Botswana-Japan SATREPS Project

Information-based optimization of Jatropha Biomass Energy Production in the Frost and Drought-Prone regions of Botswana

GSB & LACAf August Meeting
Piracicaba SP/ Brazil 27-29, August, 2014

SATREPS: Science and Technology Research Partnership for Sustainable Development
Japan International Cooperation Agency (JICA)
Japan Science and Technology Agency (JST)

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Jun KIKUCHI (RIKEN Institute)
Yoshinobu KAWAMITSU (University of the Ryukyus)
Masami UENO (University of the Ryukyus)

About our activities on sugarcane

Faculty of Agriculture, University of the Ryukyus

Research

ICT and model based high production system

Effective sugarcane biomass utilization system
bioenergy and materials

Mechanization of cultivation system

Technical training; JICA

Sustainable utilization of biomass/bioenergy in Tropics; two months course

Cultivation area of sugarcane in Japan

Sugarcane production:

1,300,000t/ year

Number of mills:

17 factories (14 islands)

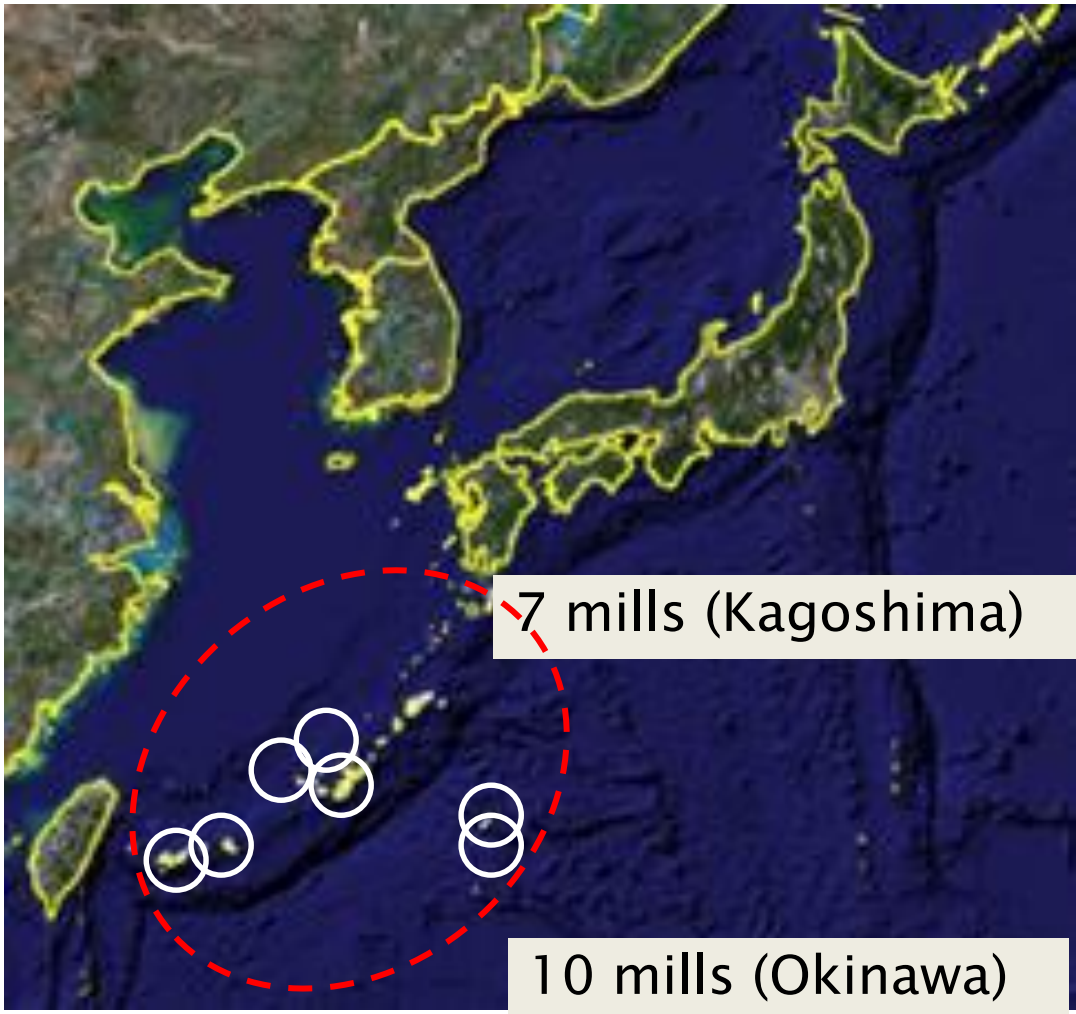
Feature of the cultivation

/ More than 50% farmer cultivate sugarcane

/ Number of fields:

more than 1,400,000-

/ Price of cane: 200$/t



Smart farming using NIR and spatial/time series analysis

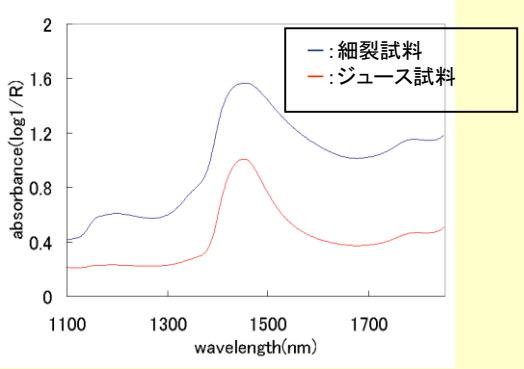
17 sugar mill's NIR system and UR's system are net-warking.

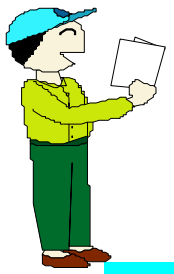
Cultivation

Harvesting/ transportation

NIR measurement of SC

NIR spectrum data





We can replace this method to soil analysis

Pol in cane for payment

Prediction of components in cane stalk

Smart farming

Database

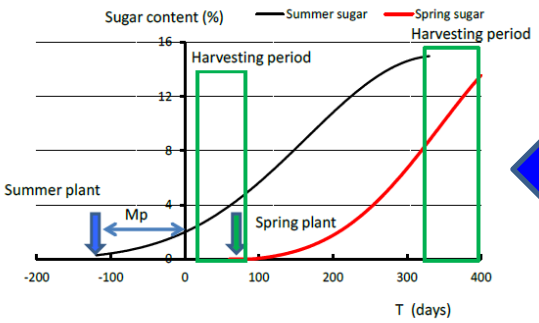
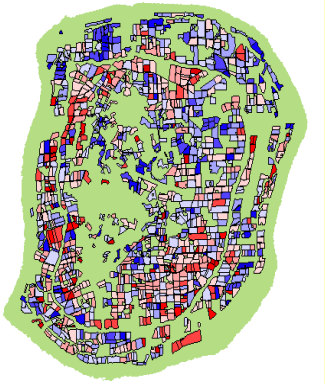
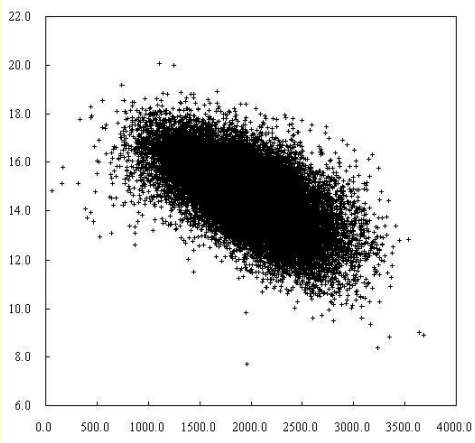


Fig. 2—Sugar content models.



Sugar production analysis



Potasium and Pol in cane

GIS

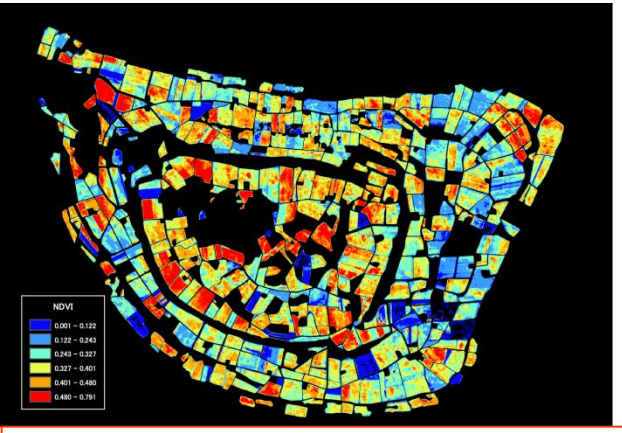
Mapping/Analysis

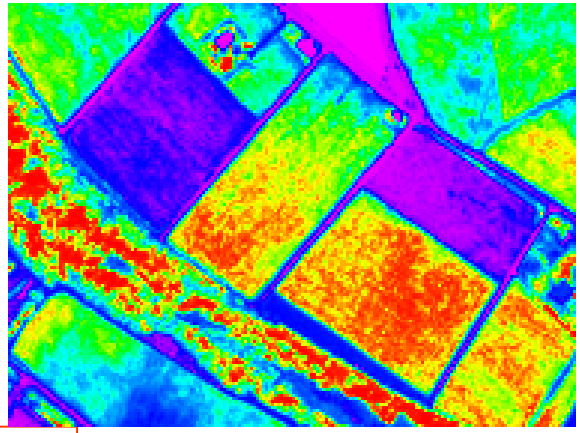
Evaluation of productive capacity using RS

It is necessary to collect information from the wide area efficiently to harmonize the environmental preservation and the production. The most powerful tool for the purpose is the remote sensing, mobile sensing, GIS, and GPS.

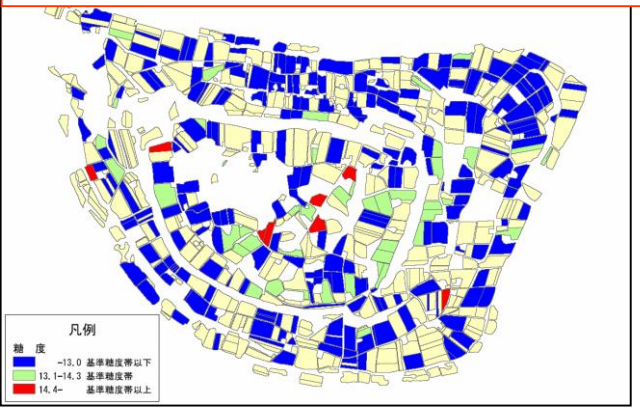
Measurement of plant biomass production by satellite remote sensing

Various adjacent RS are available to collect the right occasional data.



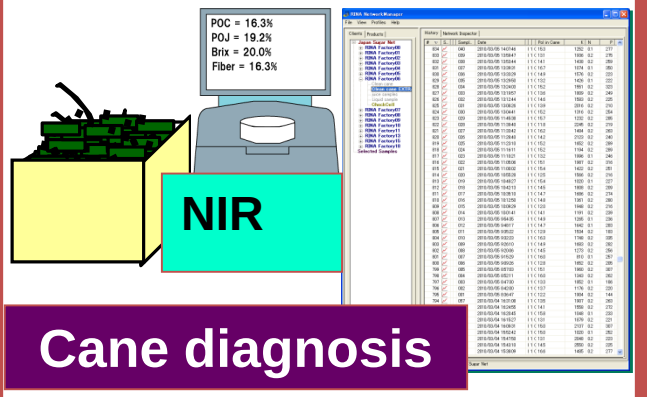


Evaluation of sugarcane production using GIS



Maximization of sugar production; from field to mill

Grower payment



Cane diagnosis

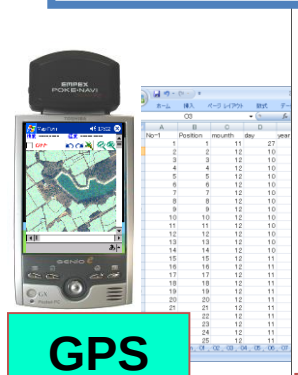
Fertilizer/water/

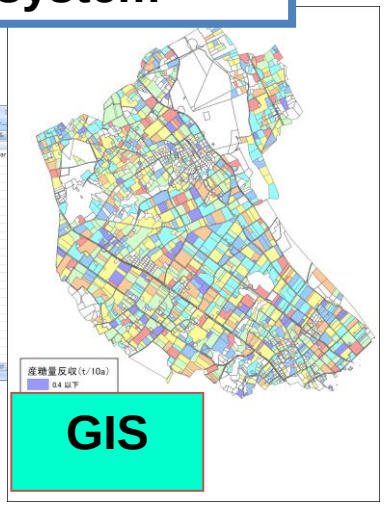
Land/labor

management

Harvest scheduling

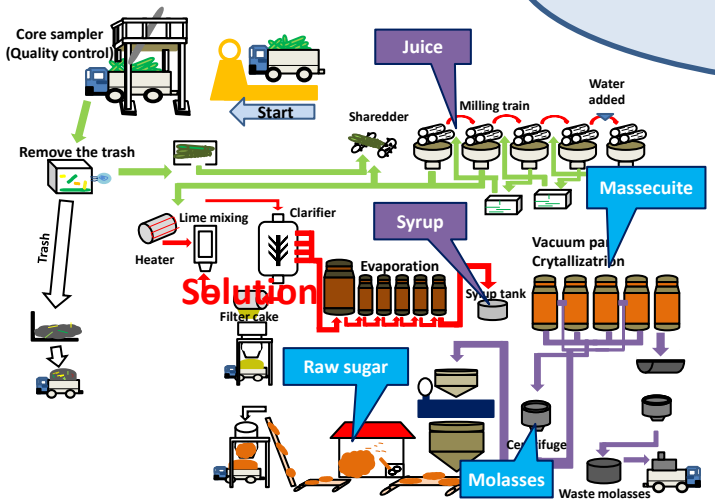
GIS system





Spatial analysis

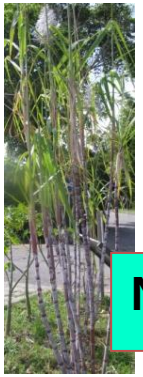
Optimization of sugar yield



Process control

Raw juice
Heated
Syrup
Molasses
Bagasse

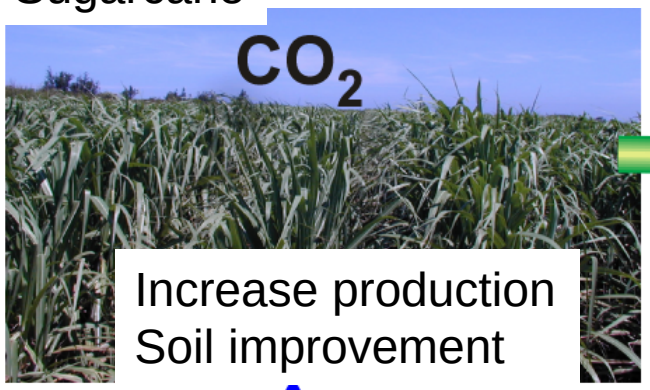
On-site analysis



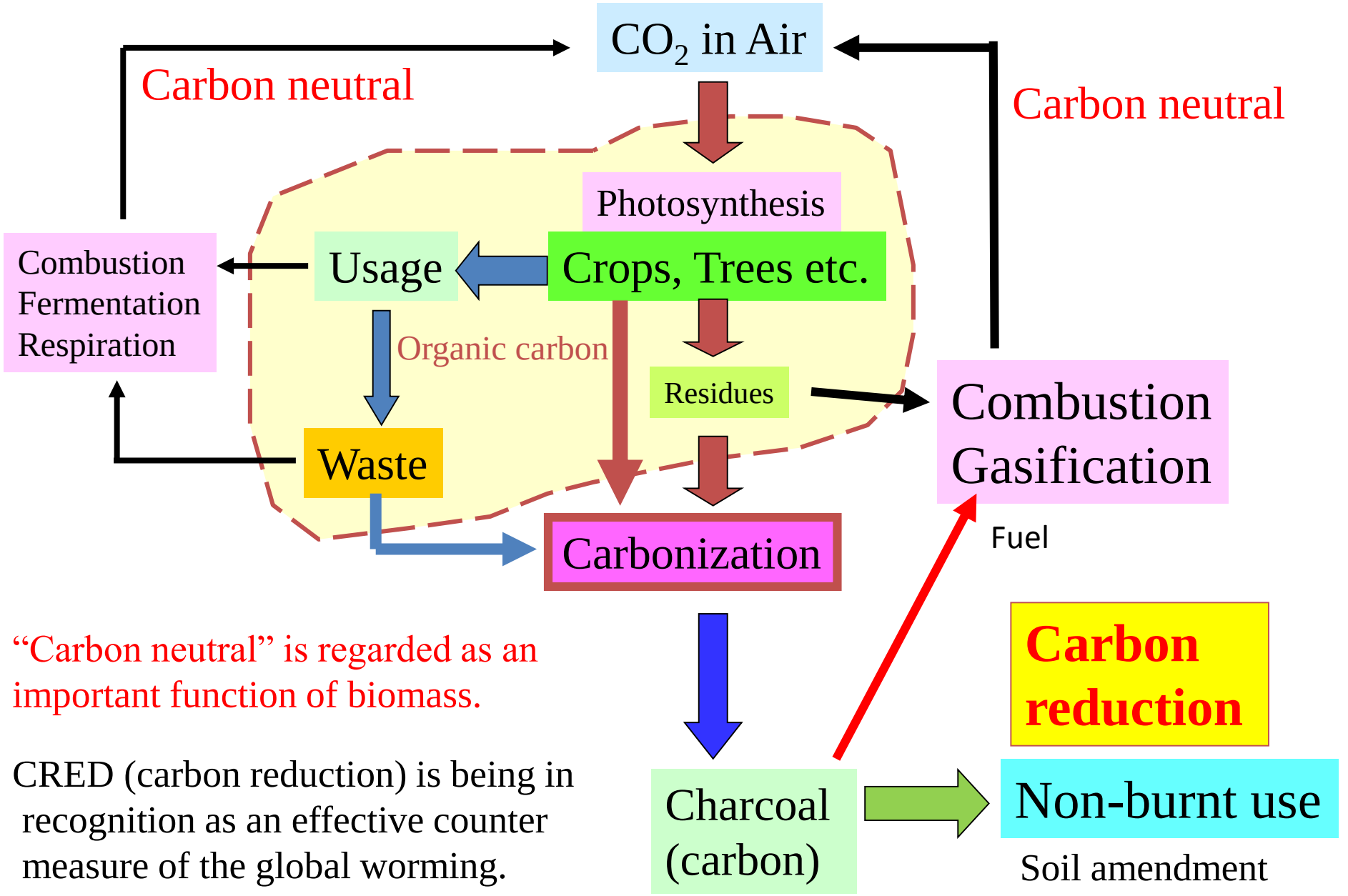
Cane diagnosis

Long term CO_2 fixing by Bagasse charcoal

Carbonization is very effective countermeasure to the global worming.



Flow of carbon by carbonization



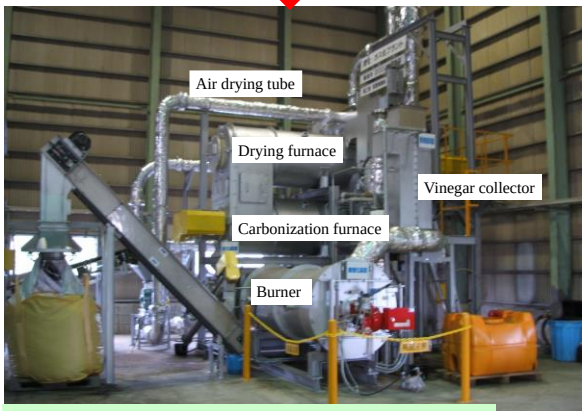
"Carbon neutral" is regarded as an important function of biomass.

CRED (carbon reduction) is being in recognition as an effective counter measure of the global worming.

Use of bagasse charcoal as material

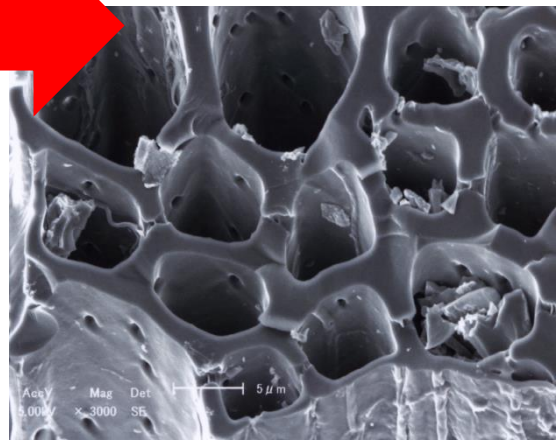
Bagasse

Bagasse is useful not only for co-generation but for charcoal.



Carbonization furnace

Bagasse charcoal



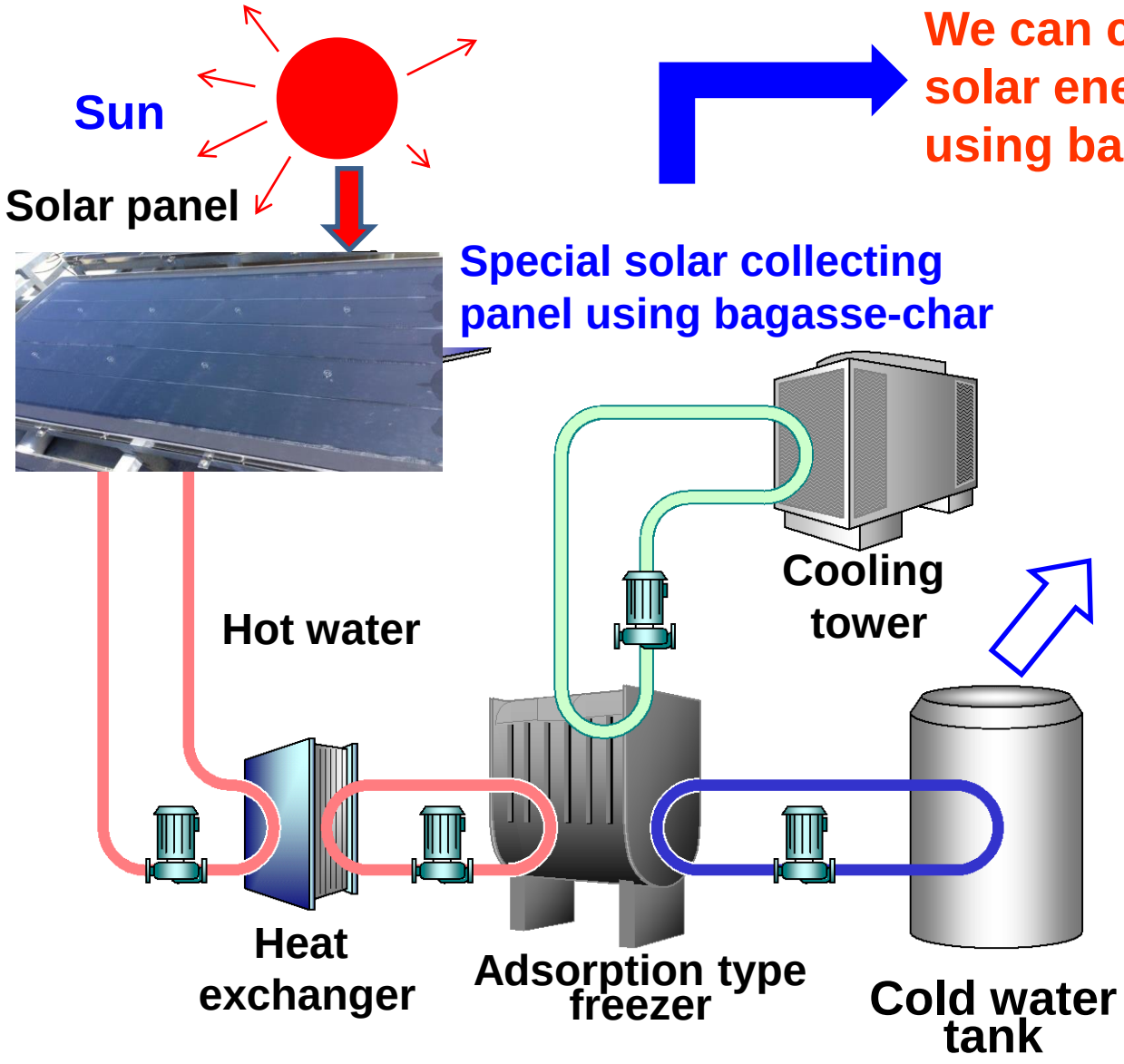
Soil amendment

Absorbent

Solar energy collector

Hybrid solar energy use system for drinking water from sea water/ polluted water.
Air conditioning system and so on.

Solar thermal energy utilization system by bagasse charcoal regarded as indirect energy



Plant factory and office Air conditioning system


Congresso e Exposição de Tecnologia Sucroenergéti
Sugar-Energy Technology Congress and Exhibition
ISGEC
ISGEC HEAVY ENGINEERING LTD.
UTTAM SUCROTECH INTERNATIONAL
SERMATEC zanini.
FMC
BLADE
CASE IH

2013

1996

My presentation starts from here.

Why Jatropha project in Botswana?

NEWS

Botswana plans a 50m-litre per year bio diesel plant

MONKAGEDI GAOTLHOBOGWE
STAFF WRITER

Coal-rich Botswana has announced its ambitious plans to reduce carbon emissions by setting up a 50 million-litre per year bio-diesel processing plant to be fed from jatropha (oil seed) plantations by 2012.

The project will be funded from the National Petroleum Fund as Botswana joins the fight against climate change and global warming.

Article Tools
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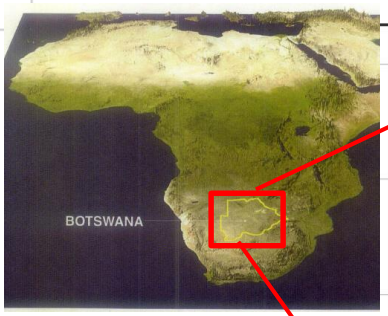
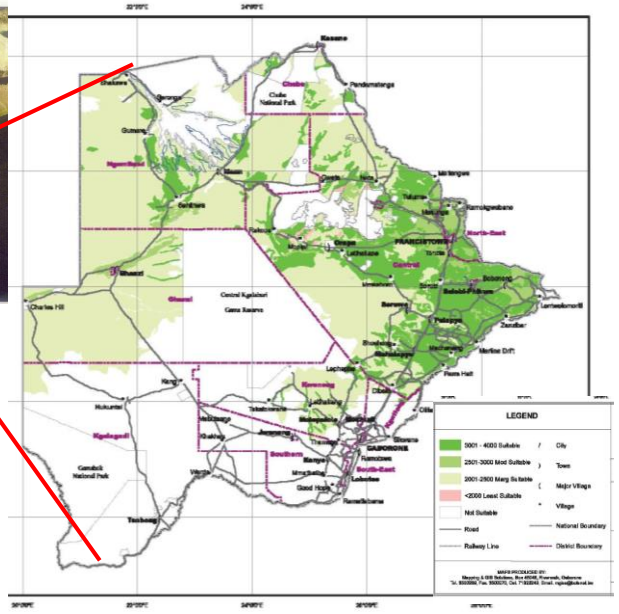
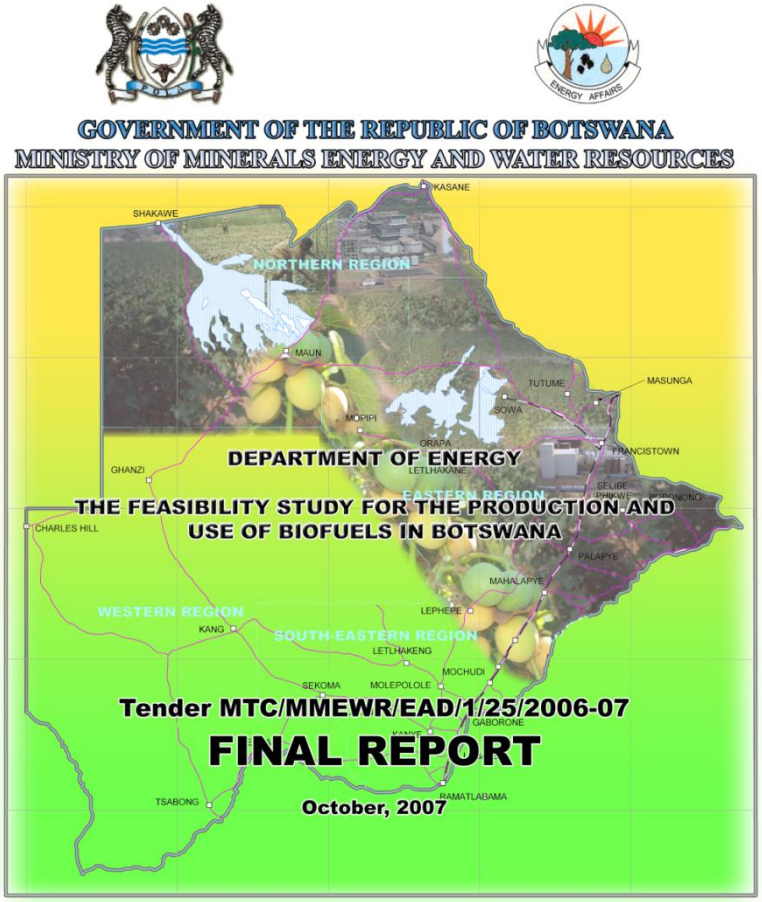
- ✓Organized by the Ministry of Mine, Energy and Water Resources, Botswana.
- ✓5 ML is from beef tallow, and 45 ML is from Jatropha.
- ✓First processing plant to be built in the southern part of Botswana
- ✓Target land of 70,000 ha for Jatropha production

Researchers and officers from Botswana and Japanese institutes in Sebele Gaborone. Aug 10, 2010





Botswana carried out the feasibility study for BDF production



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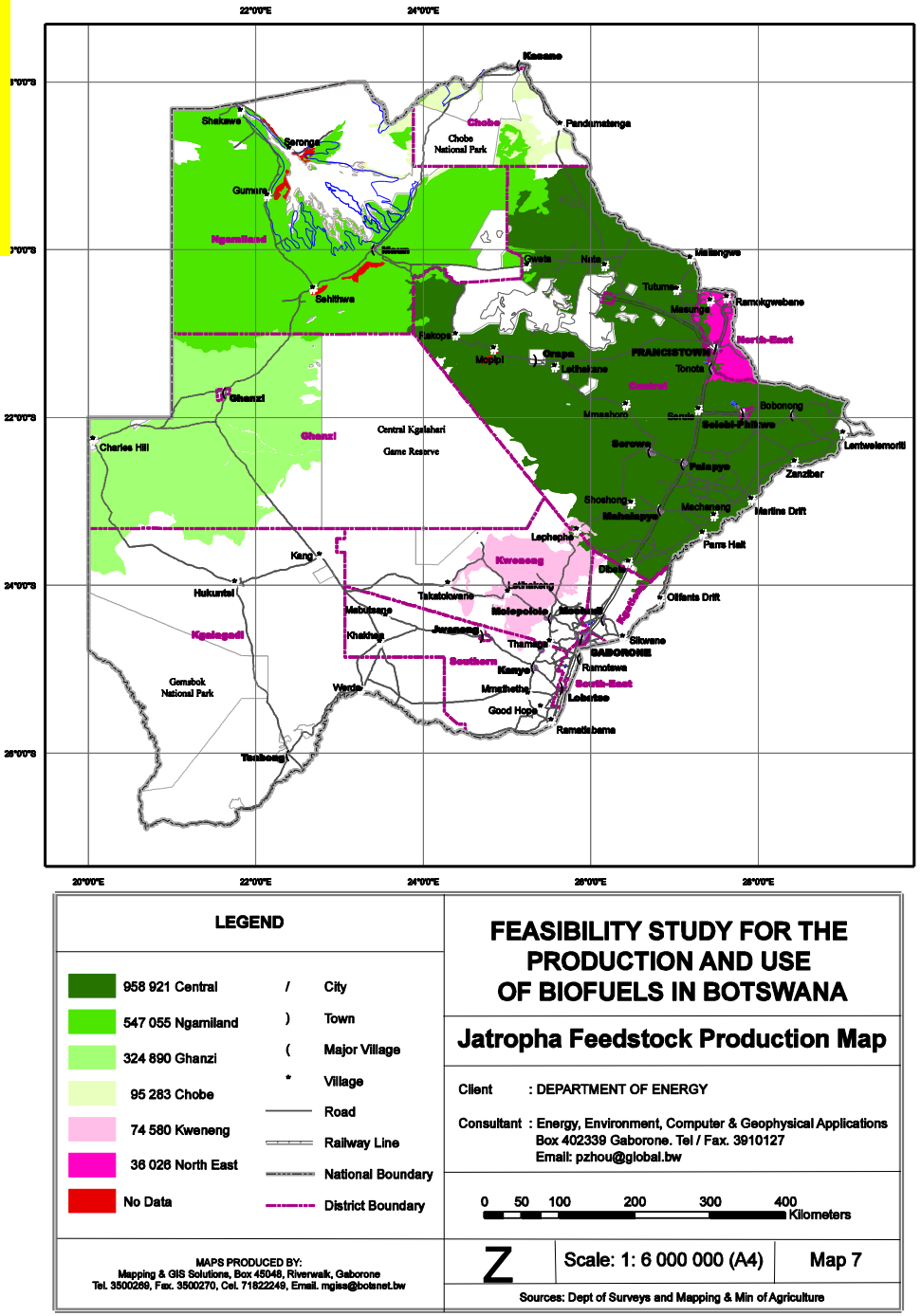


LEGEND		
958 921 Central	/	City
547 055 Ngamiland	)	Town
324 890 Ghanzi	(	Major Village
95 283 Chobe	*	Village
74 580 Kweneng		Road
36 026 North East		Railway Line
No Data		National Boundary
		District Boundary

FEASIBILITY STUDY FOR THE PRODUCTION AND USE OF BIOFUELS IN BOTSWANA

Jatropha Feedstock Production Map

Client : DEPARTMENT OF ENERGY

Consultant : Energy, Environment, Computer & Geophysical Applications
Box 402339 Gaborone. Tel / Fax. 3910127
Email: pzhou@global.bw

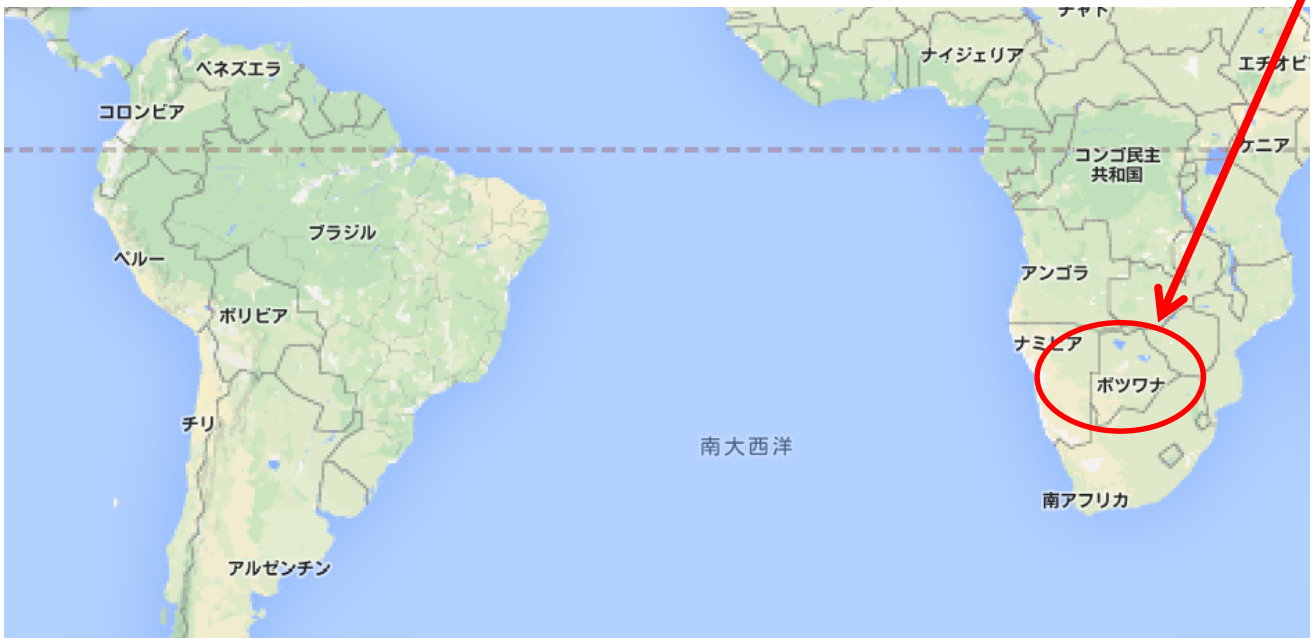
0 50 100 200 300 400 Kilometers

MAPS PRODUCED BY:
Mapping & GIS Solutions, Box 45048, Riverwalk, Gaborone
Tel. 3500268, Fax. 3500270, Cel. 71822249, Email. mgiss@botsnet.bw

Z | Scale: 1: 6 000 000 (A4) | Map 7

Sources: Dept of Surveys and Mapping & Min of Agriculture

JICA-JST SATREPS Project on Jatropha R&D in Botswana



Minister of MMEWR and Japanese Research Team
Aug 8, 2010

A reckless challenge?

Jatropha in Botswana

Winter

June 24, 2011

10 Aug., 2010

Status on Jatropha cultivation in Botswana

- ✓ Jatropha seed production is inhibited due to severe water deficits and winter cold.
- ✓ Large fluctuations in the precipitation and temperature makes management of the cultivation difficult
- ✓ Suitable Jatropha variety and its farming methods are not yet established

Outline of the Project

Botswana-Japan Jatropha Research Project

- Objectives:

  Establishment of technical platforms for production and utilization of Jatropha biomass in a dry/cold climate in Botswana

- Major target milestones:

  Seed production of 2.5 t/ha equivalent

  At least one improved Jatropha variety

  Research thesis for 6 master/PhD degree

- Duration of the project:

  From April 2012 to March 2017 (5 years)

Organization of the SATREPS Project in Botswana

Energy Affair Dept.

- Project planning and management
- Socio-economy evaluation

Dept. Agriculture

- Jatropha farming
- Germline characterization

Univ. Botswana

- Jatropha physiology
- Biodiesel characterization

Univ. Ryukyus

- ICT-farming of Jatropha
- Biomass utilization

Tottori Univ.

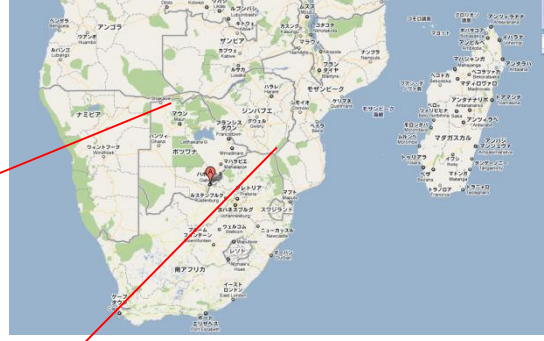
- Jatropha breeding
- Transgenic Jatropha

RIKEN

- Field biota omics
- Biomass profiling

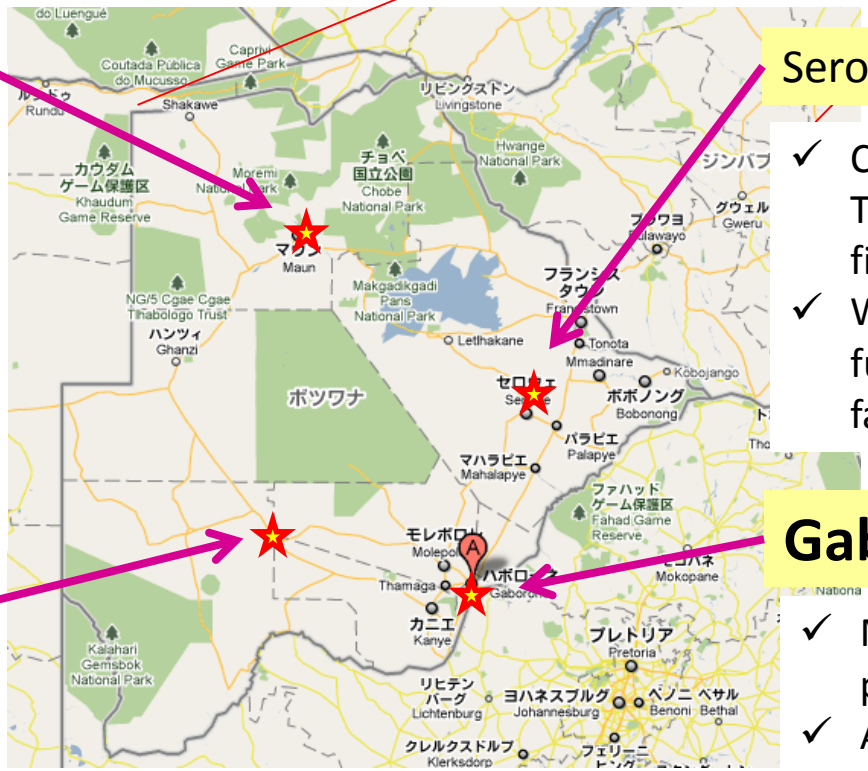
Since 2004, research collaboration on arid land plant geneticresources has been carried out between two countries.

Target geological areas for Jatropha research



Maun

- ✓ Jatropha field trial at DAR-Maun station
- ✓ Rich resources for Jatropha indigenous germlines
- ✓ Weather station is installed for future extention of ICT-based farming



Serowe

- ✓ Collaboration with Boiteko-Trust, which perfoms Jatropha field trial using indigenous lines
- ✓ Weather station is installed for future extension of ICT-based farming

Kang

- ✓ Dryland farming research at DAR station
- ✓ Weather station is installed for future extention of ICT-based farming

Gaborone (Sebele)

- ✓ Major research activity in this project
- ✓ A model place for dry/cold climate in which techniques of Jatropha production to be established
- ✓ High-tech research environment for capacity building

Botswana-Japan Jatropha SAREPS Project

Information-based optimization of Jatropha biomass energy production
in the frost- and drought-prone regions of Botswana

Research targets: Establishing technologies for:

1. Farming method suitable for Botswana climate

2. Breeding of Jatropha variety for higher and stable production

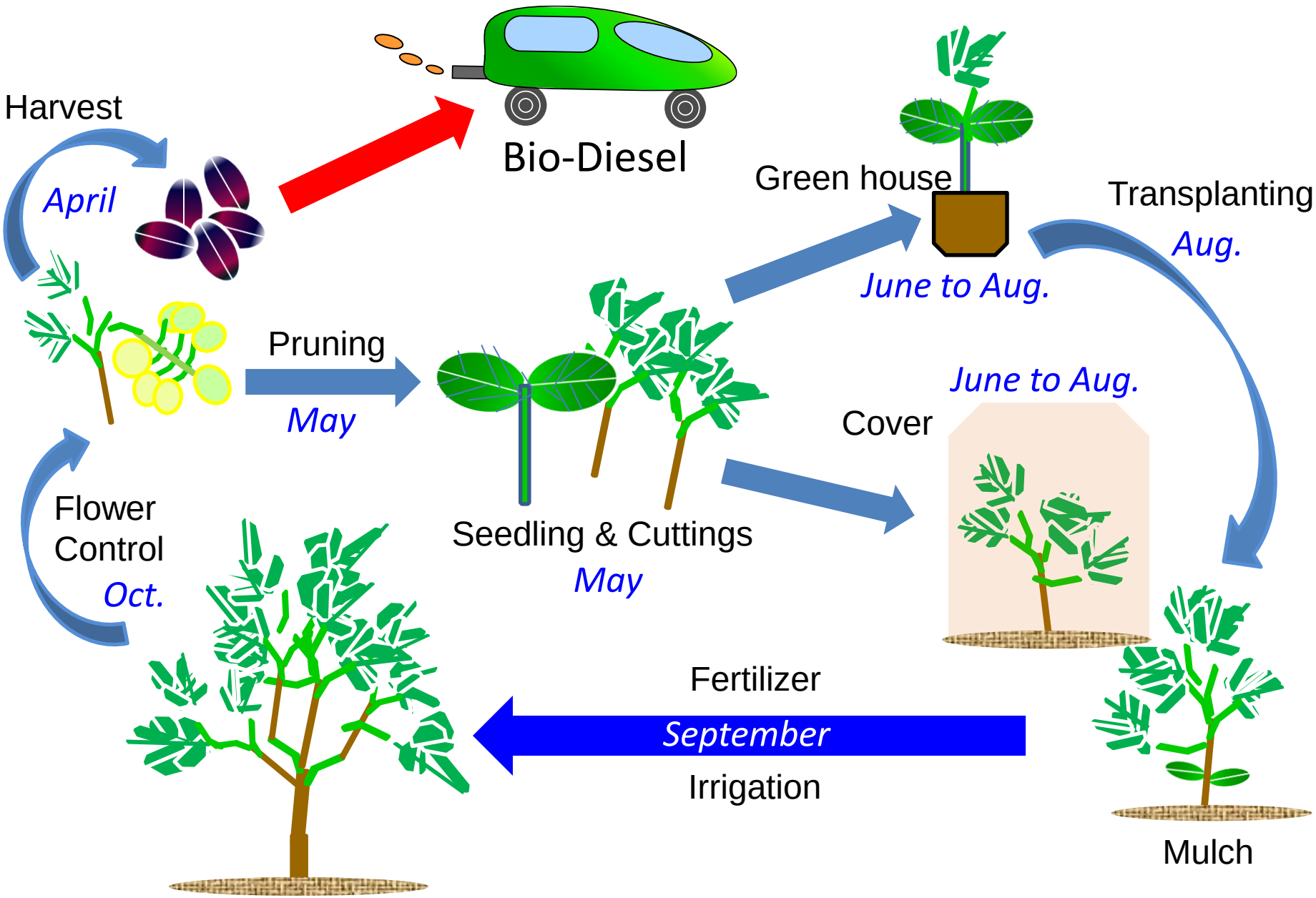
3. Post-harvest processing of Jatropha seeds for **biodiesel production**.

4. Protocols for utilization of **non-oil Jatropha biomass** (biochar, fuel, etc)

5. Evaluation of **environmental, social and economic impacts**

Building a sustainable and profitable industry based on Jatropha biomass

Establish suitable cultivation system of Jatropha



ICT-based management system for individual Jatropha trees

Characteristics
- Accession
- Genetic info
- Planting date
- Cultivation type
- ・・・・・・・

Input
- Fertilizer/biochar
- Irrigation (soil water content)
- Solar irradiation
- Pruning date/style
- Labor
- Budget
- Breeding

Database（GIS）

Output-1
- Energy value
- Combustion
- Emission
- Toxicity
- Genetic info
- Economic value
- LCA
- Etc

Jatropha tree_1
Jatropha tree_2
Jatropha tree_3
Jatropha tree_n

Growth Flowering time, etc → Harvest → Fruit yield → Crude oil yield → Biodiesel yield → Engine performance

Biomass: Pruned branches, Flesh, Seed cake, Glycerate

Biomass-derived products: Biochar Vinegar, Biomass fuel Forage, etc

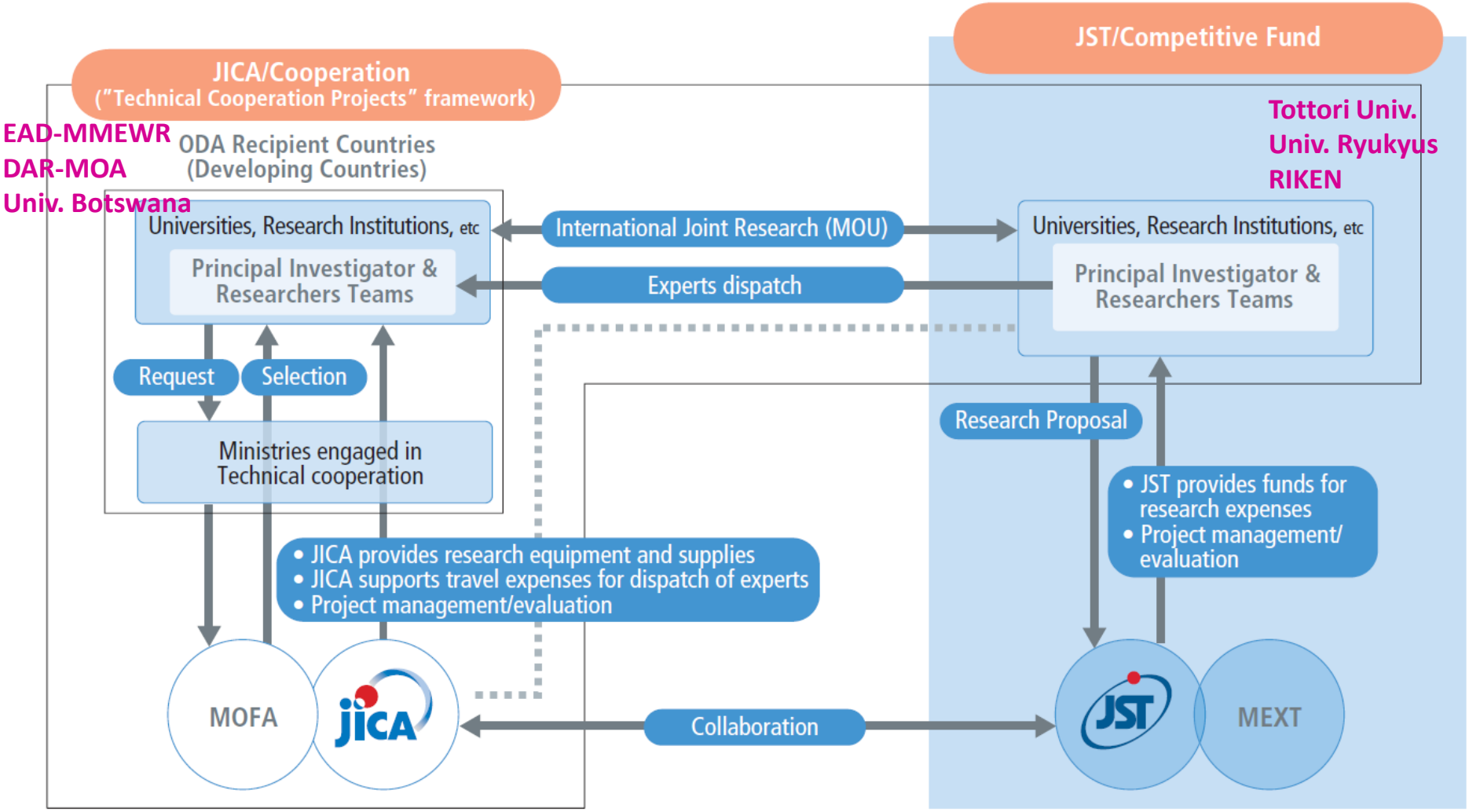
Output-2
- Environ impact
- Social impact
- Economic impact

Cultivation condition
- Weather
- Soil properties
- Irrigation
- ・・・・・・・

Information on individual jatropha tree, such as biological characteristics, cultivation condition, input, measured data, yield performance, etc, is integrated and mapped in the GIS database. The integrated information will be analyzed, and utilized for the evaluation of cultivation protocols, breeding effects, energy characteristics and economic potentials.

Funding scheme of SATREPS

SATREPS
Botswana Jatropha PJ



MOFA (Ministry of Foreign Affair of Japan)
JICA (Japan International Cooperation Agency)

JST (Japan Science and Technology)
MEXT (Ministry of Education, Culture, Sports, Science & Technology in Japan)

Questions

For the Botswana Jatropha plants,

1. Why leaf size was so small ?
2. Why leaves did not fall down in winter?
3. Why the leaves was so waved?

Because of ……..,

Low temperature at night,
Low humidity, Dry air,
Strong sun light,
High day temperature
Low soil water content,
Low soil nutrient solutions, ……

There is a way to survive Jatropha in severe climate conditions

Usually, all tree was dead.

21 June, 2011

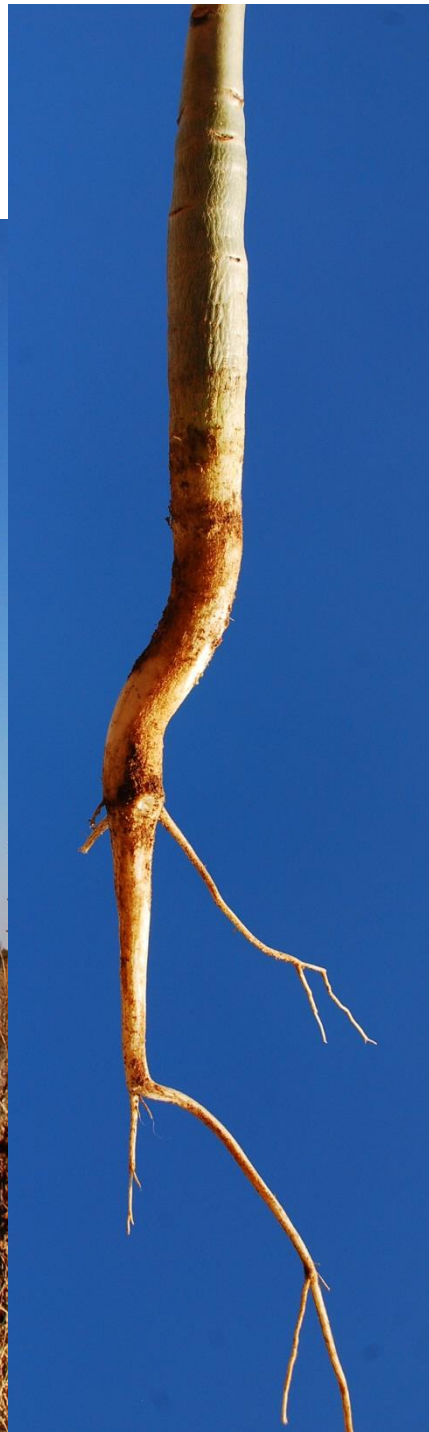
Some trees are still alive.

What is difference or reason?
There will be big hint.

Shoot was dead

21 June, 2011

Root was OK!



How should we do?

in Winter season

Prevent the transpiration from Jatropha tree.

=> Pruning

Protect from the strong wind.

=> Wind break

for young tree

Apply the water to prevent the drying.

=> Drip irrigation

Keep warm temperature during night time.

=> Covering

ICT-based precision farming

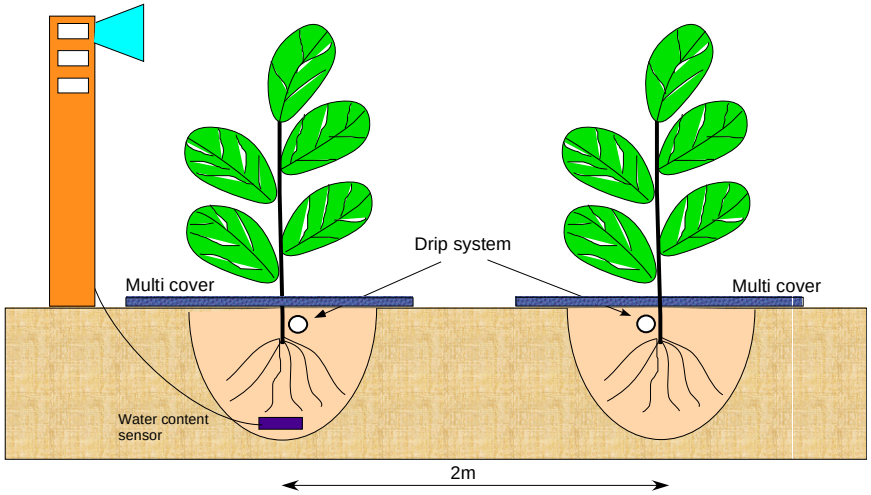
Give to Jatropha tree the strong drying tolerance by molecular breeding.

1. Farming method suitable for Botswana conditions

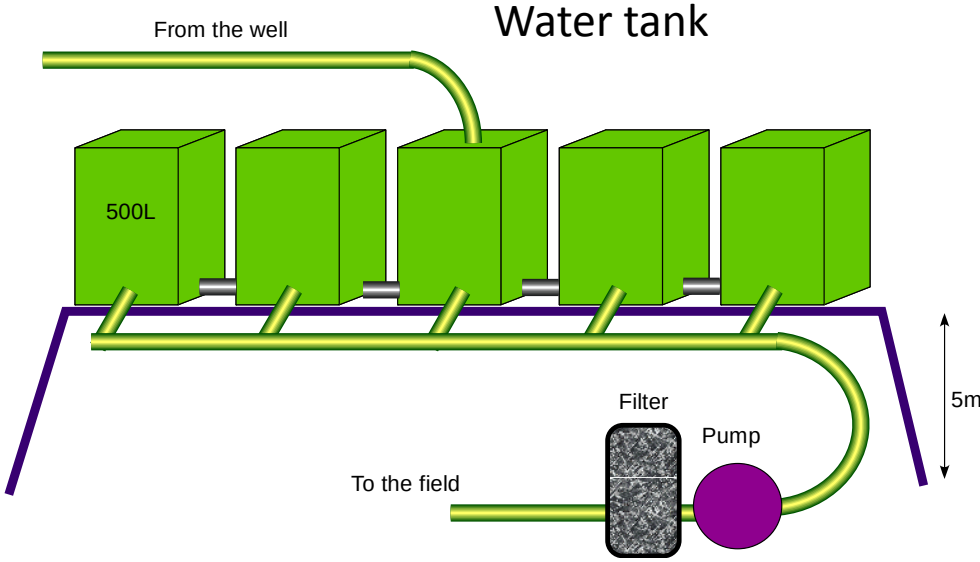
Outline of the irrigation system and cultivation

Use the valuable water carefully !

Prevent evaporation and penetration of the water

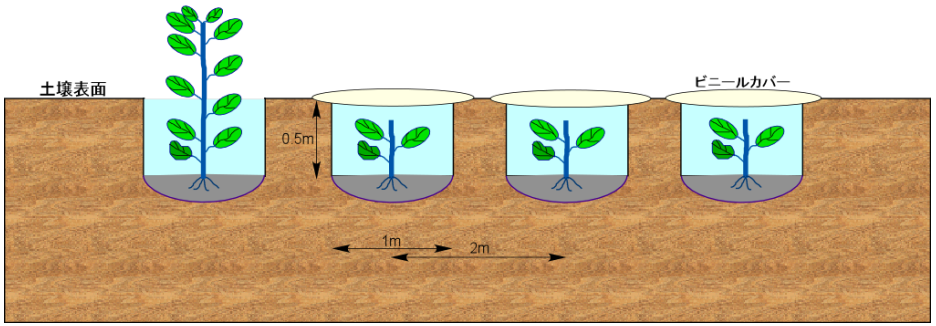


Water tank

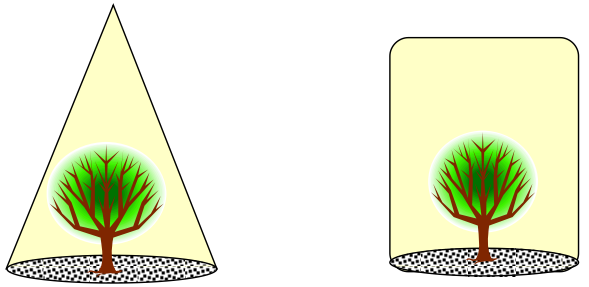


Keep soil moisture

Trench cultivation

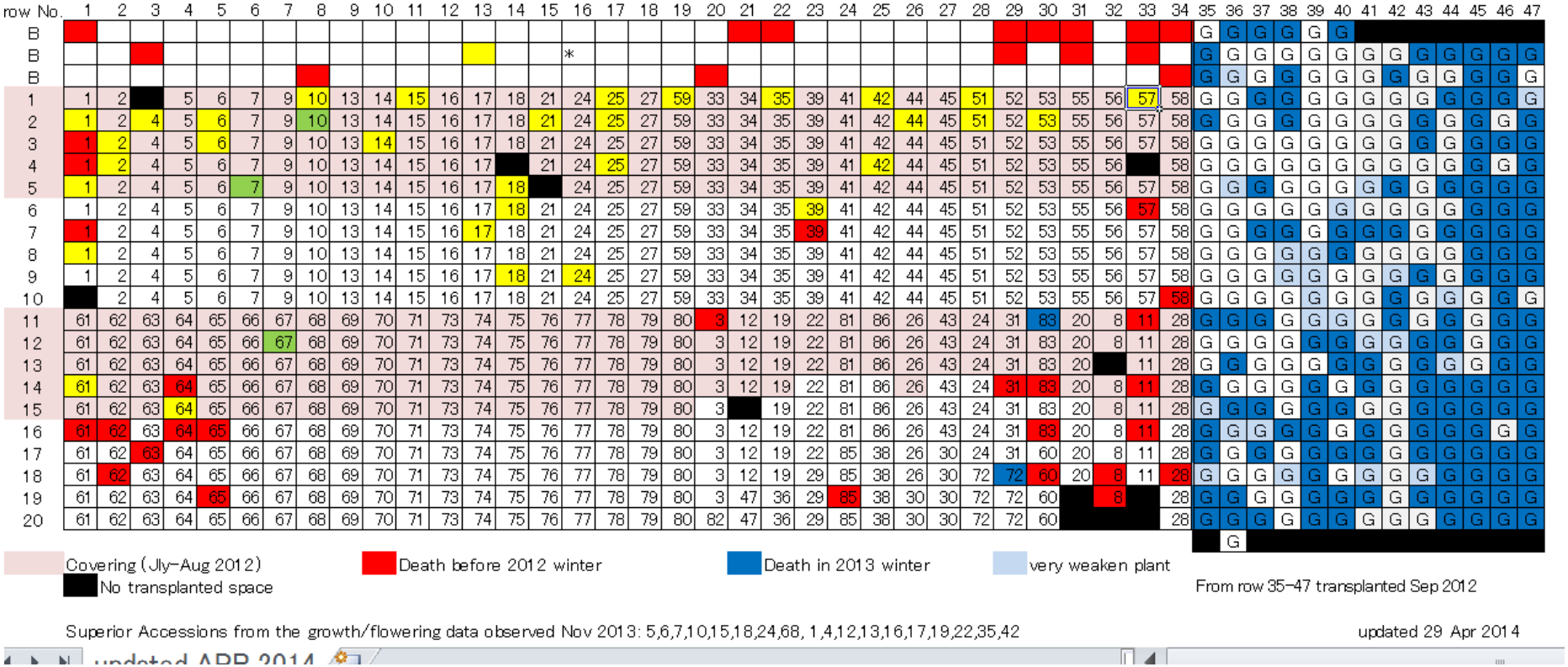


Bag for the winter



The SATREPS Project stared at 14 Dec., 2011, transplanting was a first joint work.

Mapping of flowering, fruiting, withered and dead



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3	1	2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
4	1	2	4	5	6	7	9	10	13	14	15	16	17		21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56		58	G	G	G	G	G	G	G	G	G	G	G	G	G
5	1	2	4	5	6	7	9	10	13	14	15	16	17	18		24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
6	1	2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
7	1	2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
8	1	2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
9	1	2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
10		2	4	5	6	7	9	10	13	14	15	16	17	18	21	24	25	27	59	33	34	35	39	41	42	44	45	51	52	53	55	56	57	58	G	G	G	G	G	G	G	G	G	G	G	G	G
11	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	81	86	26	43	24	31	83	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
12	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	81	86	26	43	24	31	83	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
13	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	81	86	26	43	24	31	83	20		11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
14	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	81	86	26	43	24	31	83	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
15	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3		19	22	81	86	26	43	24	31	83	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
16	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	81	86	26	43	24	31	83	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
17	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	22	85	38	26	30	24	31	60	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
18	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	12	19	29	85	38	26	30	72	72	60	20	8	11	28	G	G	G	G	G	G	G	G	G	G	G	G	G
19	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	3	47	36	29	85	38	30	30	72	72	60		8		28	G	G	G	G	G	G	G	G	G	G	G	G	G
20	61	62	63	64	65	66	67	68	69	70	71	73	74	75	76	77	78	79	80	82	47	36	29	85	38	30	30	72	72	60				28	G	G	G	G	G	G	G	G	G	G	G	G	G
																																			G												

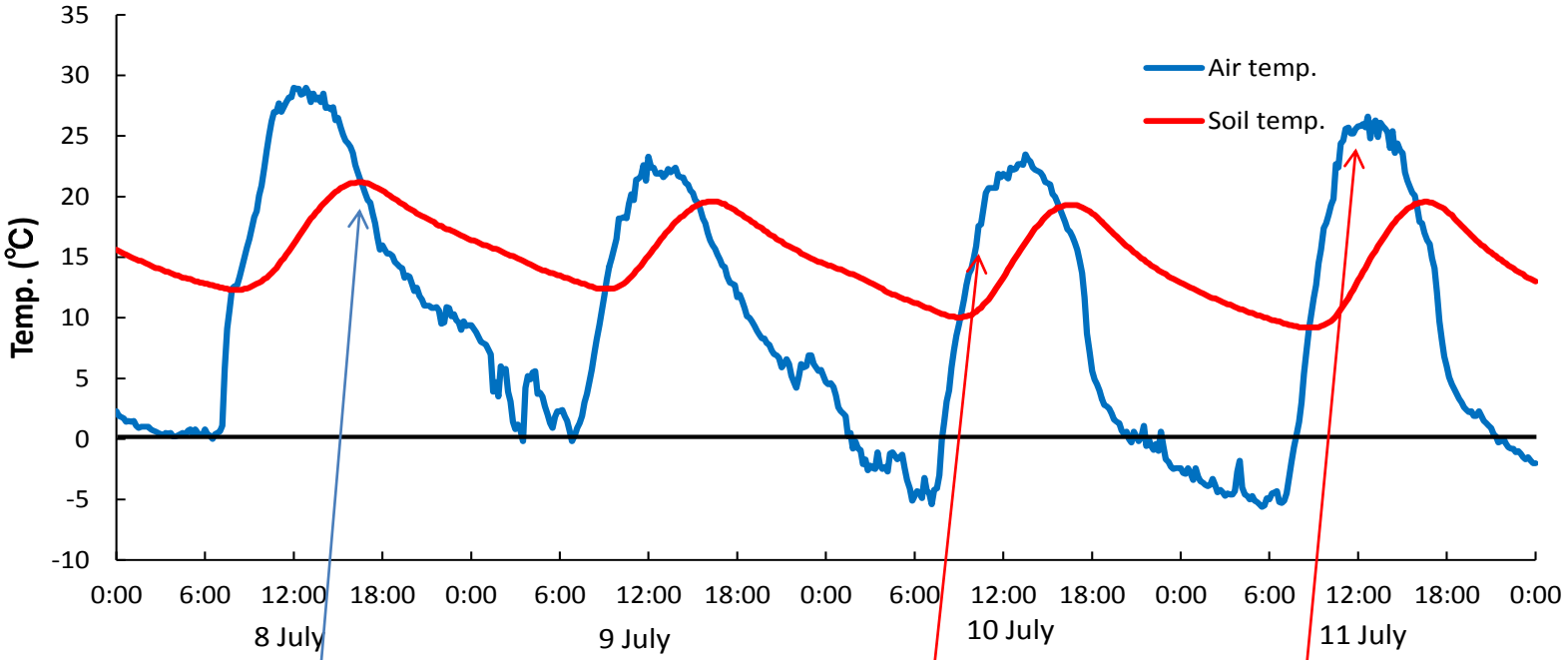
Covering (Jly–Aug 2012)
Death before 2012 winter
Death in 2013 winter
very weaken plant
No transplanted space

From row 35–47 transplanted Sep 2012

Superior Accessions from the growth/flowering data observed Nov 2013: 5,6,7,10,15,18,24,68, 1,4,12,13,16,17,19,22,35,42

updated 29 Apr 2014

Changes in air and soil temperature form 8 to 11 July, 2012

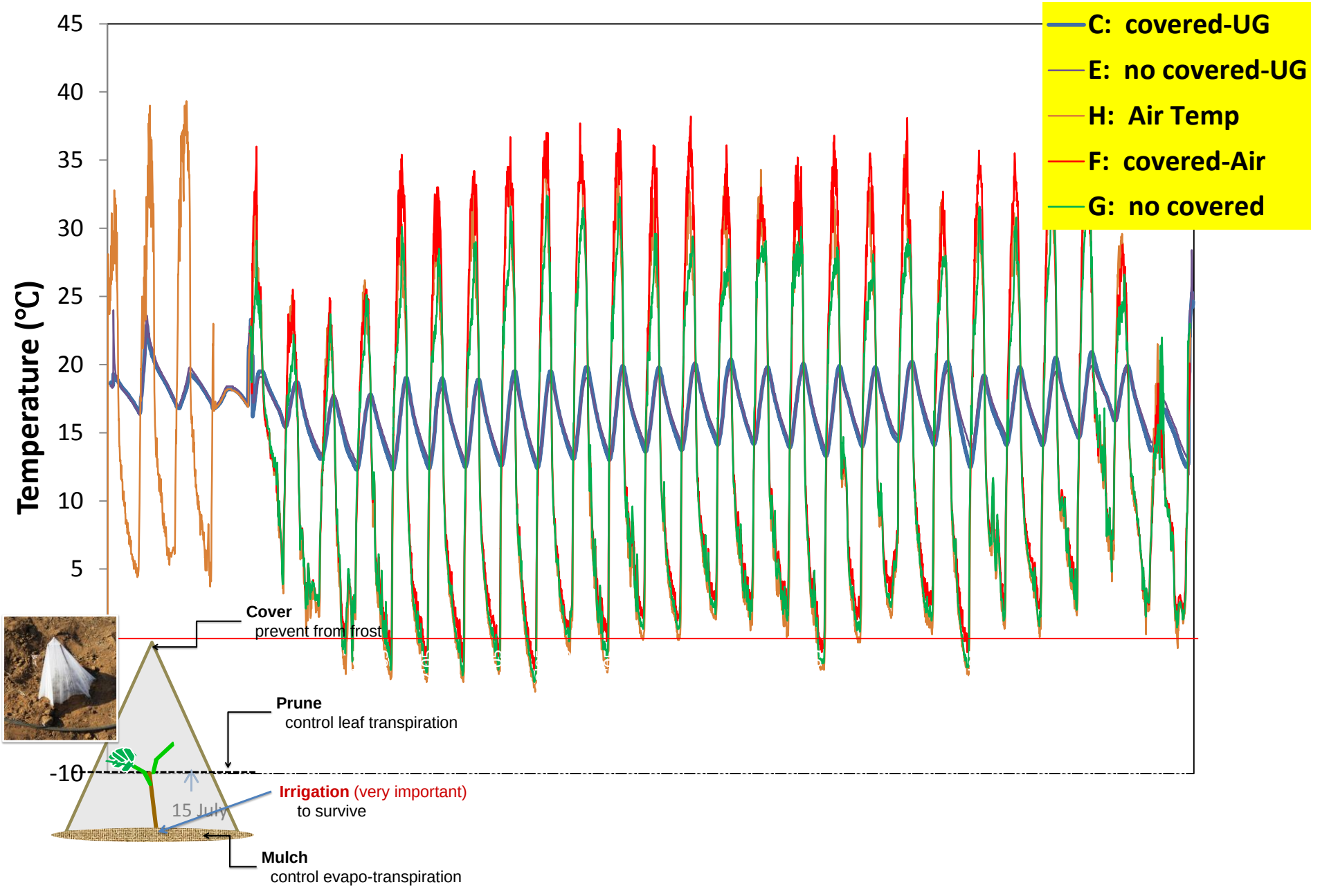


High temp.

Before the cold

After the cold

Soil Temperature 2012



Pruning

May 18th,　2012

Mulching

May 18th, 2012

Irrigation

Automatic irrigation system installed based on soil moisture.

July 9th, 2012

Drip irrigation

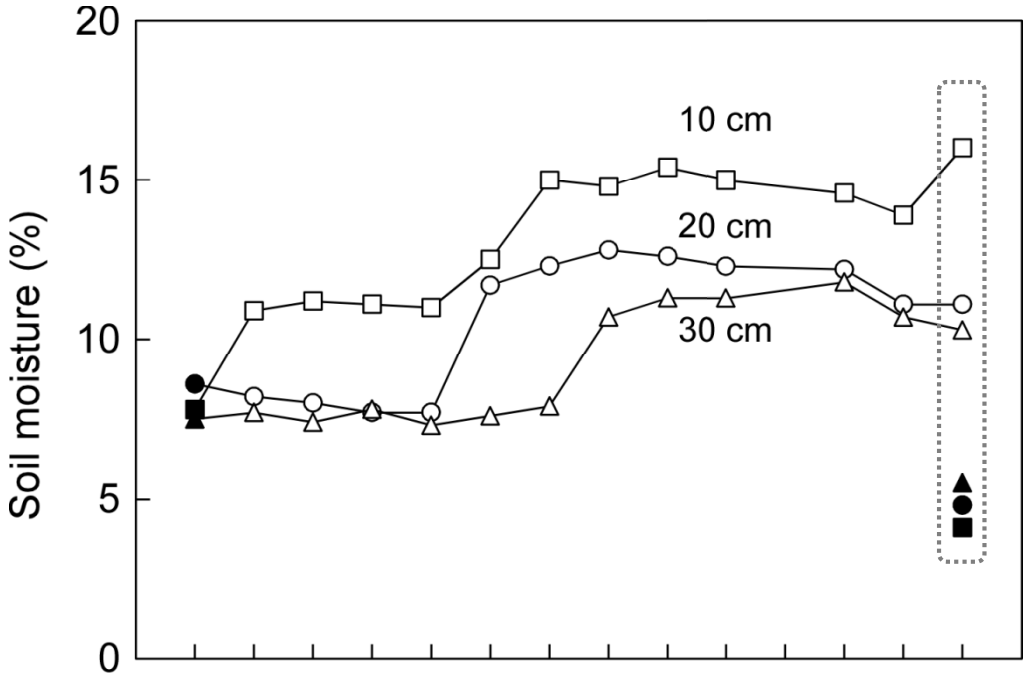
Where is water?

Change in soil moisture (10, 20 and 30 cm depths) after water treatment

Water treatment

1-4 DAW: 5L/ plant/ day

5-13 DAW: 10L/ plant/ day



19 Feb
(Pretreatment)

4 Mar
(Water treatment/ No treatment)

Jatropha has grown up well.

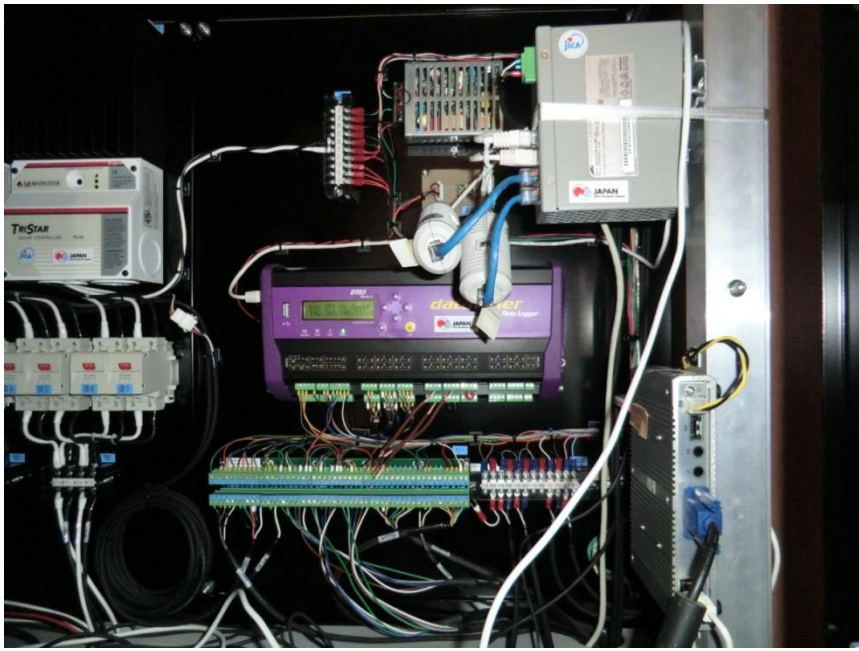
If water was given a little more, it is likely to become larger.

Set up the weather station for precise irrigation and farming

1. **Solar radiation**
2. **Air temperature**
3. **Soil temperature**
4. **Relative humidity**
5. **Wind speed**
6. **Wind direction**
7. **Rain fall**
8. **O_2 concentration**
9. **CO_2 concentration**
10. **Soil moisture**
11. **Leaf temperature**

Monitor camera

Weather station in Sebele farm




2014/03/01 18:08

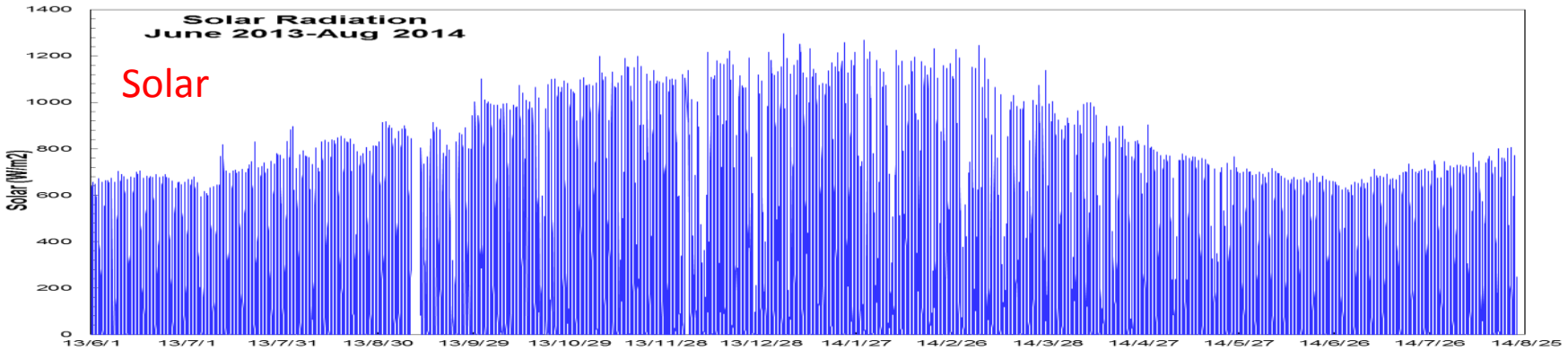
Selowe site

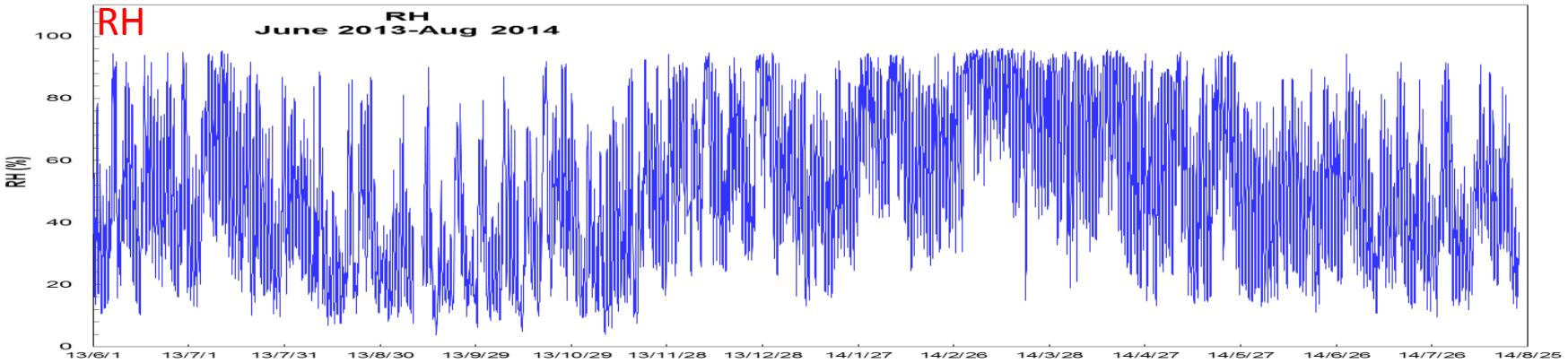

2014/03/01 18:11

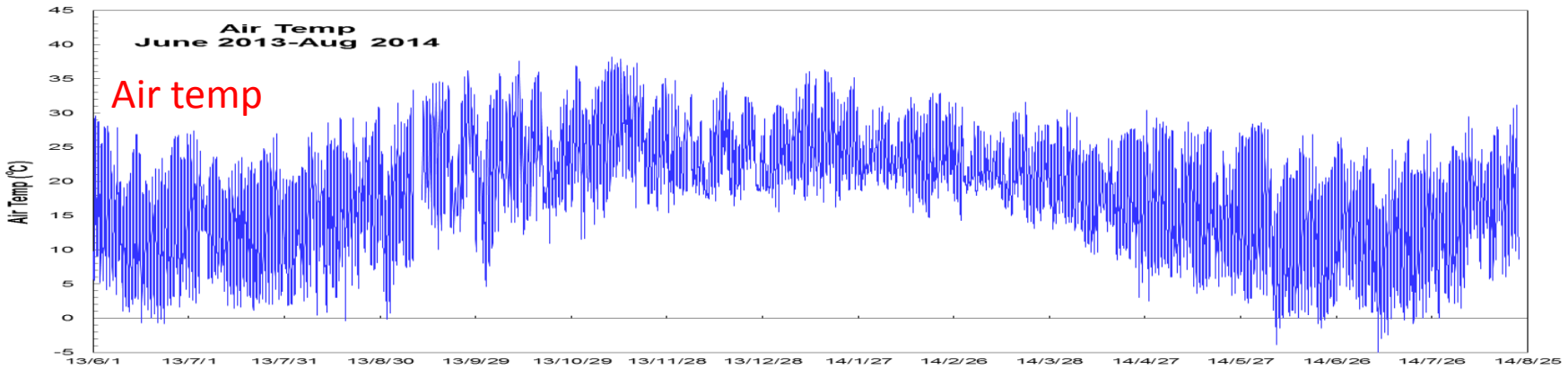

2014/03/01 18:34


MANCHESTER
UNITED
2014/03/01 18:13

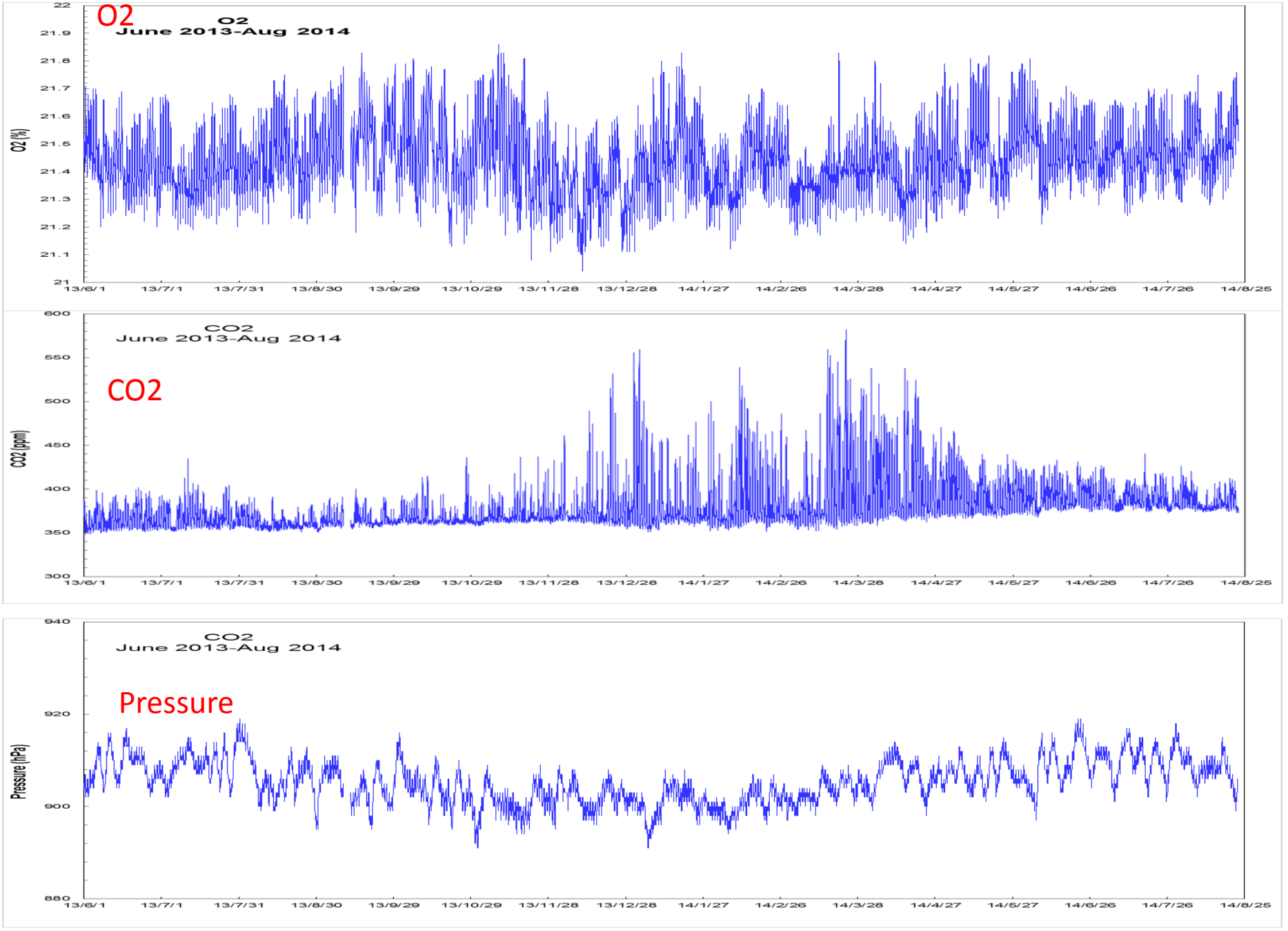
Data from weather station







Data from weather station

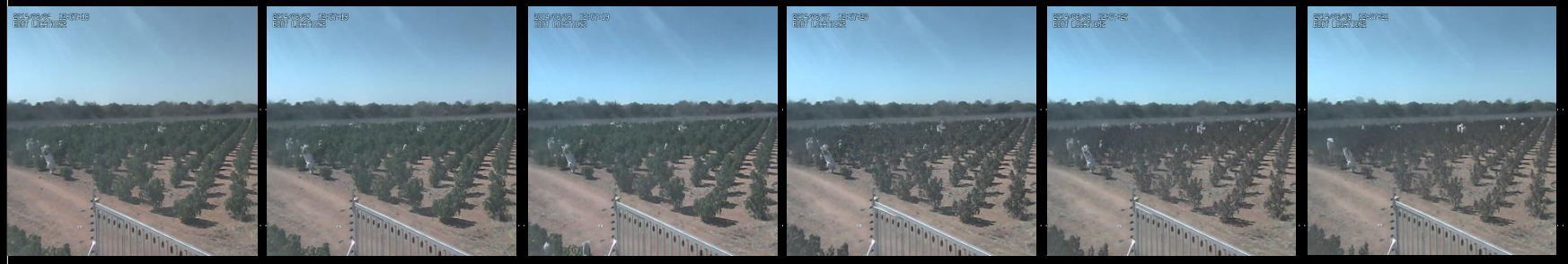


Strong hail damaged to flower, fruits and Jatropha trees.

Nov. 2013

Almost trees recovered from the hail damage, and some trees started flowering.

Feb, 2014



2014年6月4日　2014年6月5日　2014年6月6日　2014年6月7日　2014年6月8日　2014年6月9日

50.0

22.5

-5.0

Temp（℃）

Solar

Cold wave

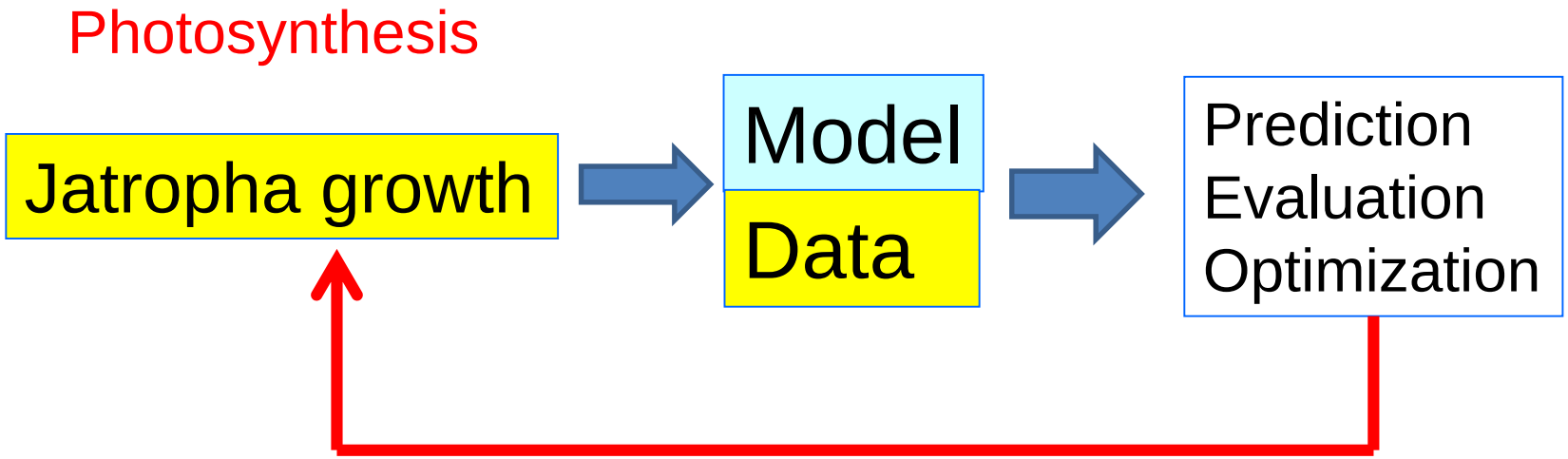
UG temp（℃）

気温低下

14/06/04 00:00　14/06/04 12:00　14/06/05 00:00　14/06/05 12:00　14/06/06 00:00　14/06/06 12:00　14/06/07 00:00　14/06/07 12:00　14/06/08 00:00　14/06/08 12:00　14/06/09 00:00　14/06/09 12:00

Model-based Jatropha production and biomass utilization

Simulations under various conditions enable us that optimization of water use, scheduling of works, estimation of oil production, evaluation by LCA and others.

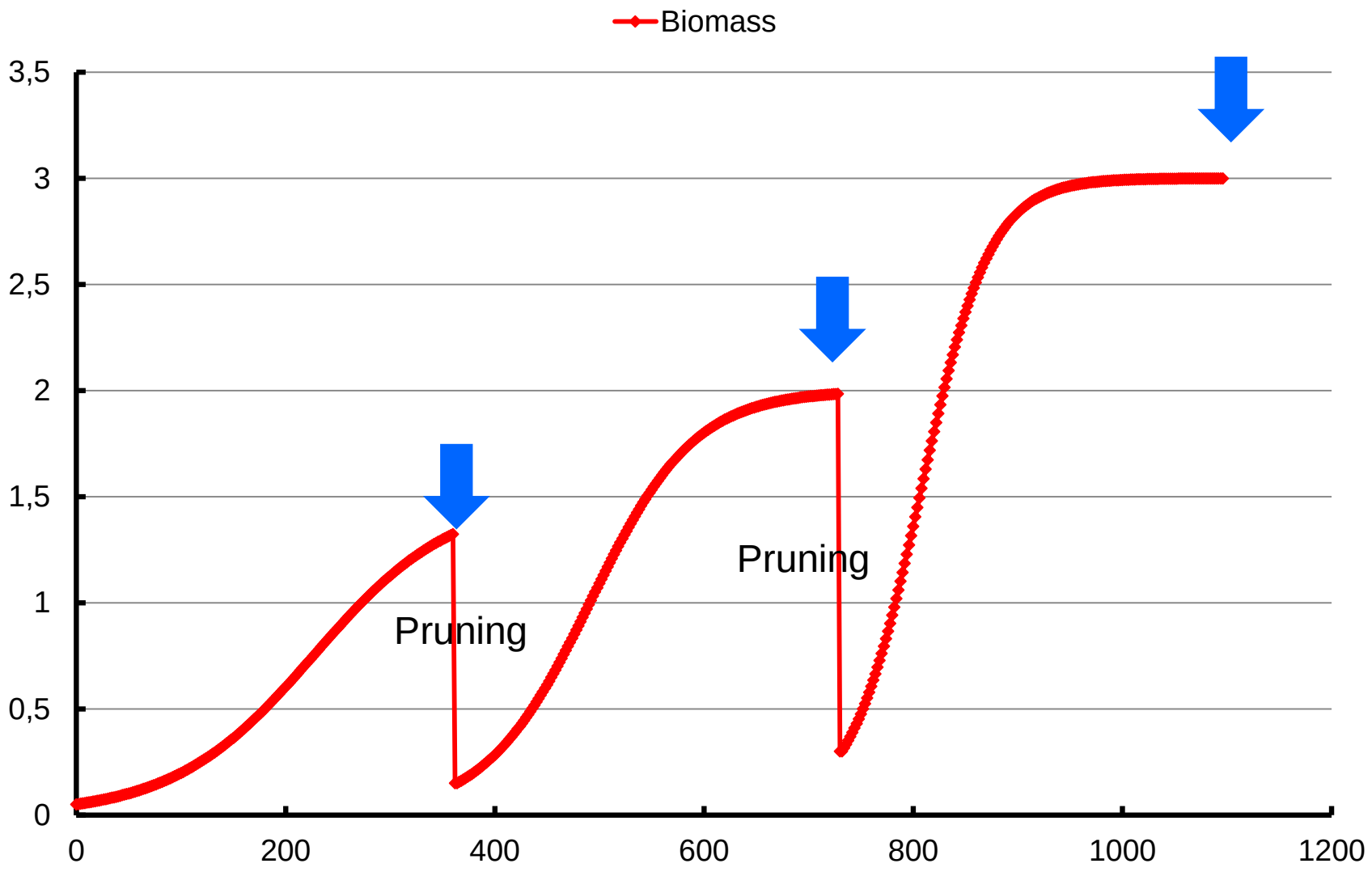


Jatropha biomass per unit area

Total biomass or growth

$$Y = \sum_j y^j_{i+1} = \sum_j \{y^j_i + \alpha^j y^j_i (\beta^j - \gamma^j y^j_i)\}$$

Jatropha growth with pruning



First year Second year Third year

Growth simulation by the model

Input data

Soil
Weed
Insect
Pest
Labor
Fertilizer

Growth data

Comparison

$$y_{i+1} <= y_i + \alpha y_i(\beta - \gamma y_i)$$

Coefficients α, β and γ are changed by the conditions.

Prediction of growth, yield of oil seed and biomass volume

For more precise farming

Soil nutrition and microbiome analysis

These data are combined with growth data and growth model.

Yasuhiro DATE[1,2], Jun KIKUCHI[1,2,3]

[1]RIKEN Center for Sustainable Resource Science
[2]Grad. Sch. Med. Life Sci., Yokohama City Univ.
[3]Grad. Sch. Agri. Bio. Sci., Nagoya Univ.

Biomass, metabolic flux and torrefaction analysis of *Jatropha curcus*

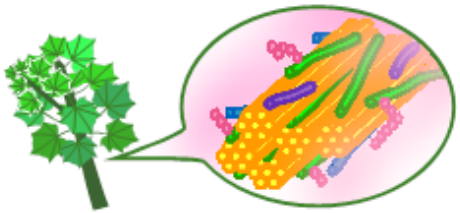
SATREPS For the Earth, For the Next Generation

鳥取大学 Tottori University | University of the Ryukyus | RIKEN

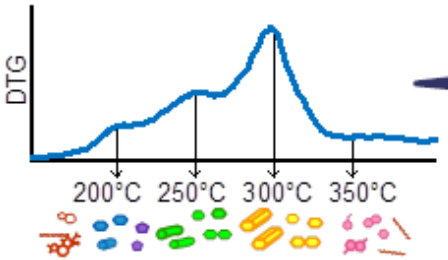
Botswana

- 70% DESERT
- POOR NUTRIENTS IN SOIL

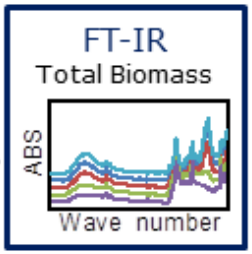
- Biomass profiling
  Plant Biotechnol (2012)
- Metabolic flux analysis
  Metabolites (submitted)
- Torrefaction analysis
  PLoS ONE (revised)

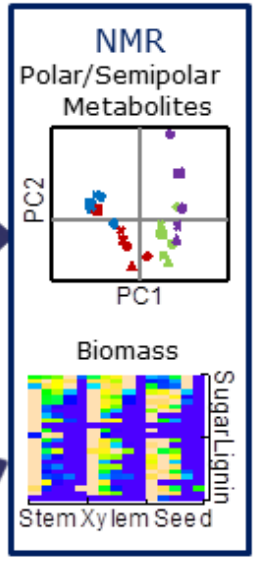


Thermal Treatment

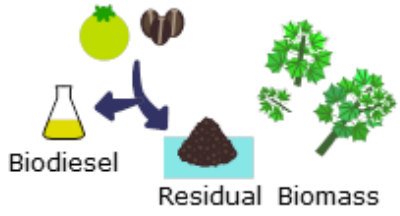


Solvent Extraction





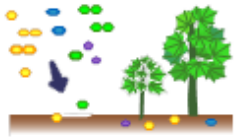
Harvest and Prune



Torrefaction

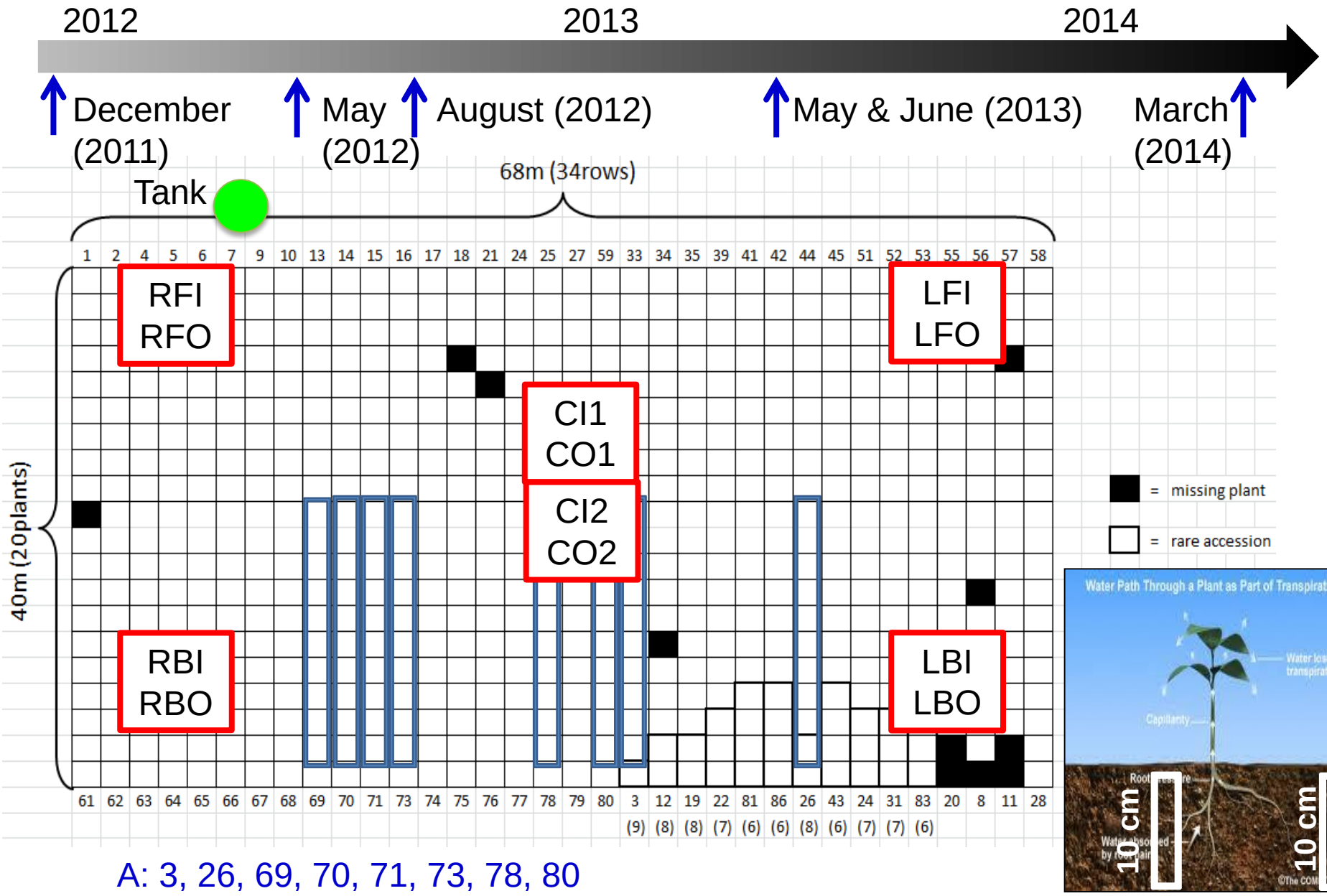
Biorefinery

Fertilizer



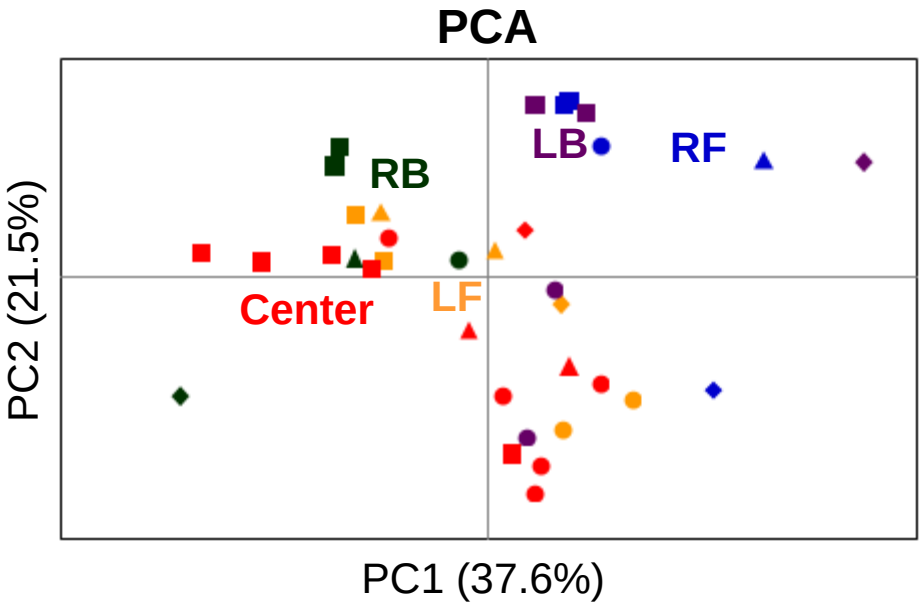
Future: Improving soil ecology

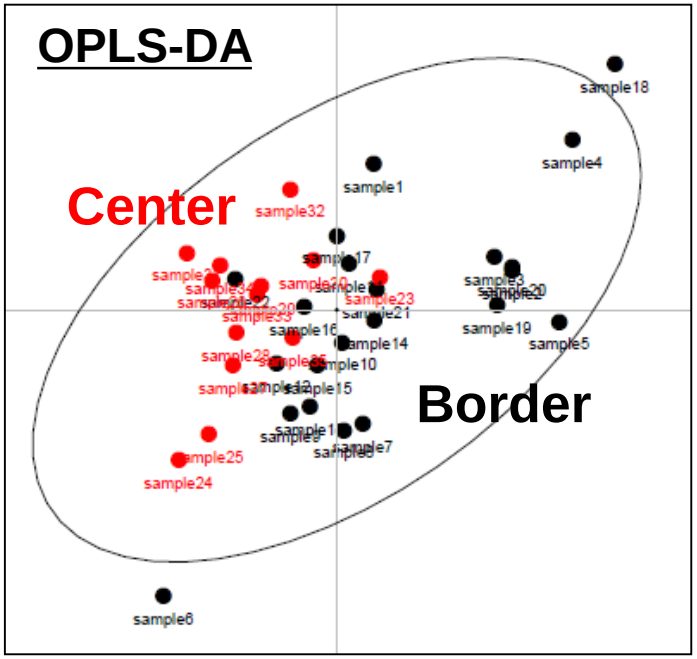
Sampling (Jatropha field in Botswana)

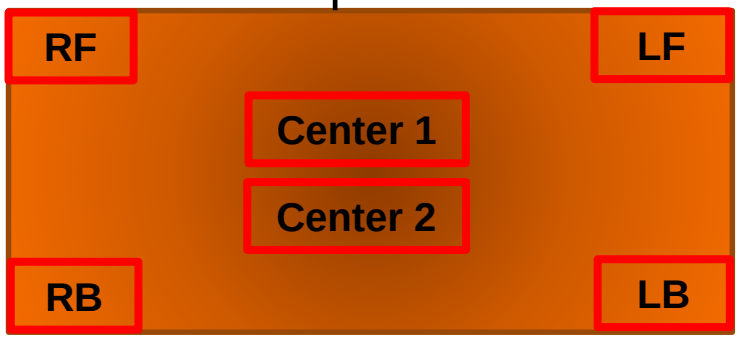


A: 3, 26, 69, 70, 71, 73, 78, 80

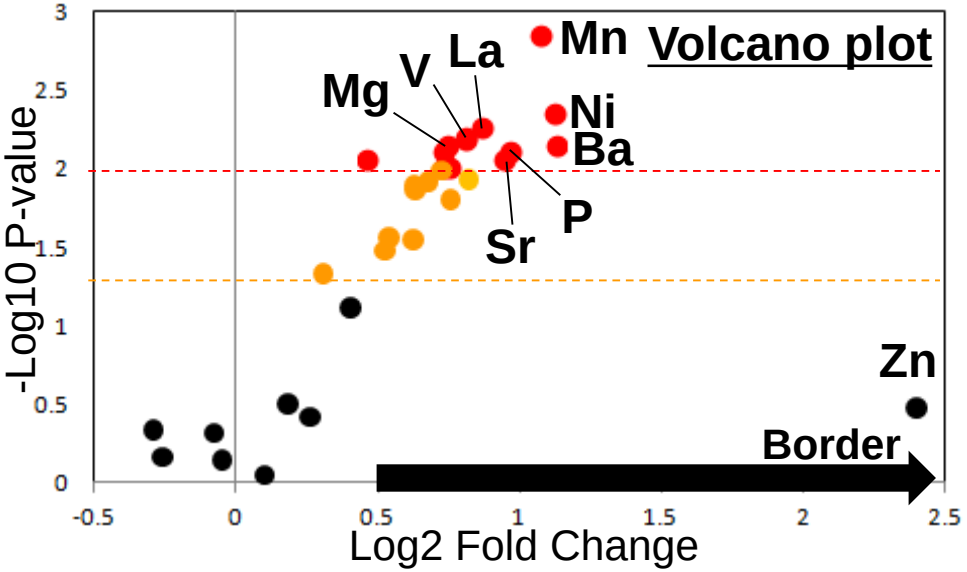
Spatial distribution patterns of elemental profiles





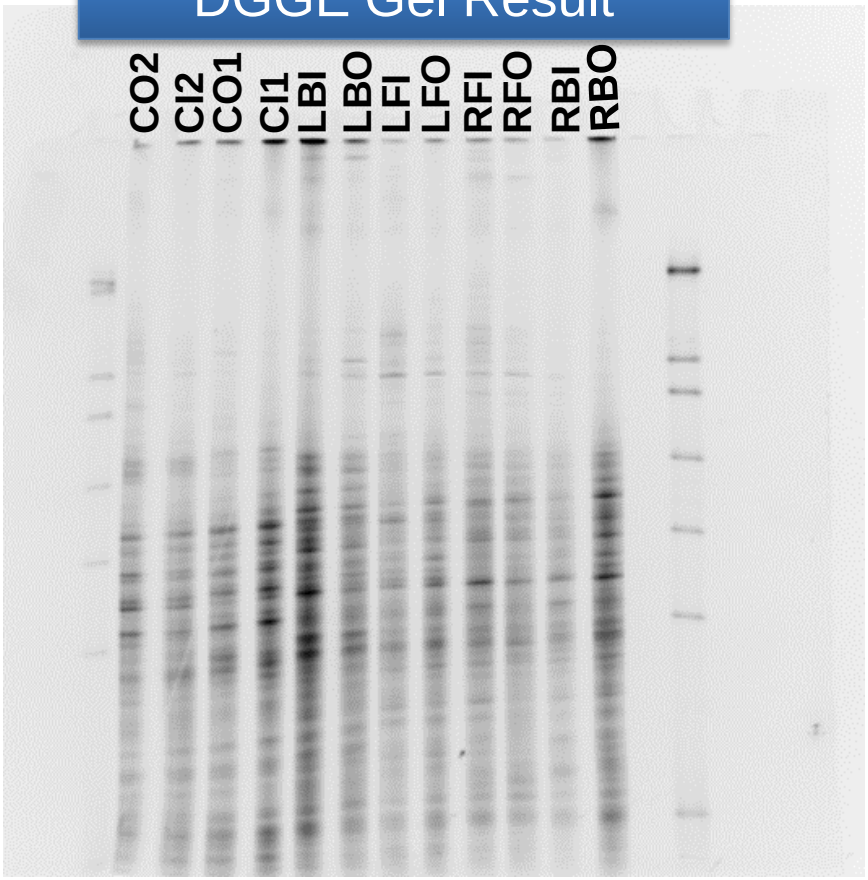


The levels of some elements such as Mn, La, Mg, Ba, and P were significantly high in the soils located in the border compared to those in the center.

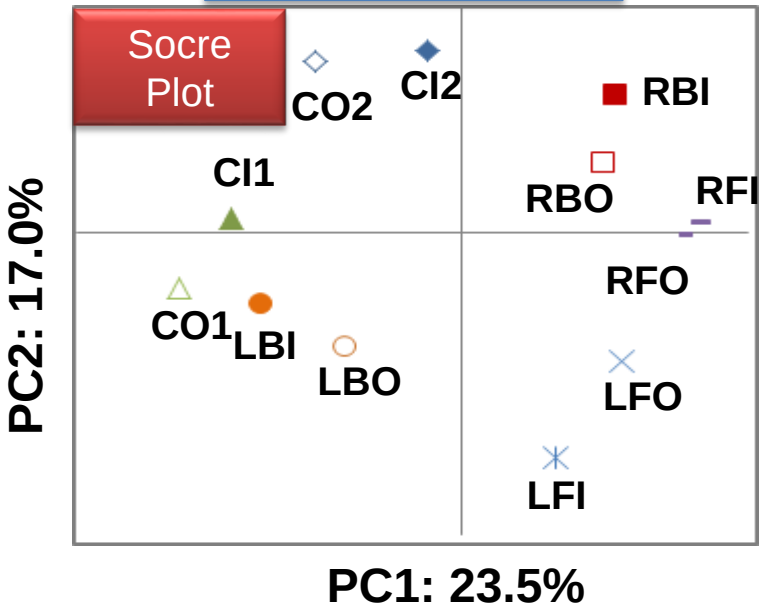


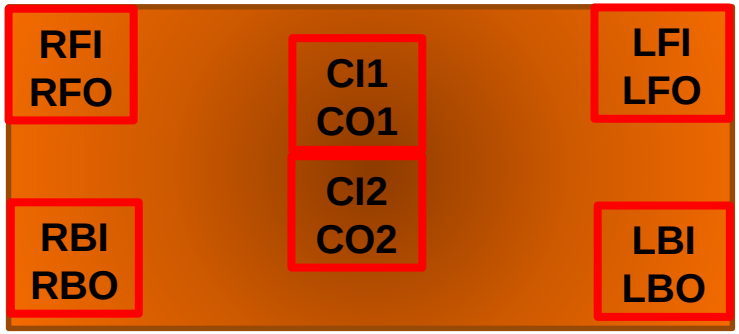
DGGE profiles (bacteria)

DGGE Gel Result



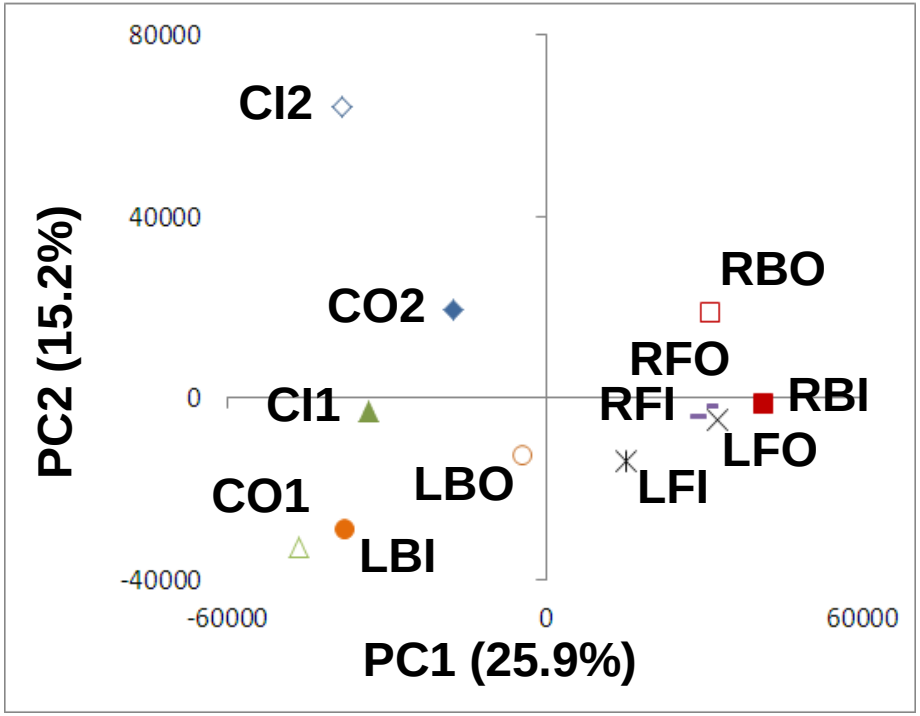
PCA Results



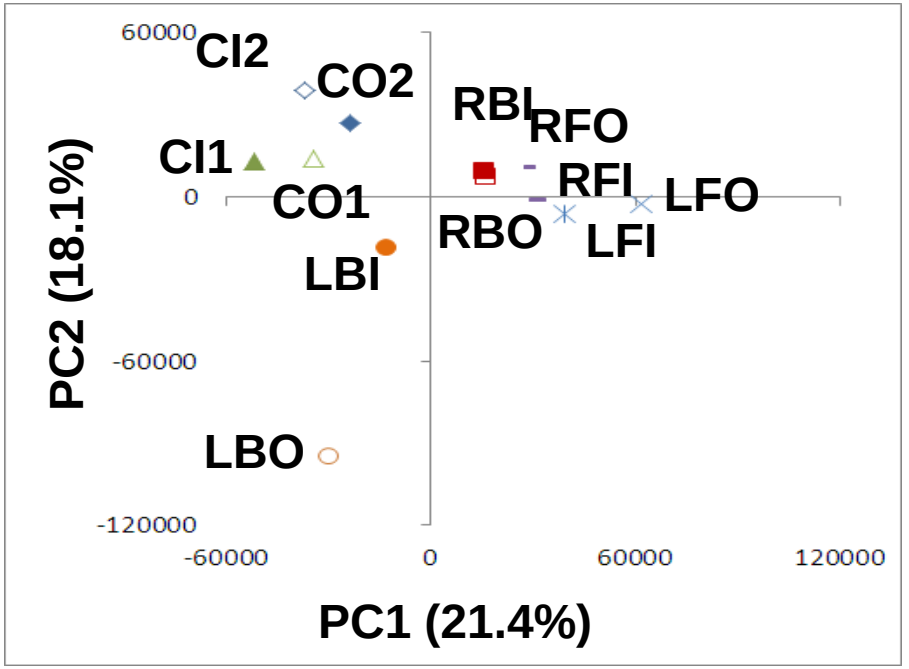


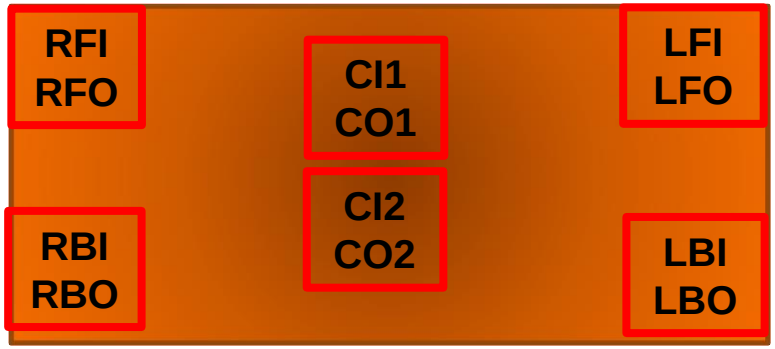
DGGE profiles (nematode & Eukaryote)

Nematode



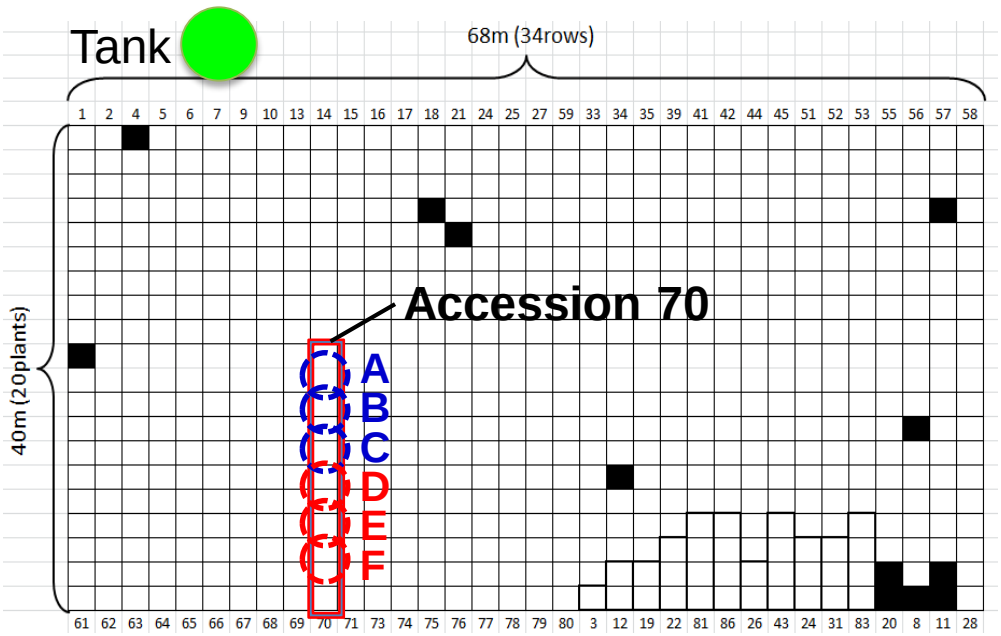
Eukaryotes

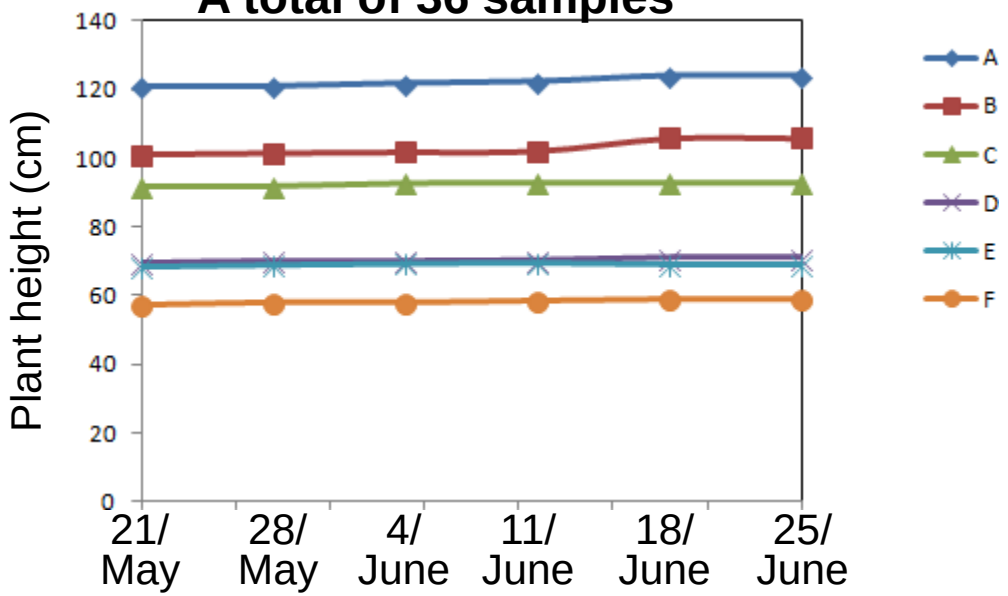


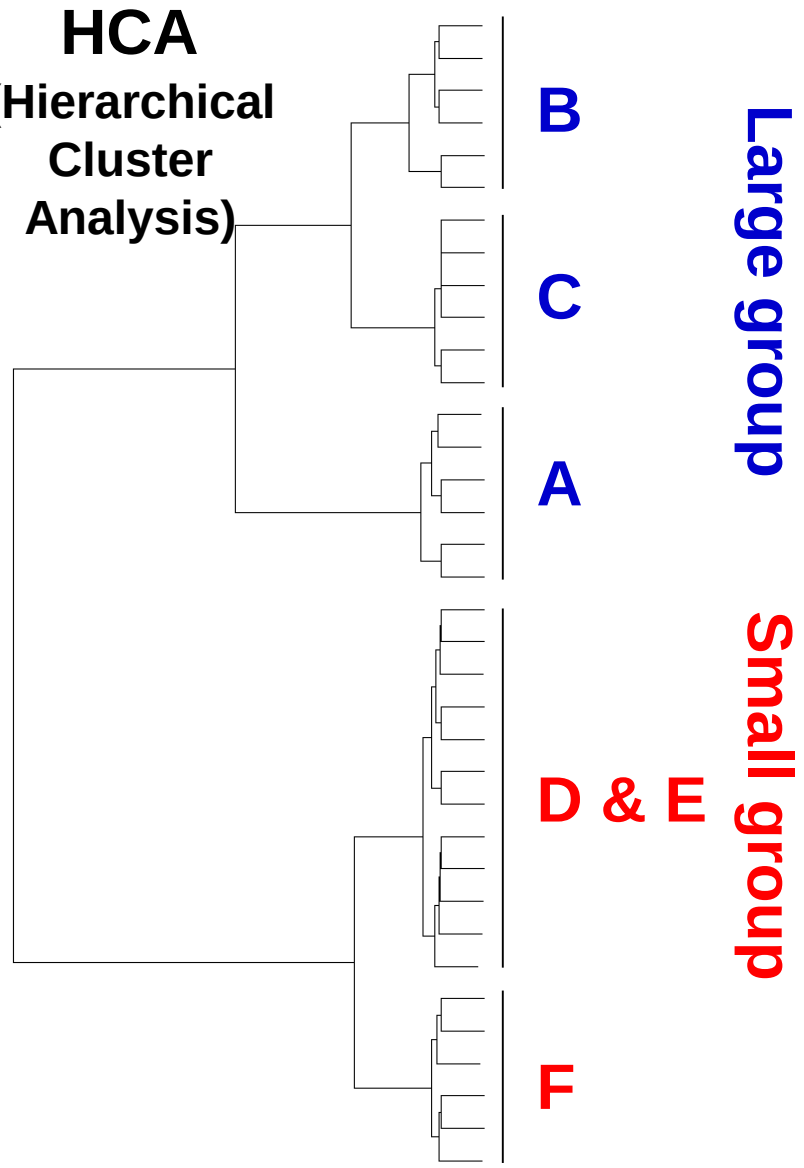


The profile of nematode and eukaryotes communities tends to be different according to the position in the field.

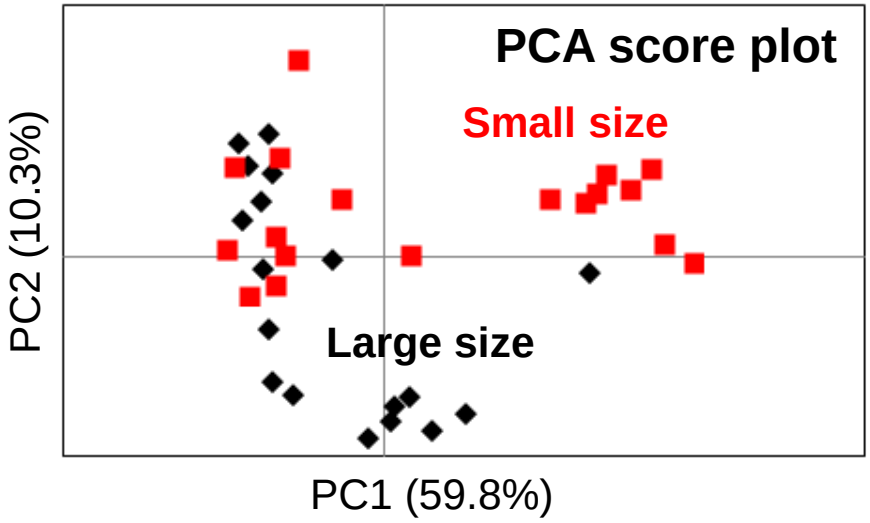
Soil profiling andJatropha growth

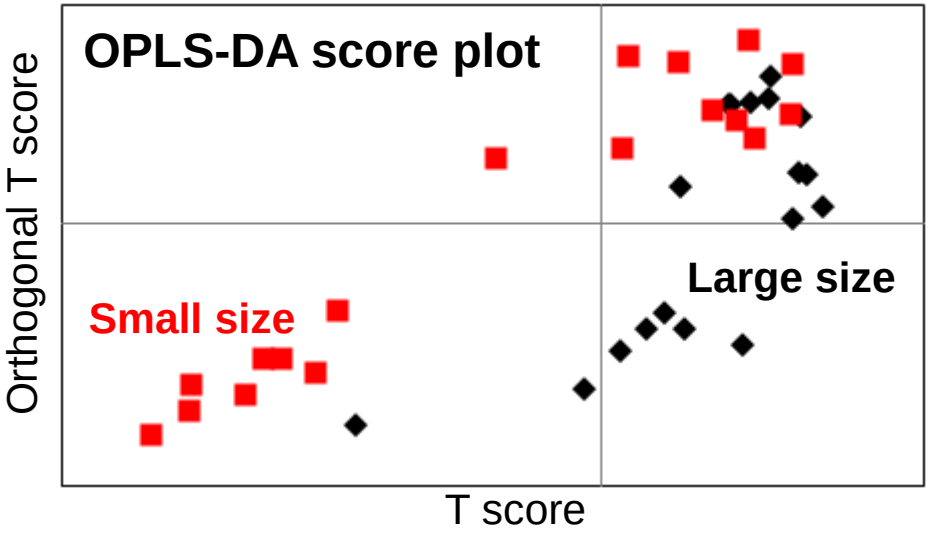


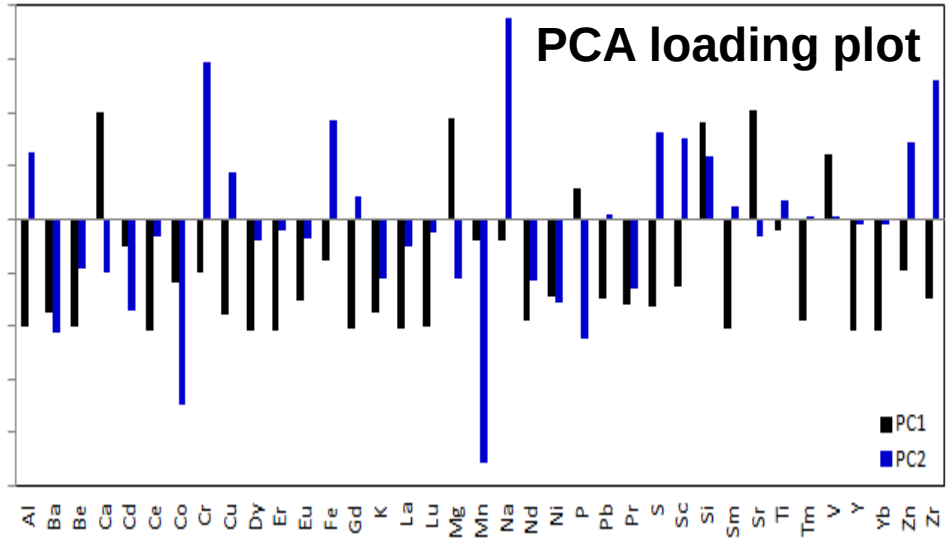


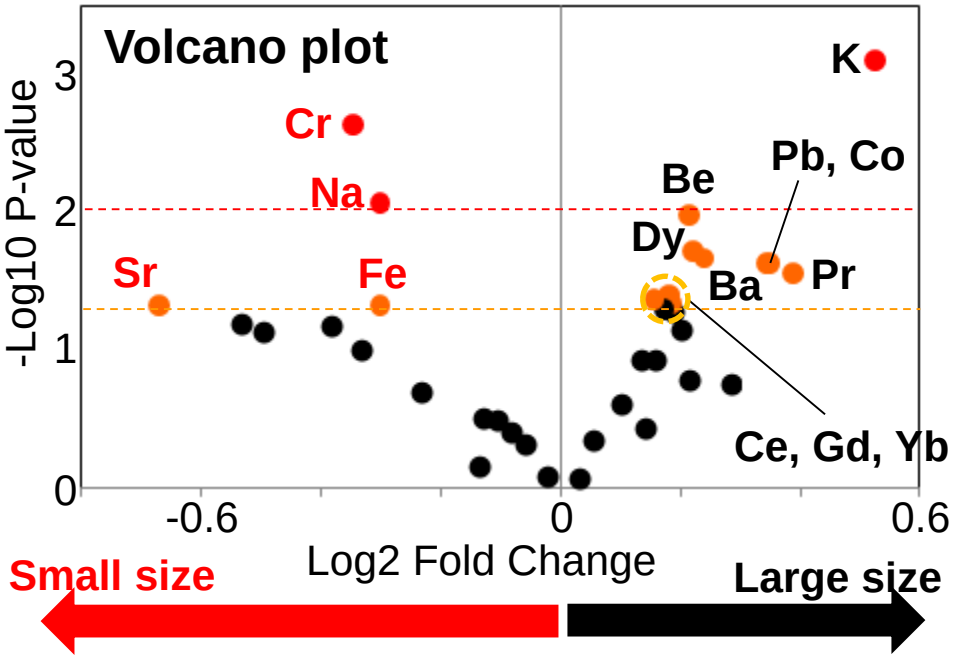


Elemental profiles related to Jatropha growth



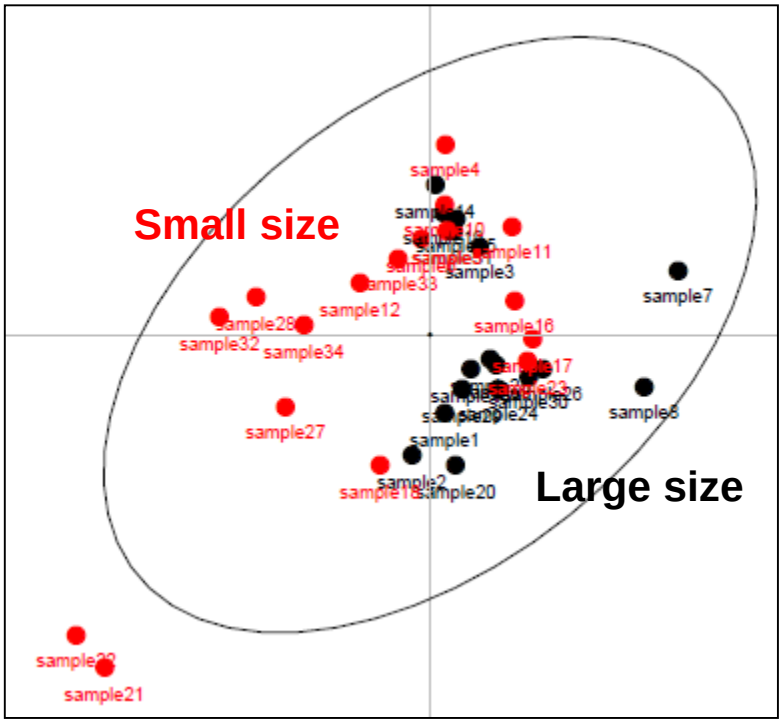




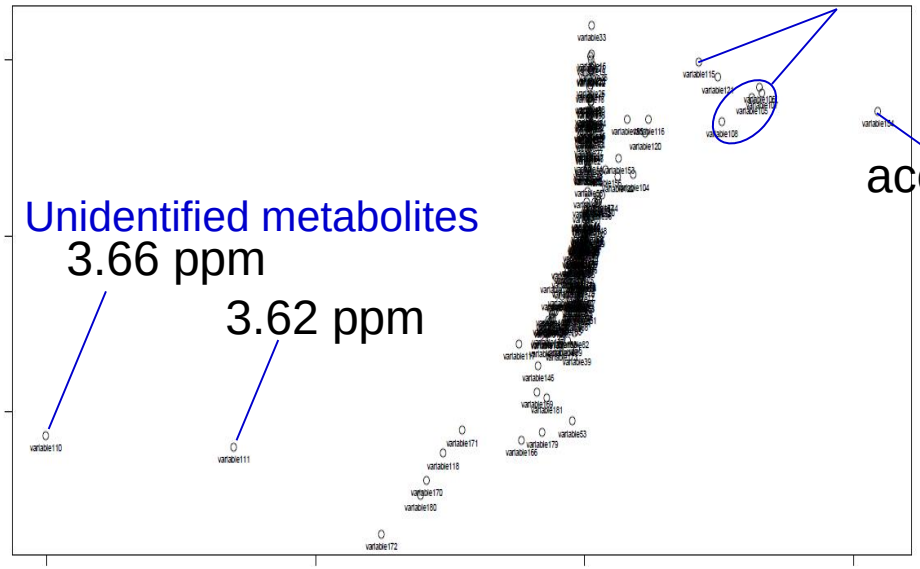


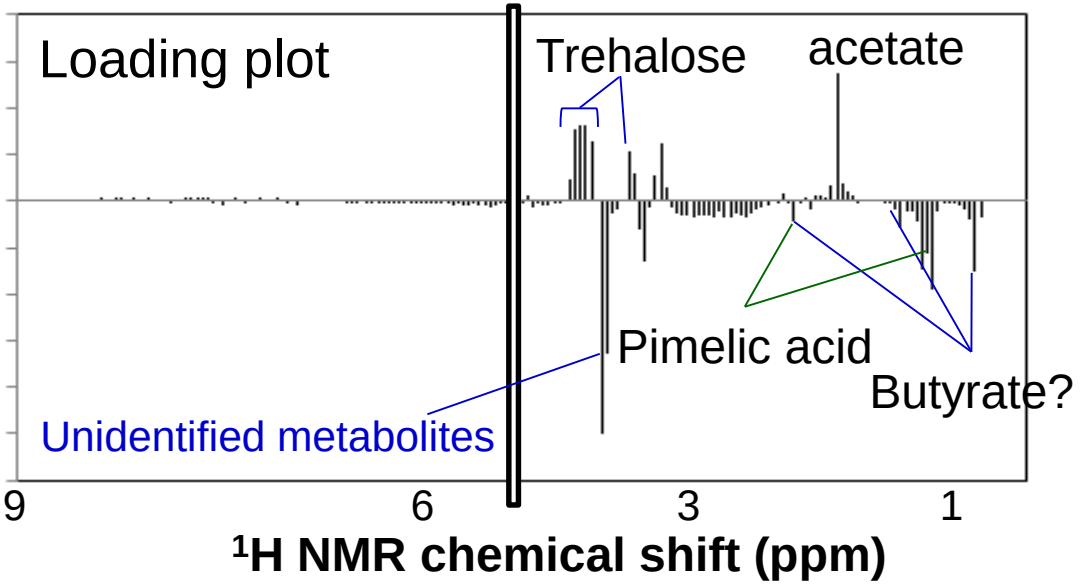
Metabolic profiles related to Jatropha growth

OPLS-DA



S-plot

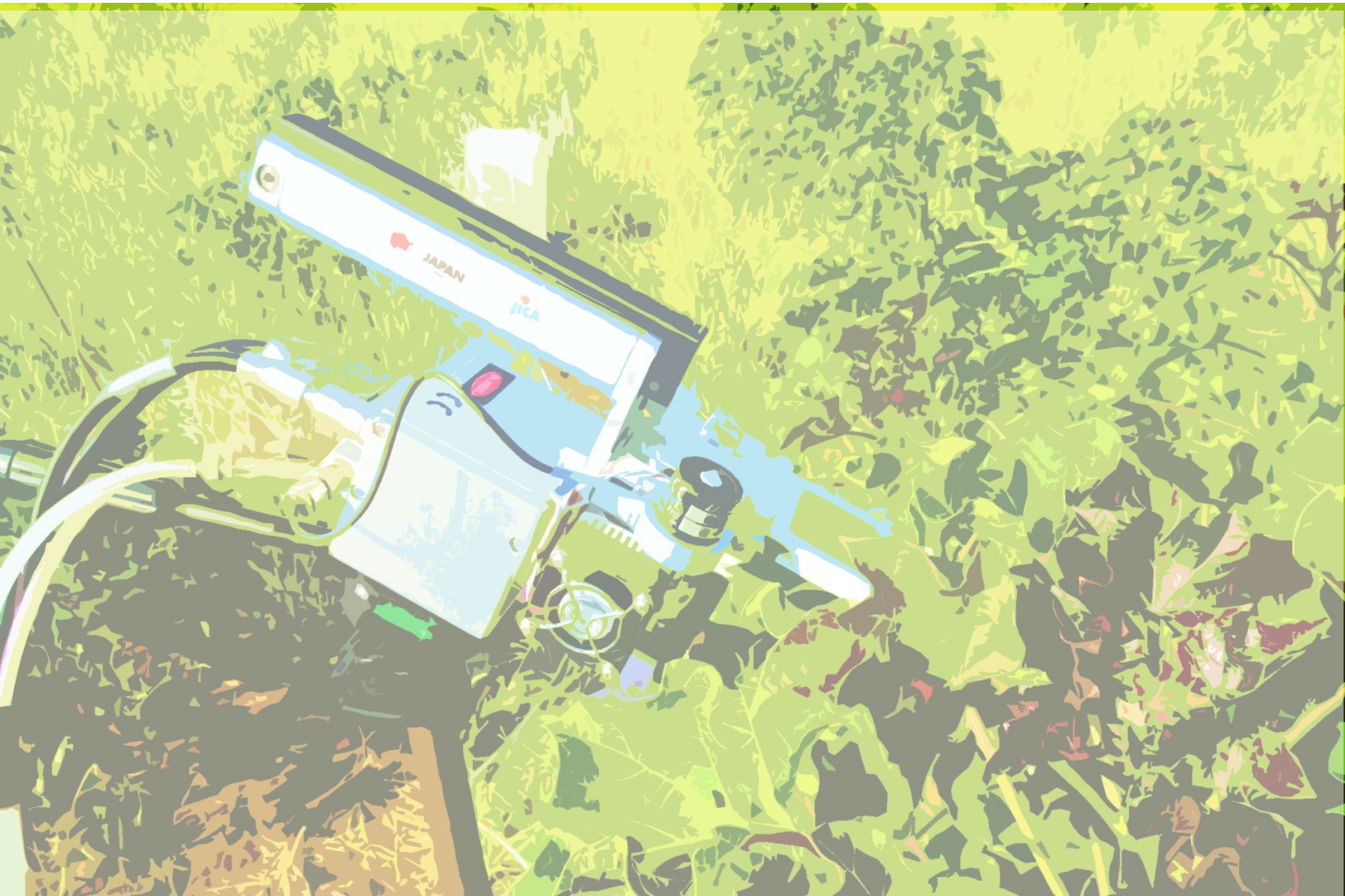




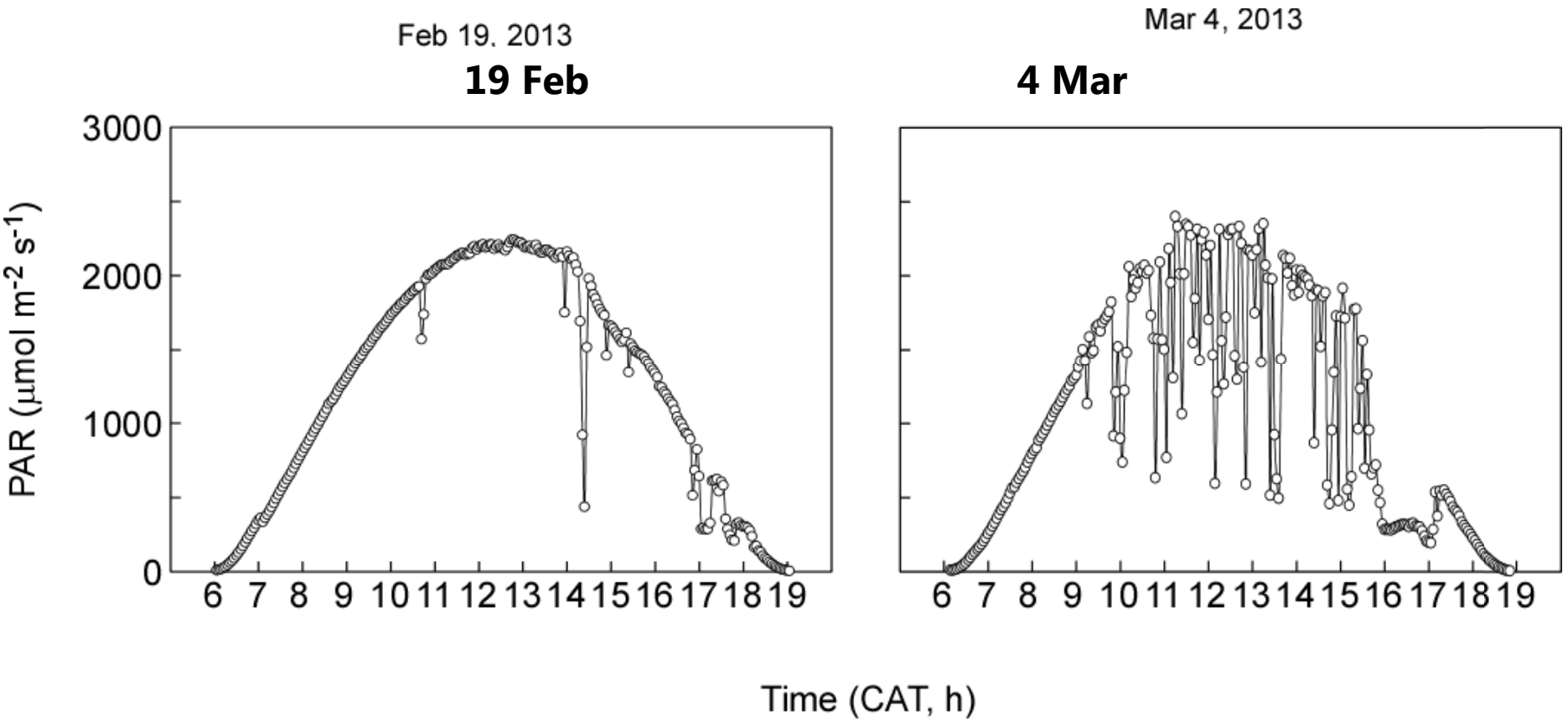
The metabolic profiles were likely to be clustered according to the differences between small and large size groups.

Acetate and Trehalose was abundantly included in the soils at the larger size of Jatropha compared to those at smaller size of Jatropha.

Photosynthesis characteristics in Botswana



Solar radiation



Diurnal series of PAR in 19 Feb and 4 Mar

PAR: Photosynthetically active radiation

Jatropha taking a "midday nap" through stomatal closure

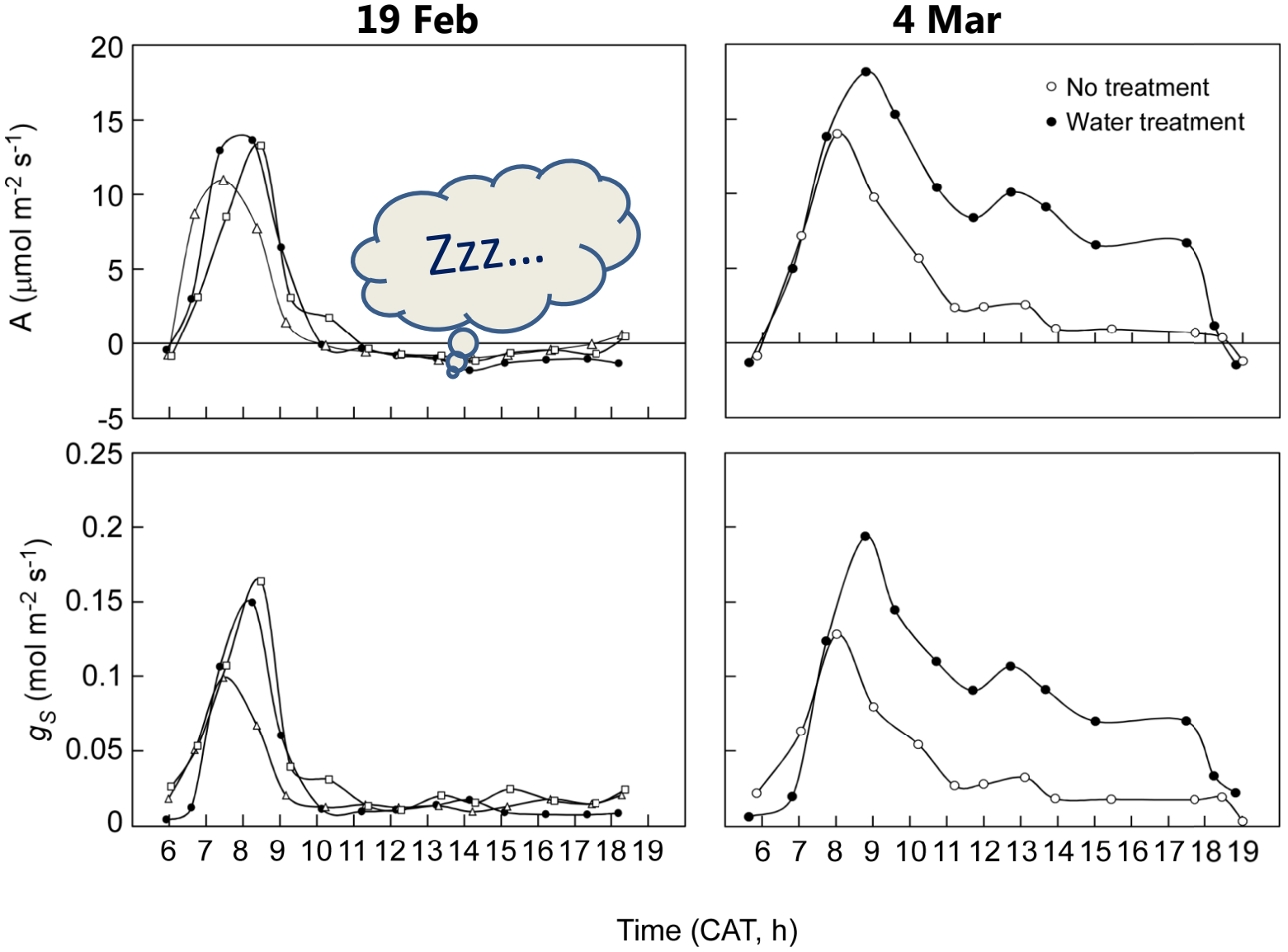


Fig. 3 Diurnal series of *A* and g_S in 19 Feb and 4 Mar

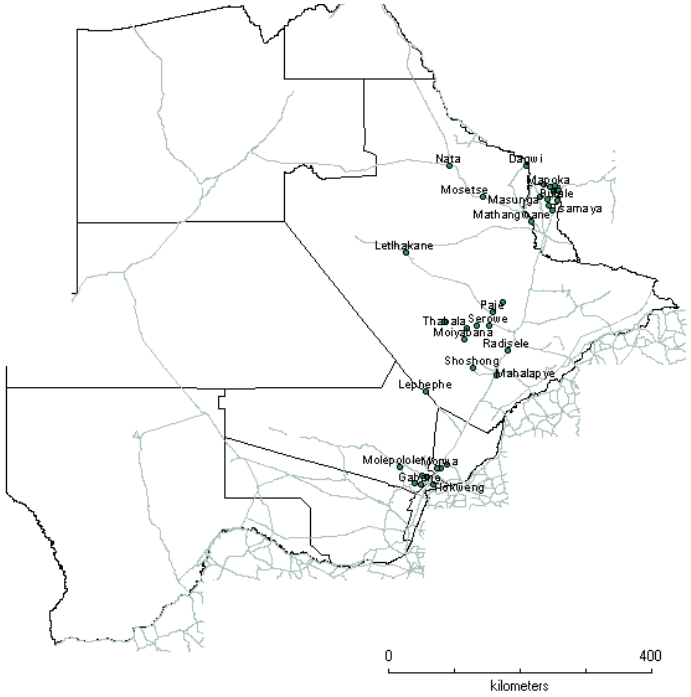
A: CO_2 assimilation rate, g_S: stomatal conductance (openness)

2. Breeding of Jatropha variety for higher and stable production

Indigenous Jatropha germplasms in Botswana.

- Indigenous Jatropha germplasms, which thrive in the semi-arid climate, are found in different regions of Botswana.
- These accessions potentially serve as breeding source for establishing elite jatropha varieties for stress tolerance, disease/pest resistance and higher yield.

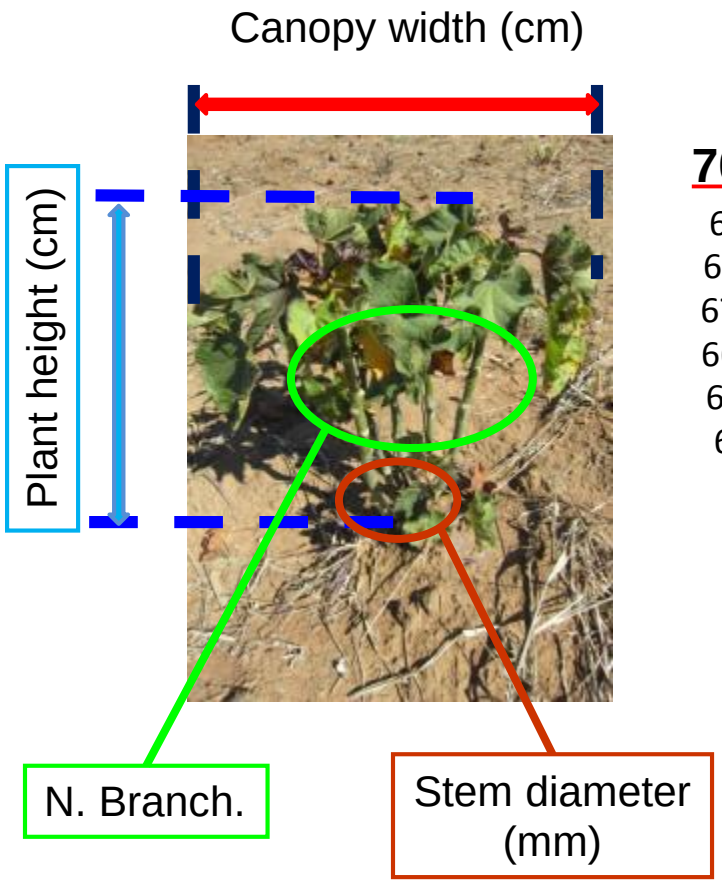
A jatropha tree in the yard of Mr Galathwe Kgari, Serowe

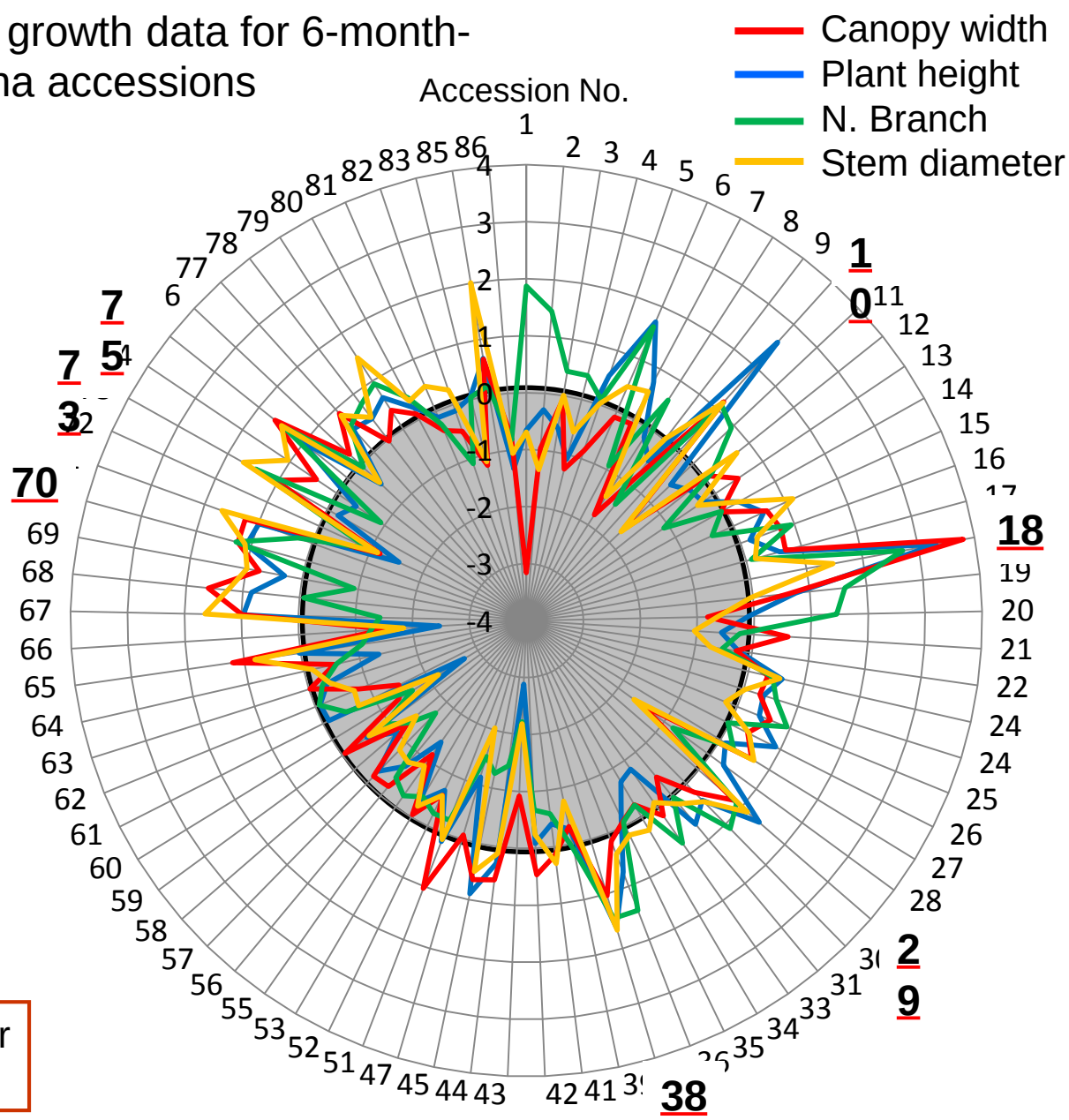


A jatropha tree in Maun

Diversity of Jatropha indigenous accessions in Botswana

Normalized growth data for 6-month-old Botswana accessions





One of elite : Acc:1-5

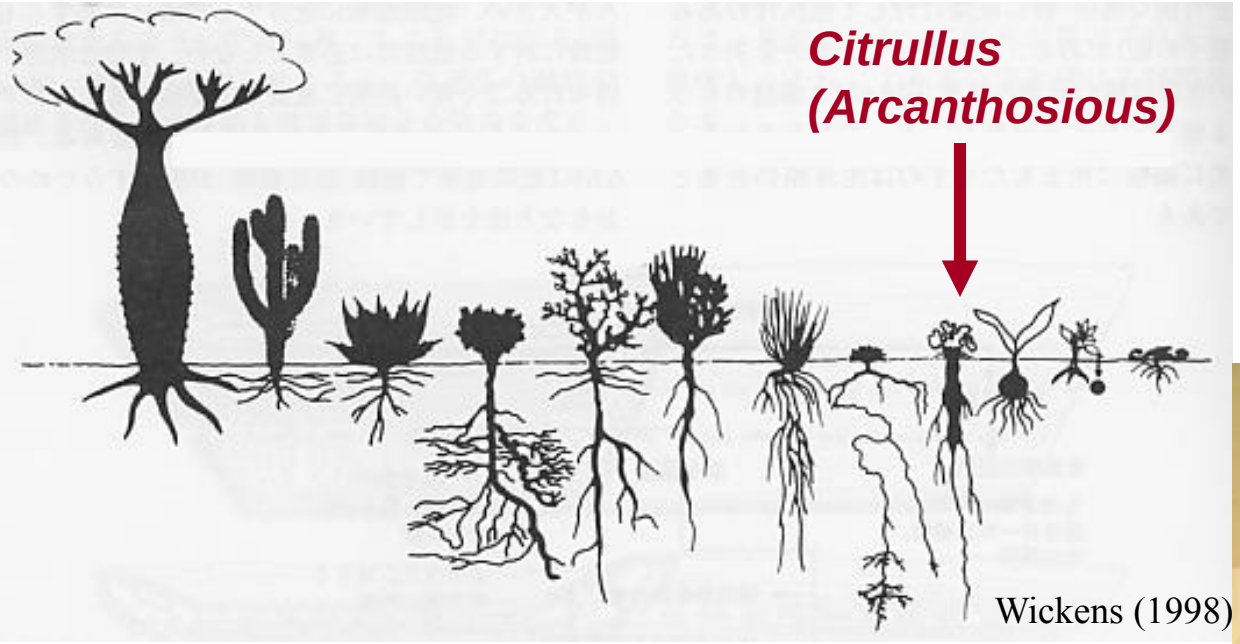
Passport data of Jatropha accessions from Botswana

- Over 80 accessions of Jatropha were collected from different areas of Botswana.
- Collections are either as seeds or stem cuttings
- Accompanied by collection site data such as GPS coordinates, growth conditions, usage, etc.
- All the available accessions are under evaluation at the Experimental Field.
- Differences in growth and flowering are observed.
- Further field investigation, establishment of propagation protocol and database are underway.

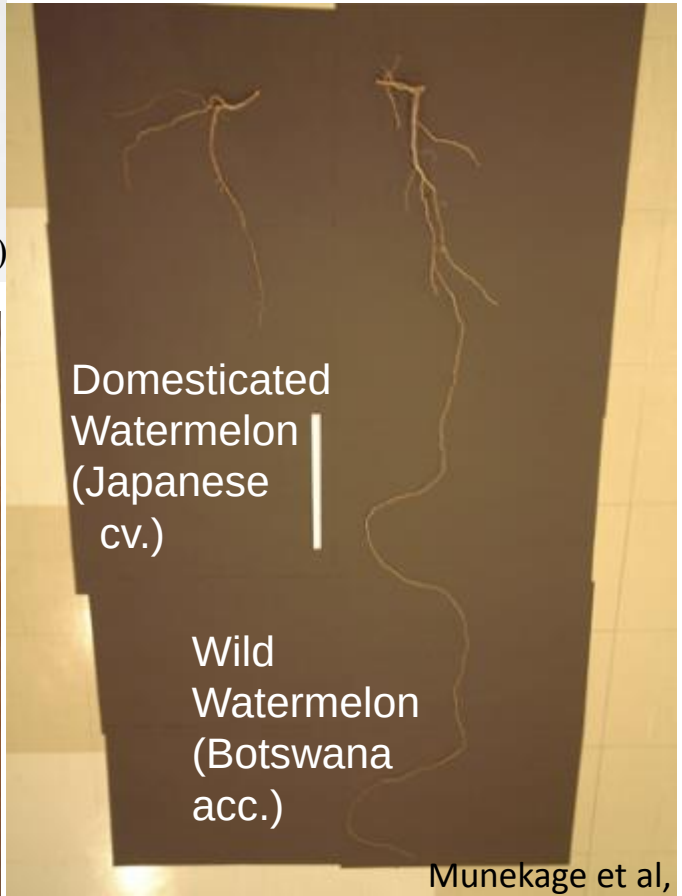
Passport data Jatropha

Collector's Number	Donor Name	Village/Town	Latitude	Longitude (DMSM)	Elevation	Collecting date	Planted from		USES
							Seeds	Cuttings	
GKMG 01	Rebonamang Rancholo	Nata	20"12'32.8	026"10'14.6	928m	2010/6/7		/	Ornamental
GKMG 02	Alfred Lesetedi	Nata	20"12'49.2	026"11'31.9	916M	2010/6/7		/	Ornamental
GKMG 04	Keaboka Mapini	Nata	20"13'04.1	026"11'27.4	913M	2010/6/7		/	Ornamental
GKMG 05	Badisa Mazhani	Mosetse	20"39'09.6	026"39'03.5	942M	2010/6/7		/	Ornamental
GKMG 06	Libengo Mojiwa	Mosetse	20"39'11.8	026"39'05.0	997M	2010/6/7		/	Shade
GKMG 07	Polokokgolo Kebailele	Mosetse	20"39'19.1	026"39'20.0	-------	2010/6/7		/	Ornamental
GKMG 08	Ramokapane	Matlhangwane	20"59'57.4	026"19'57.0	-------	2010/6/7		/	Ornamental
GKMG 09	Kudzanani Mbambanyi	Tsamaya	20"51'26.8	027"37'45.5	1135M	2010/6/8		/	Ornamental
GKMG 010	E. Moses	Tsamaya	20"51'09.9	027"37'44.3	1123M	2010/6/8		/	Ornamental
GKMG 011	Lernard Mokgosi	Tshesebe	20"45'13.0	027"35'34.8	1159M	2010/6/8		/	Ornamental
GKMG 013	John Bofa Ndlovu	Butale	20"41'45.9	027"41'15.2	1189M	2010/6/8		/	Shade
GKMG 014	Babhati Mogoma	Moroka	20"32'58.9	027"38'54.3	1303M	2010/6/8		/	Ornamental
GKMG 015	Itumeleng Moeng	Moroka	20"32'13.4	027"38'59.7	1306M	2010/6/8		/	Ornamental
GKMG 016	Keetsheletse Matebu	Nlapkhwane	20"31'15.9	027"31'57.3	1258M	2010/6/8		/	shade

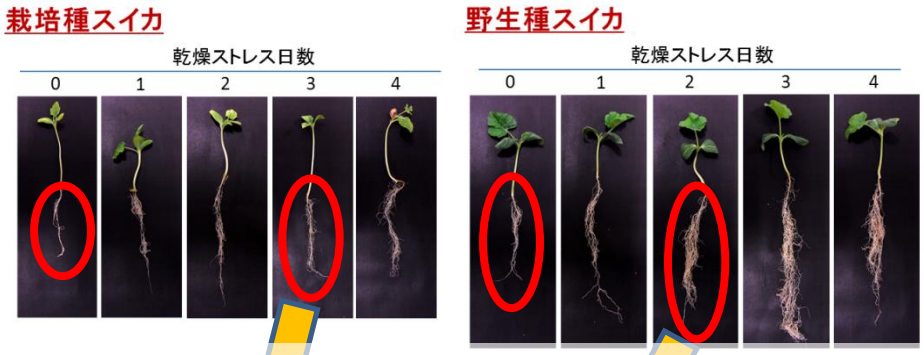
Root system architecture of xerophytes



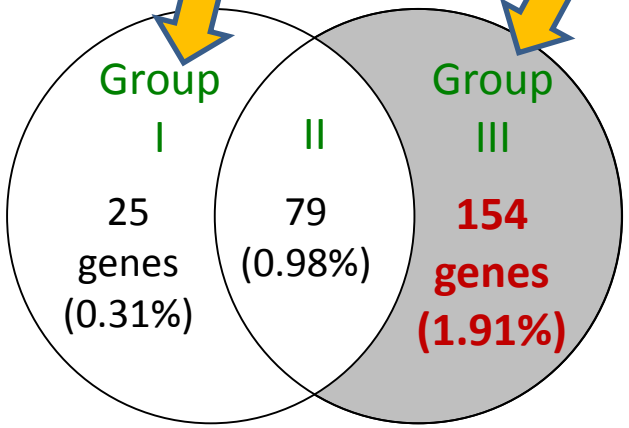
Several xerophytes (plants in arid lands) develop deep root system architecture in response to water deficits, thereby reaching to deep water layers (drought avoidance).



Root genes that are activated under water deficits in xerophytes

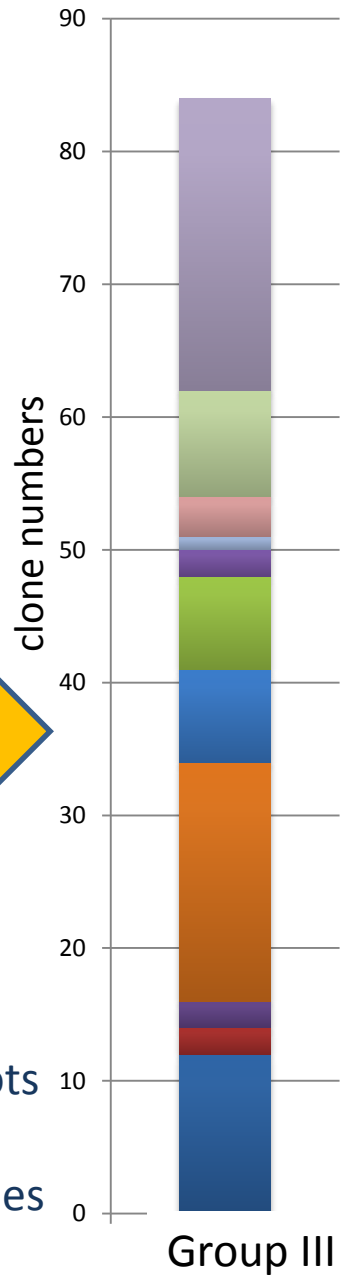


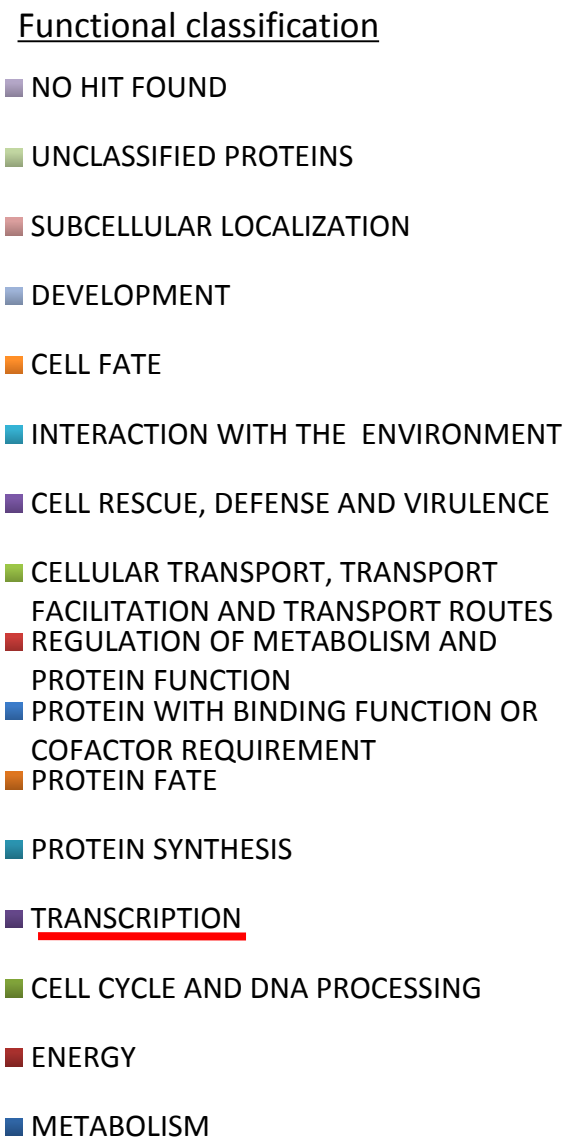
32k DNA array for 8,069 target genes (60mer) from 57,168 unigenes



Up-regulated genes (> 2-fold)

154 genes are up-regulated by drought in the roots of wild watermelon but not in the domesticated watermelon. These wild watermelon-specific genes included two transcription factors.

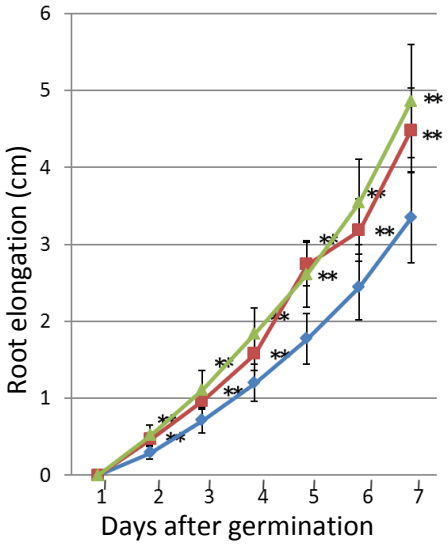




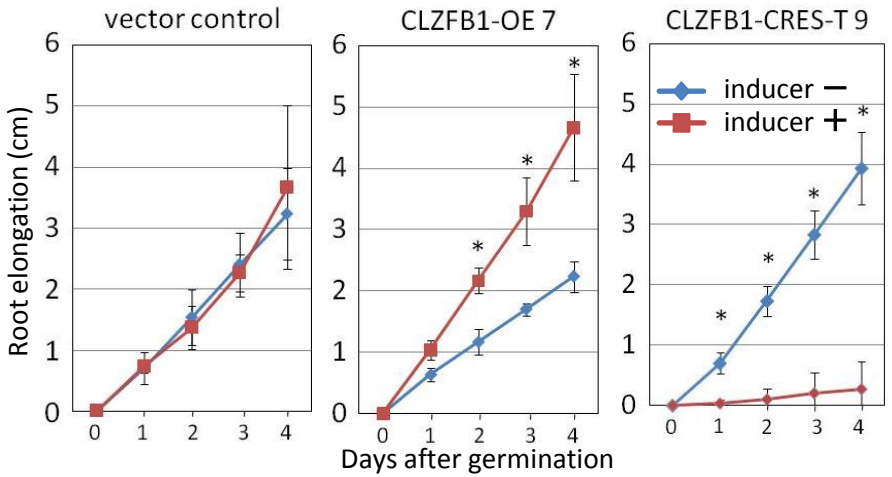
Kajikawa et al, in preparation

Root growth stimulation by transcription factor CLZFB1

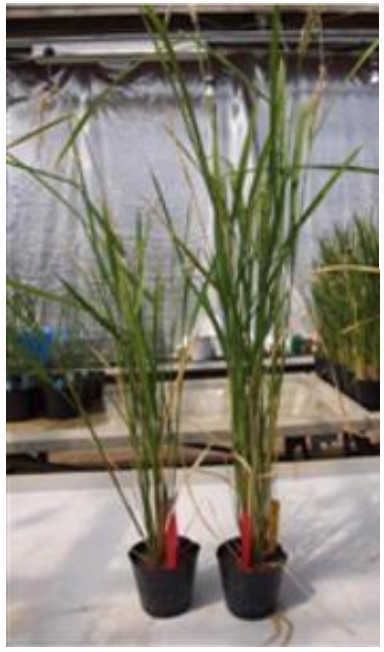
- Transgenic Arabidopsis and rice plants overexpressing CLZFB1 showed enhanced root growth and improved biomass production.
- This gene offers attractive molecular tools for developping root system architecture of Jatropha via molecular breeding.



Transgenic Arabidopsis overepressing CLZFB1 showed enhanced root growth



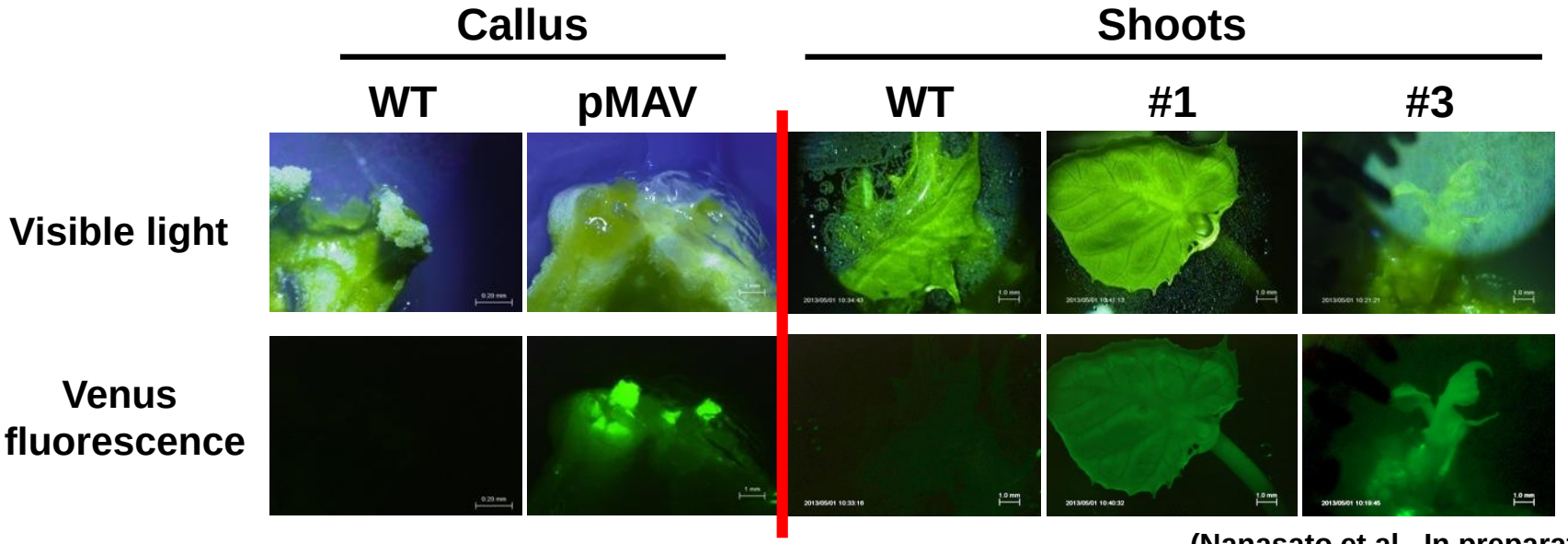
In transgenic watermelon hairy roots, overexpression of CLZFB1 enhances root growth, while suppression of CLZFB1 function by CRES-T technique inhibit root growth.



Transgenic rice overexpressing CLZFB1showed enhanced root growth and yield.

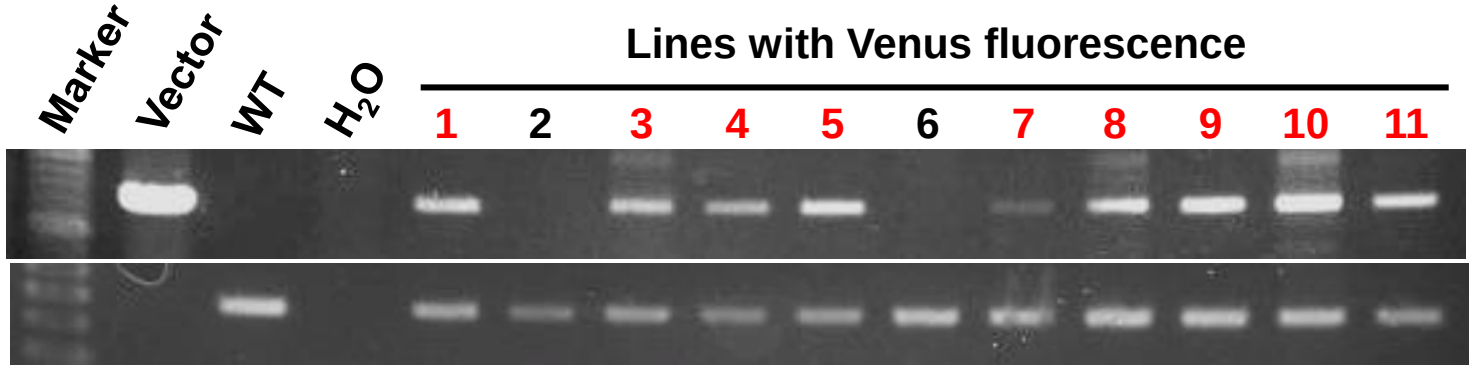
Screening of transgenic Jatropha shoots with Venus marker fluorescence

Venus: a GFP variant (Nagai et al., 2002, Nature Biotech)



(Nanasato et al., In preparation)

Genomic PCR

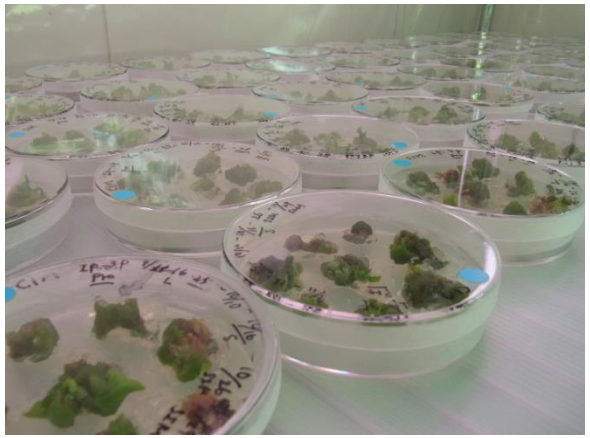


→81% of shoots with Venus fluorescence proved to be true transgenic shoots.

Generation of Cold-/drought-resistant GMO Jatropha

Introduced genes

1. Root-growth promoting transcription factor for enhancing water absorption from deep soil — ***CLZFB1***
2. A defense protein for protecting membrane integrity and cellular structure during cold and water deficits — ***Dehydrin***
3. A biosynthetic gene for trehalose, which protects cellular integrity during cold stress — ***TPSP***



Regenerated Transgenic Jatropha

Thank you for your attention!

Obrigado!