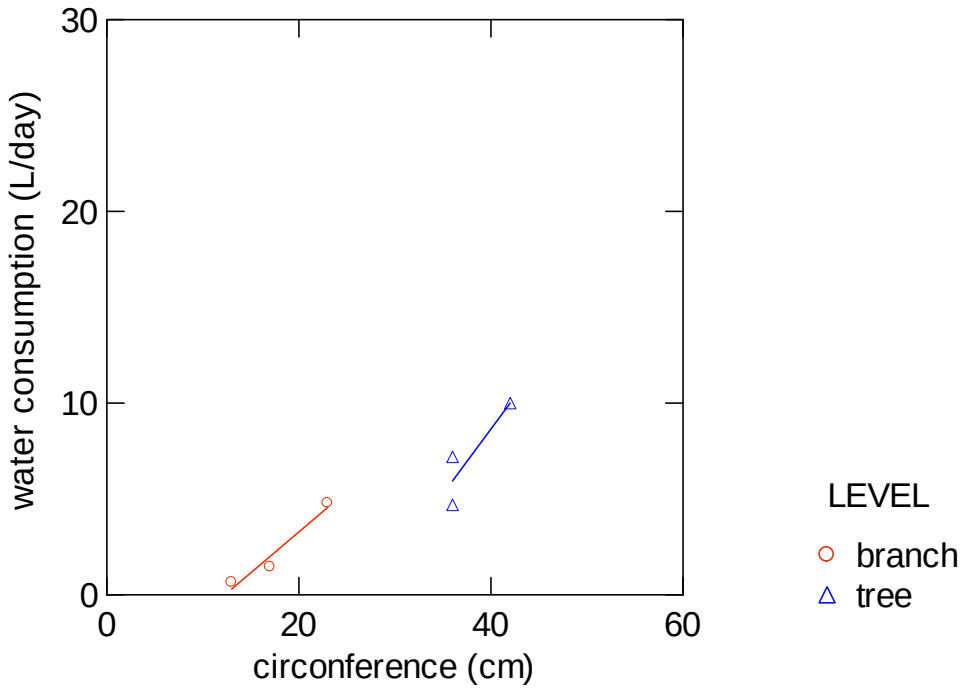
Use of sap flow sensors in *Jatropha curcas*

Use of sap flow sensors in *Jatropha curcas*

Normal water

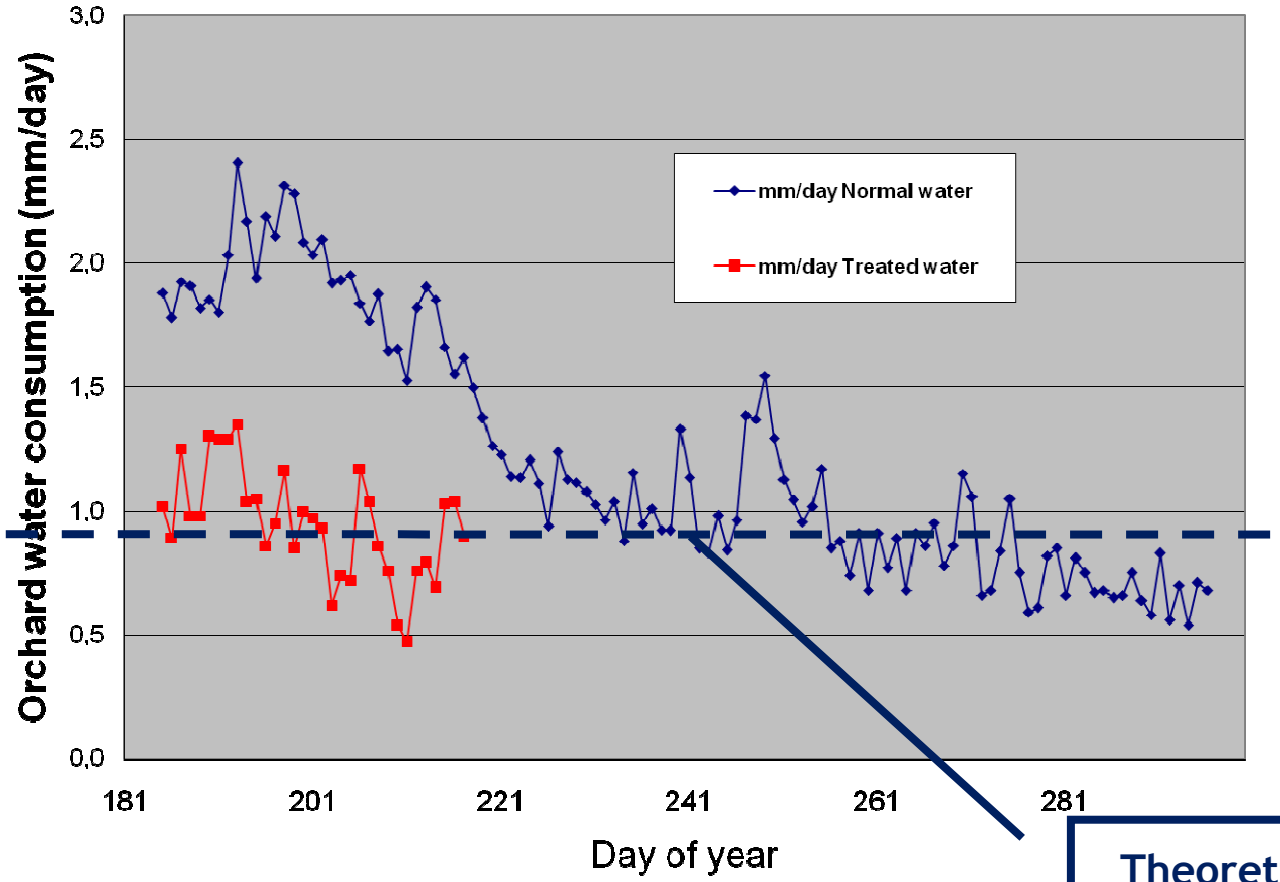


Treated water



Water typology	Trunk cross sectional area(cm^2)	Tree leaf area (m^2)	LAI (m^2/m^2)
Normal water	166 ± 18,4	33,8 ± 5,9	4,2
Treated water	114 ± 8,3	10,3 ± 1,3	1,3

Use of sap flow sensors in *Jatropha curcas*



DOY 181: 30th of June;
DOY 291: 18th of October.

In "normal water plants" a continue decreasing of plant water consumption was observed!:

1. water consumed in June: 54,5 mm/ha;
2. water consumed in August: 33,3 mm/ha;
3. water consumed in September: 28,9 mm/ha.

4. field was irrigated weekly with about 70 m3 per hectare: 28 mm per hectare per month (0,93 mm per day).

Hypothesis for water consumption decreasing:

- from June to September, plants were irrigated with about 1120 m3 (corresponds to 29 mm/ha month);
- considering the sandy nature of the soil, plants received less water then that consumed: also because the weekly scheduling of irrigation (possible water stress!!)

Application of a soil water balance for B*rassica carinata*

University of Milan (Italy)
Faculty of Agriculture
Department of Agricultural Engineering
Agricultural Hydraulics

Water balance FAO-PM v. 2.3

By:
Dr. Gabriele Baroni
Prof. Claudio Gandolfi

Calculation of the water balance of a cropped field with a daily time step using the "single crop coefficient" proposed by FAO (Allen et al. 1998).

The file is divided into different sheets where the data and parameters are processed:

1. *weather station*
2. *meterelogical data*
3. *calculation of the reference evapotranspiration*
4. *choice of crop and reference parameters*
5. *choice of the soil*
6. *management of irrigation*

Last sheet calculates the water balance.

References
[1] Allen R., Pereira L.S., Raes D., and Smith M.: FAO, Irrigation and drainage Paper 56, Crop evapotranspiration. Guidelines for computing crop water requirements, 1998.
[2] C. Gandolfi, Ortuani, A. Facchi, D. Ferrari, M. Rienzner, A. Tediosi, D. Casati, G. Sali, C. Bulgheroni, G. Provolo, L. Baldi: Governo dell'acqua in Lombardia verso gli standard europei : definizione e validazione tecnico-scientifica delle azioni prioritarie previste dal piano di bacino idrografico : Parte B. Analisi degli effetti di variazioni di uso del suolo sui fabbisogni irrigui. Fase 2 / B. Regione Lombardia. Responsabile di progetto: Alessandro Colombo, IReR. Codice IReR: 2007B058. pagg. 419, 2008.
[3] ERSAL (Ente Regionale Sviluppo Agricolo Lombardo), Progetto carta pedologica – Regione Lombardia, 2001.
[4] Rawls W.J. and Brakensiek D.L.: Estimation of soil water retention and hydraulic properties. In: H.J. Morel-Seytoux, Editor, Unsaturated flow in hydrologic modelling, Theory and Practice, Kluwer Academic Publishers, pp. 275–300, 1989.

Info: *gabriele.baroni@hotmail.it*

Input of the model:

- Evolution of LAI;
- Soil moisture;
- Phenological stage;
- Meteorological data (Air temperature and humidity, wind speed, solar radiation and rain)

Output of the model:

Brassica carinata Kc

NOT YET READY

Baroni G., Gandolfi C. (2009): Reference manual of the spreadsheet Water balance with FAO –Penman Monteith method v.2.0 (In Italian)

Application of a soil water balance for B*rassica carinata*

Day of the year	variety	Root depth (cm)	Plant height (cm)	Number of plants per m2	LAI (m2/m2)
352 (2012)	Syncron	2,8 ± 0,3	6,9 ± 0,5	130,7 ± 18,5	0,06 ± 0,01
	Defen	3,9 ± 0,2	8,2 ± 0,3	147,0 ± 33,9	0,07 ± 0,02
7 (2013)	Syncron	9,4 ± 0,7	16,0 ± 1,2	92,0 ± 7,3	0,26 ± 0,05
	Defen	7,8 ± 0,7	18,6 ± 1,4	98,7 ± 18,9	0,54 ± 0,15
85	Syncron	19,9 ± 0,9	102,0 ± 4,7	88,0 ± 17,2	2,18 ± 0,34
	Defen	23,7 ± 2,8	122,0 ± 10,3	57,3 ± 15,2	2,97 ± 1,10
106	Syncron	15,0 ± 1,5	122,0 ± 5,8	87,0 ± 17,2	0,80 ± 0,20
	Defen	19,0 ± 1,4	188,9 ± 7,0	56,0 ± 15,2	0,74 ± 0,10
150	Syncron	17,3 ± 1,6	131,6 ± 6,2	67,3 ± 5,8	0
	Defen	21,0 ± 1,1	201,0 ± 10,1	56,0 ± 10,4	0

Observation were carried out sampling (casually) 3 plants in 3 different zone (1 m2 each) in each experimental plot: also the 3 zones were casually chosen during each campaign (Haouaria site).

Sub-activity 2.2 Evaluation of atmospheric CO2 accumulation capacity and carbon credit determination

The CDM (Clean Development Mechanism) projects are those implemented by the countries included in Annex I of the Kyoto Protocol, in developing countries (Non-Annex I Countries) with the dual purpose of:

- Increasing the absorption or reduce emissions of greenhouse gases whose generated credits (Certified Emission Reductions - CERs) can be accounted in the National Register of greenhouse gases in the country that funded the project;
- Helping countries to pursue their development objectives of sustainable development.

Among the possible CDM projects, reforestation/afforestation may be included:

- Decision 16/CMP.1 , Land use, land-use change and forestry:

"Forest" is a minimum area of land of 0.05–1.0 hectare with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 metres are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest

Sub-activity 2.2 Evaluation of atmospheric CO2 accumulation capacity and carbon credit determination

Atmospheric CO2 accumulation in *Jatropha curcas* was obtained using a specific allometric relation (*Hellings B. 2012*):

$$SSC = 0.0042\ D^{2.8361}\ (R^2 \geq 0,84)$$

where SSC is the total canopy dry matter accumulation (Kg); D is the trunk diameter.

This allometric relation was applied on the Jatropha curcas plants in Nabeul (normal water):

Irrigation treatment	Trunk cross sectional area (cm^2)	Tree leaf area (m^2)	LAI (m^2/m^2)
"normal" water	166 ± 18,4	33,8 ± 5,9	4,2
"treated" water	114 ± 8,3	10,3 ± 1,3	1,3

At the present time, "normal water" plants (INGREF) accumulated about 16 tons/ha of CO2.

Brassica carinata (Haouaria field):

	Haouaria	Mornag
Defen	3,11	0,79
Sincron	1,75	0,78

Biomass (expressed in tons/ha of atmosferic CO2) measured during harvesting time.

Sub-activity 2.3 Possible uses of seed by-products ;

Sub-activity 2.4 Physic-energetic characterization of energy oil.

- Calorific value (kJ/kg);
- Kinematic viscosity at 40° ;
- Acidity (KOH / g);
- Water content (Mg/Kg);
- phosphorus content (Mg/Kg).

Energy plant seeds → • Soxhlet method • Mechanical extraction → -Oil, -press cake

- ashes
- Organic matter (%);
- humidity;
- pH;
- total nitrogen (N);
- phosphorus and potassium

Chemical oil extraction from *Brassica carinata* seeds in CBBC lab

Conclusions

- *Jatropha curcas*: Tunisian winter temperatures in the future could be a problem for the cultivation of this crop (global climate change). Moreover, the irrigation appears to be fundamental to have an economical sustainable yield;

- *Brassica carinata*: best results were obtained on sandy Tunisian soils;

- In choosing between the two crops, it should be considered that the *Brassica carinata* **is sown in rotation with cereals,** so it does not produce vegetable energy oil each year (as is the case of *Jatropha curcas*);

- Given the variability of the biofuels economic policies in the world, it might be risky to invest in *Jatropha curcas*, given that the permanence of this crop is at least 30 years;

- The intercropping of food crops in plantations of *Jatropha curcas*, could be an ideal solution to avoid the "separation" of food crops from the energy ones: need for research activity especially for *Jatropha curcas* (poisonous substances released into the soil)!