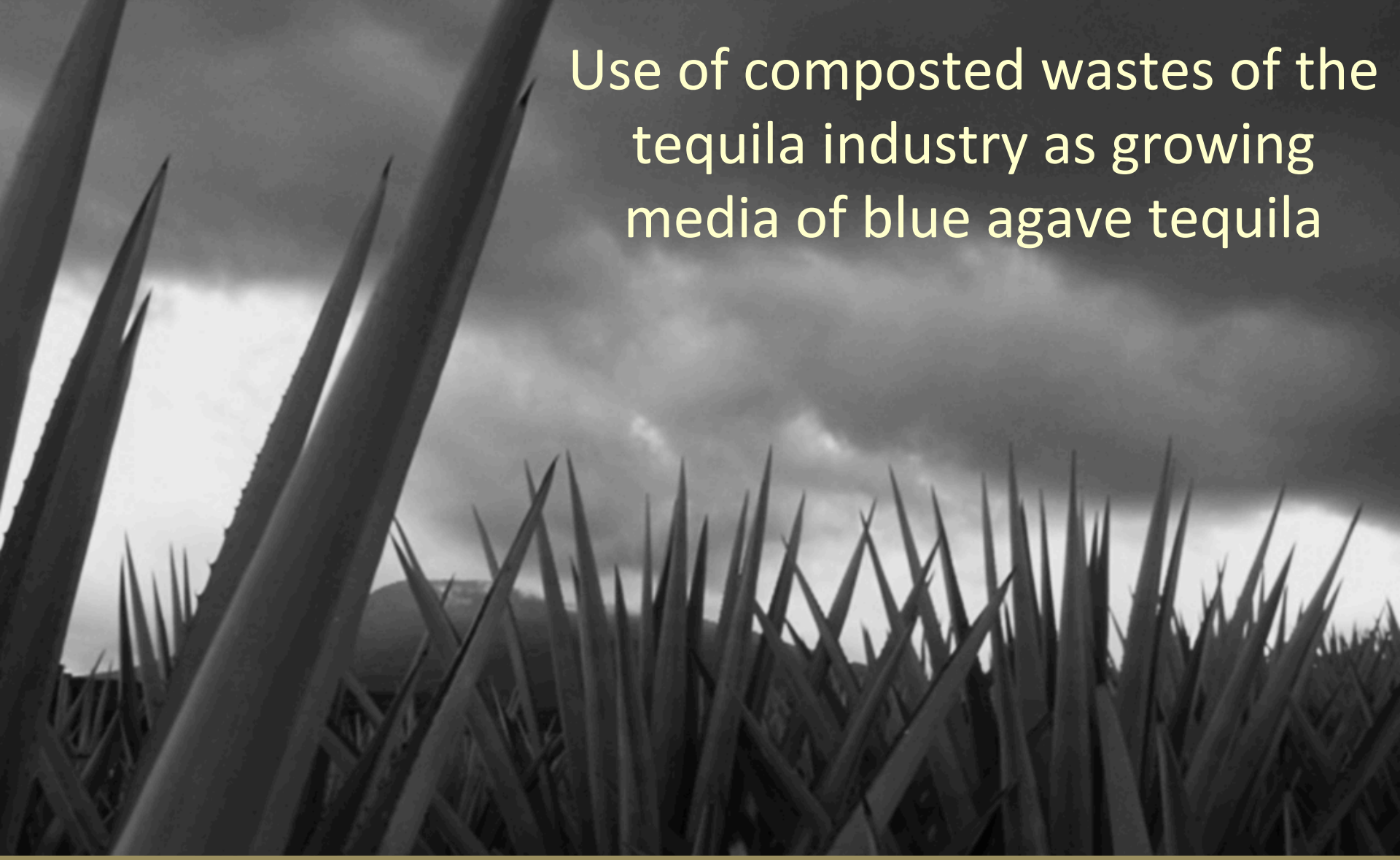

Use of composted wastes of the tequila industry as growing media of blue agave tequila

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1. Introduction

Tequila: The most emblematic destilled drink of Mexico is produced from blue agave (*Agave tequilana* W.)

- **1600**: First tequila factory established in Tequila town, Jalisco State, Mexico.

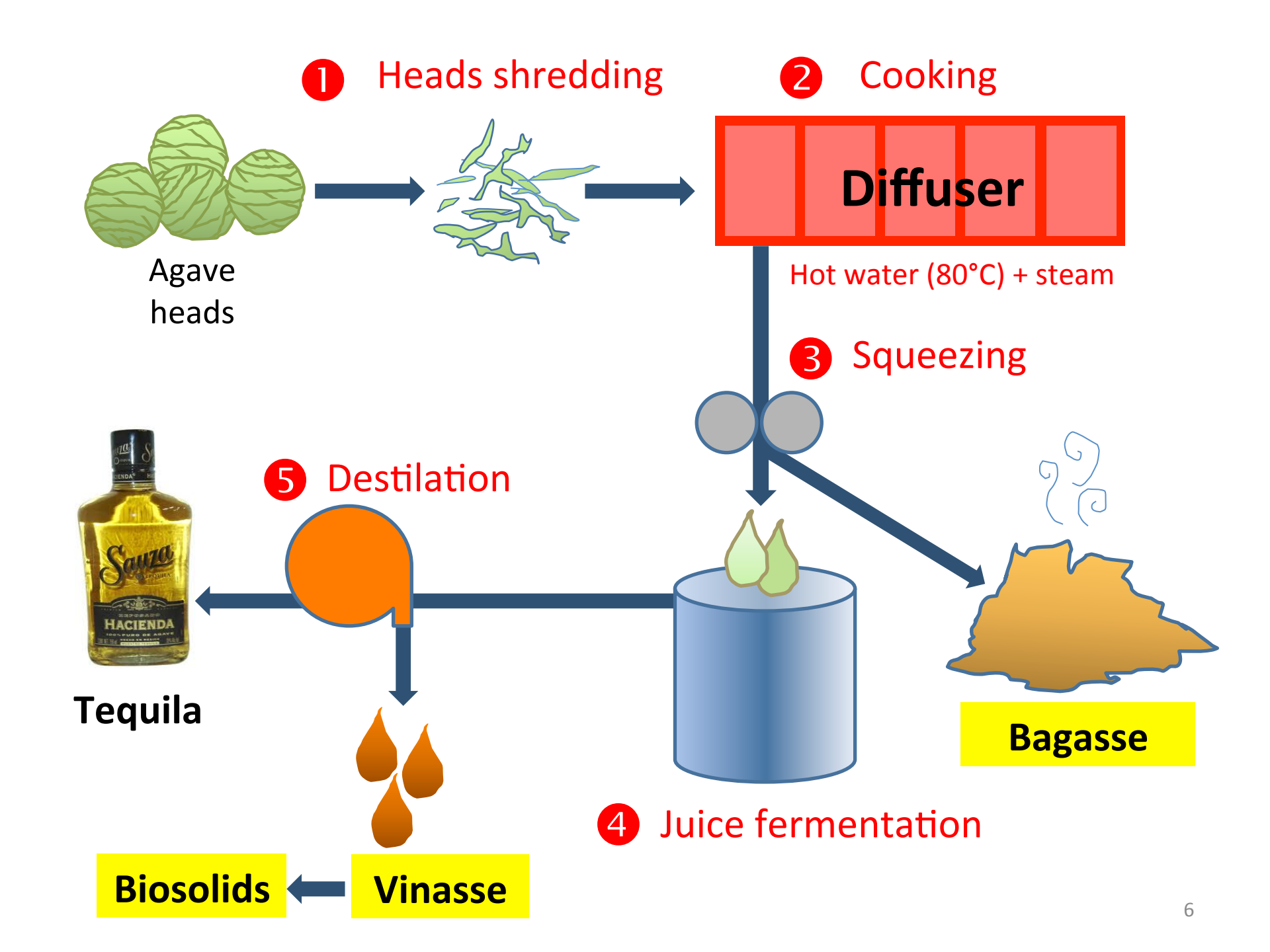
"Heads" of agave

- **Growth period of blue agave**: 6 to 8 years to harvest.

- **Tequila production** (2012): 254 million liters
  (67 million gallons)

- **Wastes generation**
  - ✓ **Agave bagasse:** 350 000 metric tons
    (~385 000 US-tons)
  - ✓ **Vinasse:** 2,500 million liters
    (668 million gallons)
  - ✓ **Biosolids:** Currently few industries.

The tequila production process in 5 steps


1 Heads shredding
2 Cooking
Diffuser
Agave heads
Hot water (80°C) + steam
3 Squeezing
5 Destilation
Tequila
Bagasse
4 Juice fermentation
Biosolids
Vinasse

Bagasse

Characteristics:

Humidity:	70-90%
C/N:	~90
Cellulose:	43%
Hemicellulose:	19%
Lignin:	15%

Vinasse: highly polluting waste

pH: < 3.5
EC: 3.48 dS m^{-1}
Temperature: 90°C (195 °F)

Chemical Oxigen Demand (COD): >35,000 mg O_2 L^{-1}

Biochemical Oxigen Demand (BOD): >100,000 mg O_2 L^{-1}

Biosolids

WWTP

800 m^3
(1040 yd^3)
per day

Energy generation

Co-composting bagasse + biosolids

pH: 8.5
EC: 4.2 dS m^{-1}
More nutrients than **vinasse**:
Na, P, N, Ca, K, Mg

Problem:

Bagasse and vinasse pollution

Solution:

Co-composting: Bagasse + vinasse

Bagasse + biosolids

Composting: Bagasse + water

Blue agave nursery cultivation

Plant origin: Tissue culture (13-18 months).
Nursery time: 9 – 12 months growing-period in container.

Agave sprouts

Sauza® TEQUILA

Commercial substrate v/v:

- 80% coir (coconut powder).
- 10% Pine bark.
- 10% Agave bagasse compost.

2. Aim of the study

To evaluate the use of **compost from agave bagasse** produced with **vinasse**, **biosolids** and **water**, mixed with different amounts of **coir** to **grow blue agave** in container.

Other targets…

Coir

80%

Pine bark

10%

Agave bagasse compost

10%

In addition: Comparative costs.

3. Materials and methods

Facilities and container

- Shaded box.
- 1.1 liter (0.3 gal) capacity biodegradable container.
- Fertirrigation.

Evaluation time

Nine months

Compost types

1) **120**-days **co-composted bagasse + biosolids** (LC4).
2) **150**-days **co-composted bagasse + vinasse** (VC5).
3) **150**-days **composted bagasse + water** (C5)
4) **365**-days **composted bagasse + water** (C12).

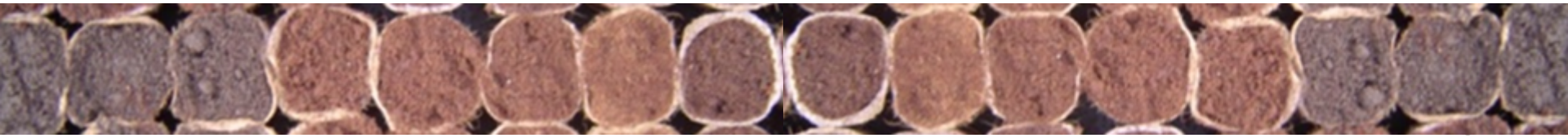
Substrates to evaluate

- **Three volume-based mixtures of each compost type**

  30%, 50% and **70%** + **coir**

- **Control (commercial substrate)**

  80% Coir (coconut powder).
  10% Pine bark.
  10% Agave bagasse compost.



Substrates preparation

Fertilization and fertirrigation

Fertilization at the beginning:

7.2 g per container of 16-16-16

Fertirrigation during 9 months

- Chelates: Fe, Mn and Mg.
- 18-18-18 (4 months) and 15-30-15 (five months).
- Foliar fertilizer (montly).

Evaluation factors of plants

1. Stem diameter.
2. Number of leaves.
3. Leaf lenght (the longest one only).
4. Leaf width (from the longest one only).
5. Total dry weight (leaves + roots).

Substrates lab analysis

Physical analysis (Ansorena 1994)

- ✓ Porosity.
- ✓ Bulk density.
- ✓ Water absorption capacity.

Chemical analysis (TMECC, 2001)

- ✓ pH.
- ✓ Electric conductivity (EC).
- ✓ Cation exchange capacity (CEC)
- ✓ Organic matter (OM).
- ✓ C/N ratio
- ✓ Total nitrogen
- ✓ P
- ✓ K

Compost quality test

Solvita

Statistical design

Completely randomized design 4 x 3 factorial arrangement with four replications.

Statistical analysis

- **Analysis of variance**.
- **Means comparation**: **Loan S**ignificant **D**ifference.

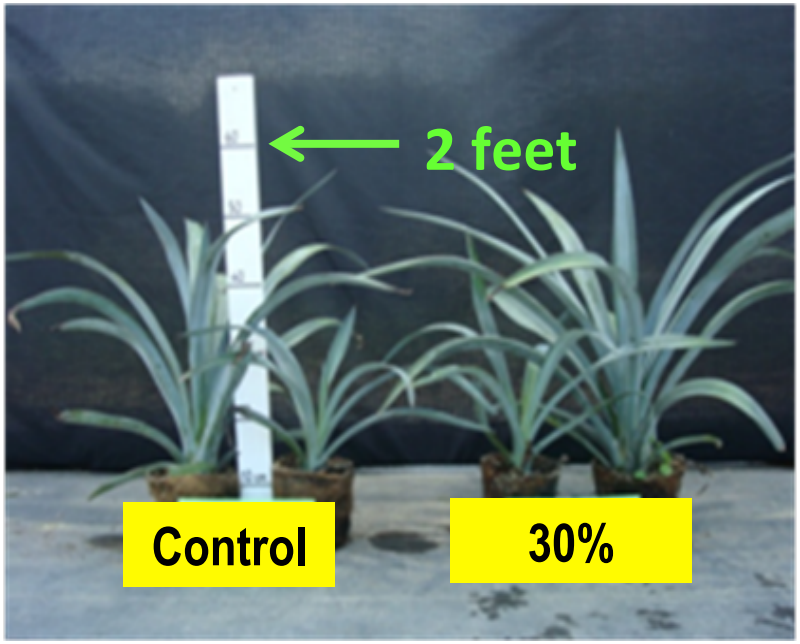
Statistical Program

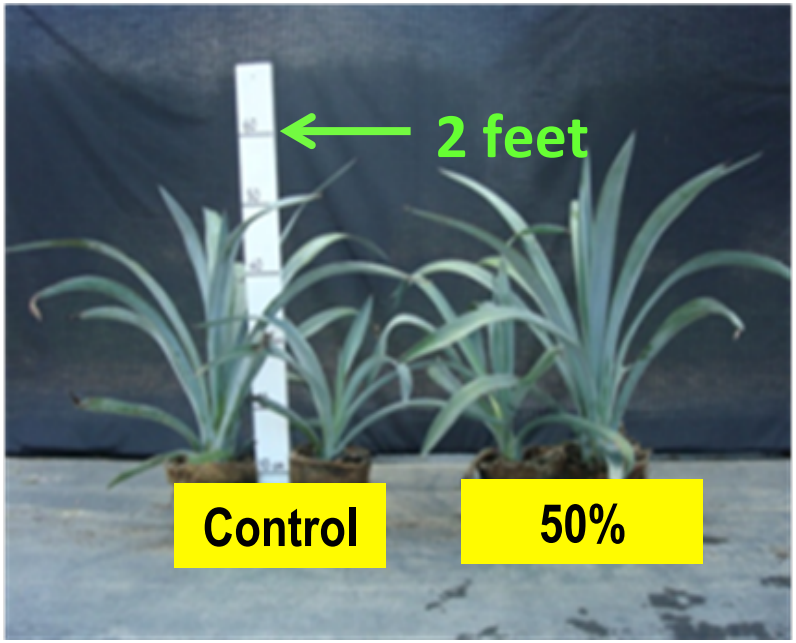
Minitab Release 13.20 (2000).

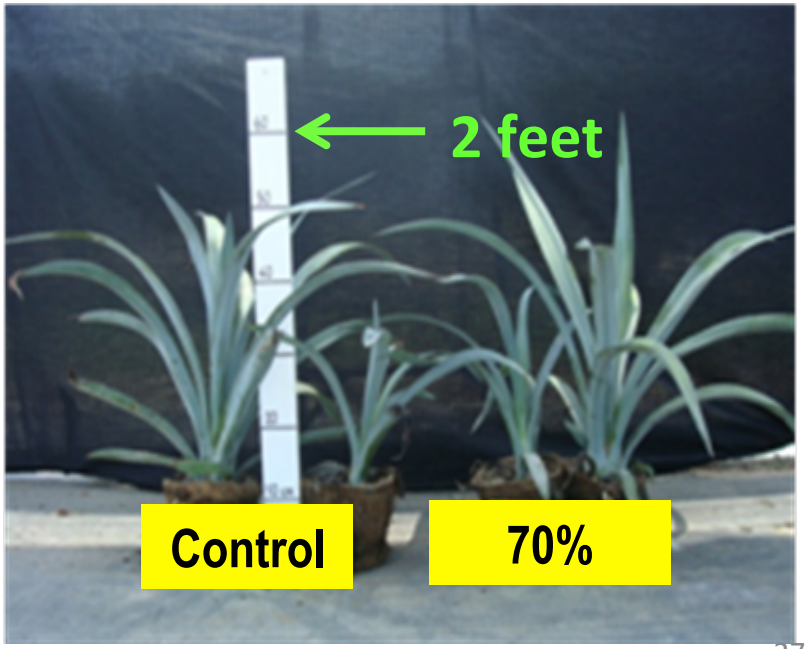
4. Results and discussion

- There were **statistical significant differences** ($p<0.05$ and $p<0.01$) between almost **all compost types** and **mixtures** compared to **control**.

- All composts types and mixtures were similar, however the substrate **compost + biosolids** was “slightly” better.

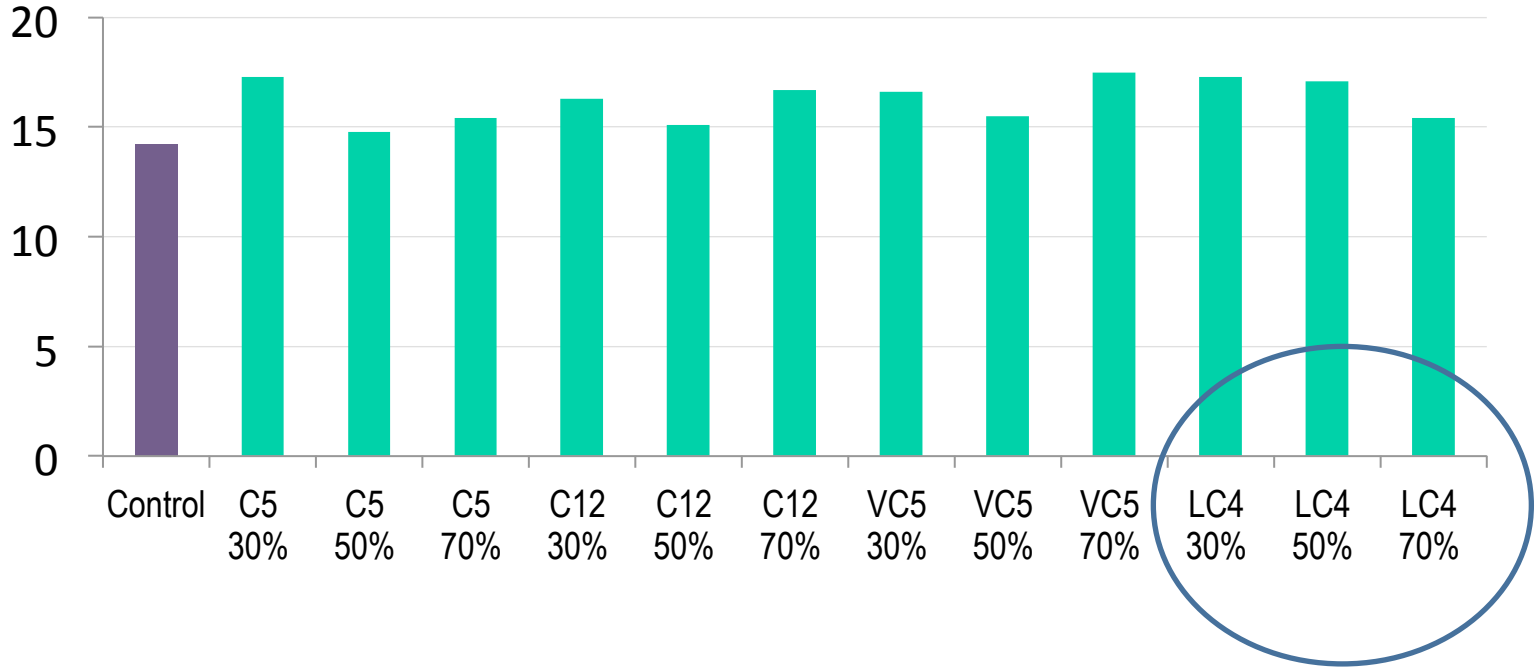






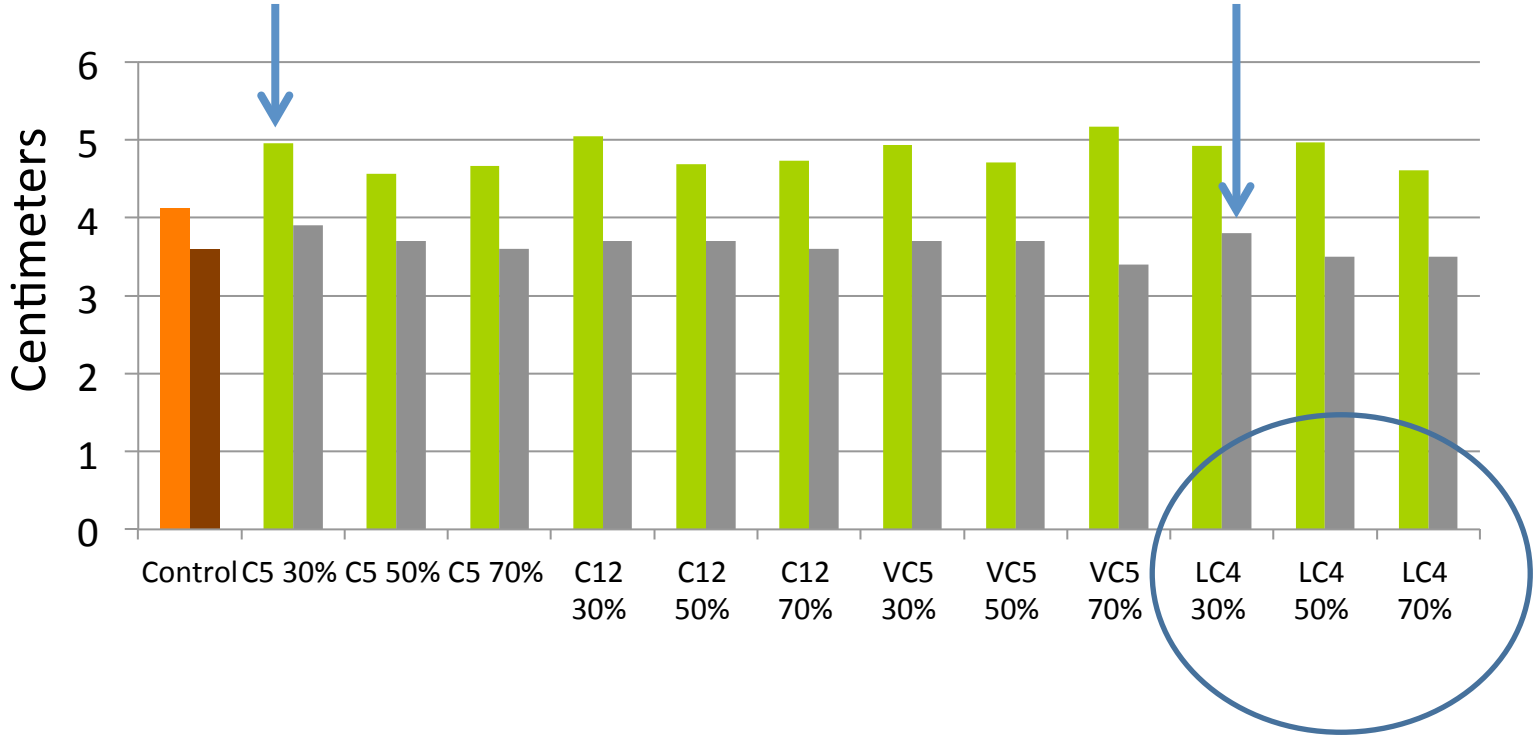
- Contrasting phenotypical differences between agave plants within the same treatment probably due to **somaclonal variation**.

Number of leaves



1) 150-days **bagasse compost** + **tap water** (**C5**).
2) 360-days **bagasse compost** + **tap water** (**C12**).
3) 150-days **bagasse compost** + **vinasse** (**VC5**).
4) 120-days **bagasse compost** + **biosolids** (**LC4**).

Stem diameter and leaf width



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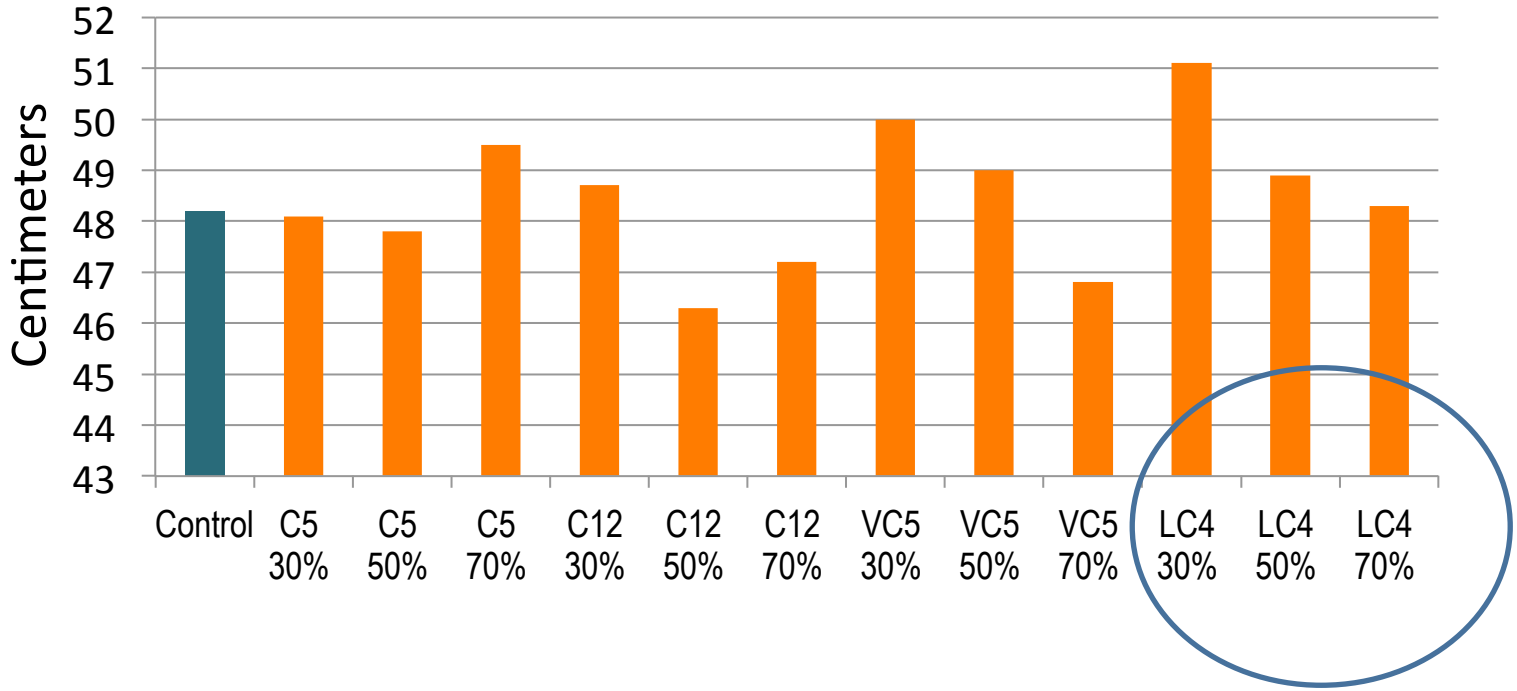
Leaf lenght



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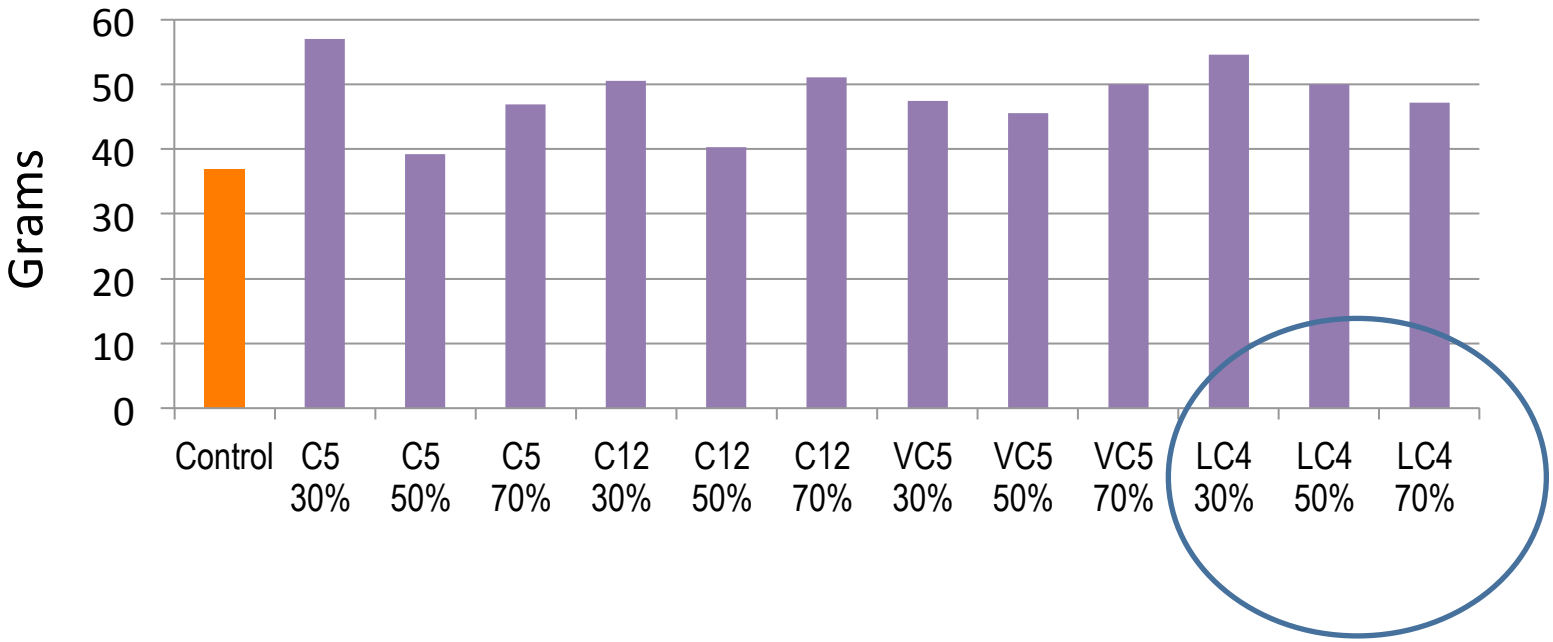
Total dry weight



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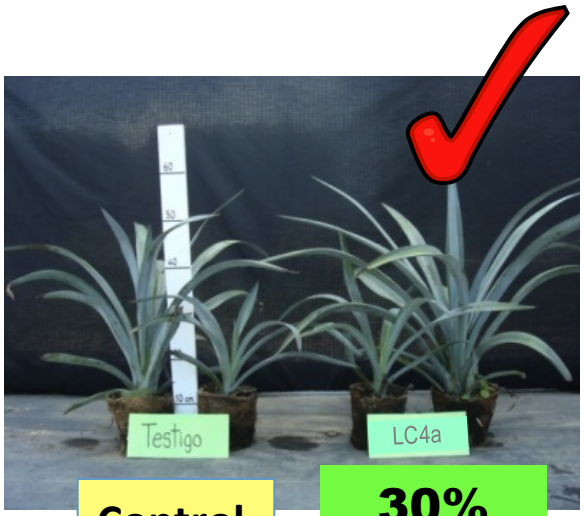
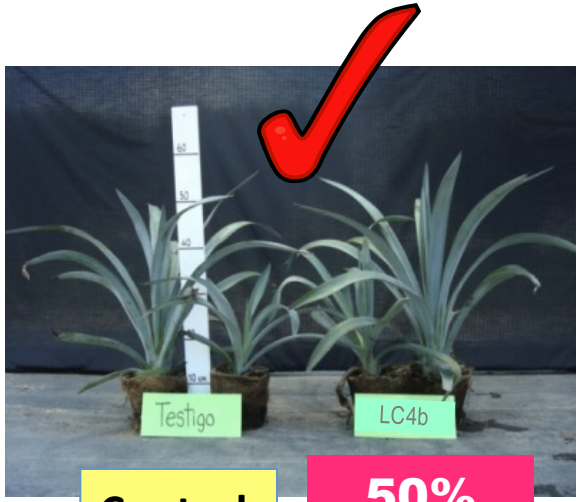
Compost + biosolids substrate



Control

30% compost

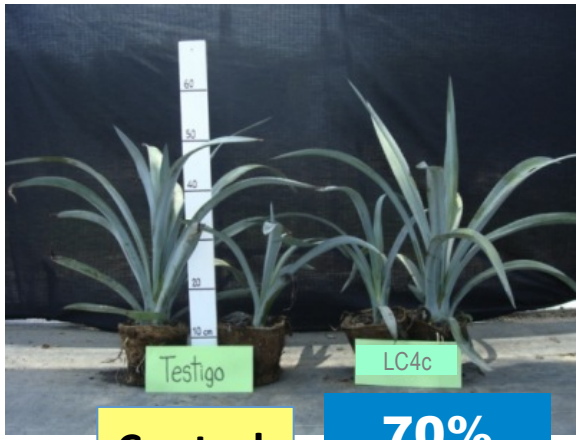
Costs reduction 10%



Control

50% compost

Costs reduction 32%

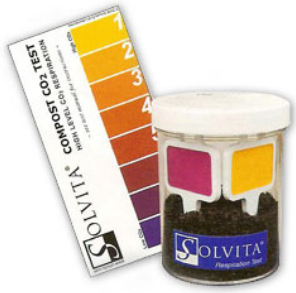


Control

70% compost

Costs reduction 53%

SOLVITA test



Evaluated compost types

Compost type	Maturity index (CO_2 + NH_3)	Stage of the composting process	
C5	6	Active compost (curing)	✓
C12	7	Finished compost	✓
VC5	7	Finished compost	✓
LC4	7	Finished compost	✓

Chemical characteristics of control and compost + biosolids substrates

Substrate	pH	EC dS m^{-1}	CEC Meq 100^{-1} g	OM %	C/N	TN %	P %	K %
Control	6.7	1.17	84.3	49.0	94.5	0.32	0.19	0.32
LC4 30%	6.6	1.21	84.5	48.2	31	0.91	0.18	0.34
LC4 50%	7.1	1.39	110.5	45.2	26	1.02	0.21	0.37
LC4 100%	7.3	1.50	97.5	37.8	20	1.10	0.24	0.32

No problem with heavy metals

Physical characteristics of control and compost + biosolids substrates

Substrate	**Bulk density** g cm^{-3}	**Total porosity** %	**Water absorption capacity** %
Control	0.25	83.3	80.0
LC4 30%	0.30	80.0	78.6
LC4 50%	0.40	74.0	73.8
LC4 70%	0.53	64.7	66.2

5. Conclusions

- **The four compost types:** good maturity level and suitable materials as substrates for blue agave.
- **Compost + biosolids**: Showed the better effects as substrate with the formulations 30% and 50%.
- **Commercial substrate for agave:** It is possible to replace 100% pine bark and up to 50% coconut powder using agave bagasse compost. This can reduce costs up to 32%.
- **Environment:** Co-composting agave bagasse with vinasse and biosolids can avoid pollution, both of soils and water.

Continued…

Tequila not only makes happy people, but also happy plants too…

Thank you!

Main effects of Tequila on the people