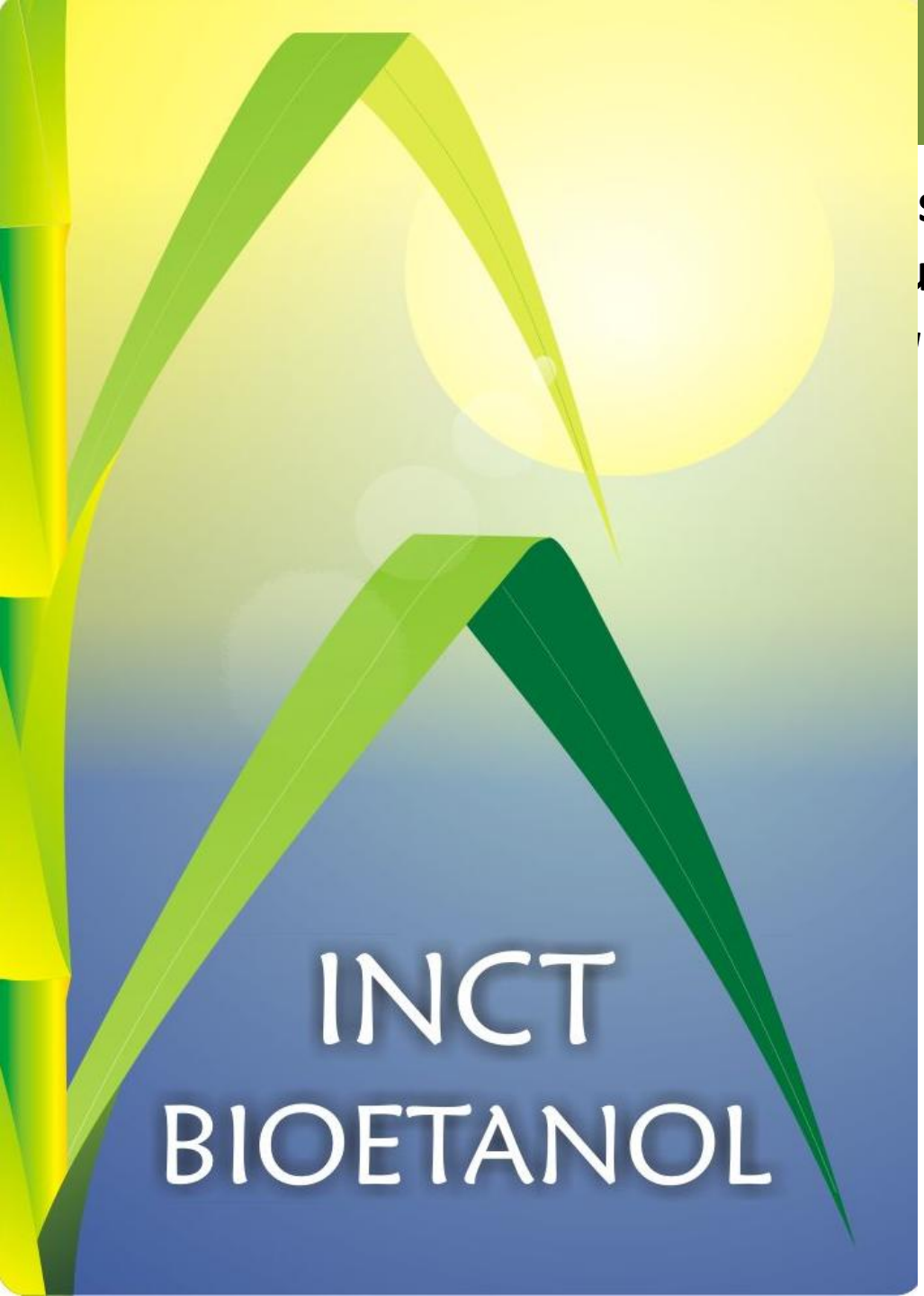

s in the control of carbohydrate ugarcane: *a possible relationship nsion and sucrose accumulation*

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FAPESP, Cane Improvement Workshop, Mar. 2009

Lines of research in sugarcane biology

Sugarcane responses to the climatic changes

(CO2, temperature and water)

Sugarcane cell wall

(structure, architecture and metabolism)

Sugarcane physiology

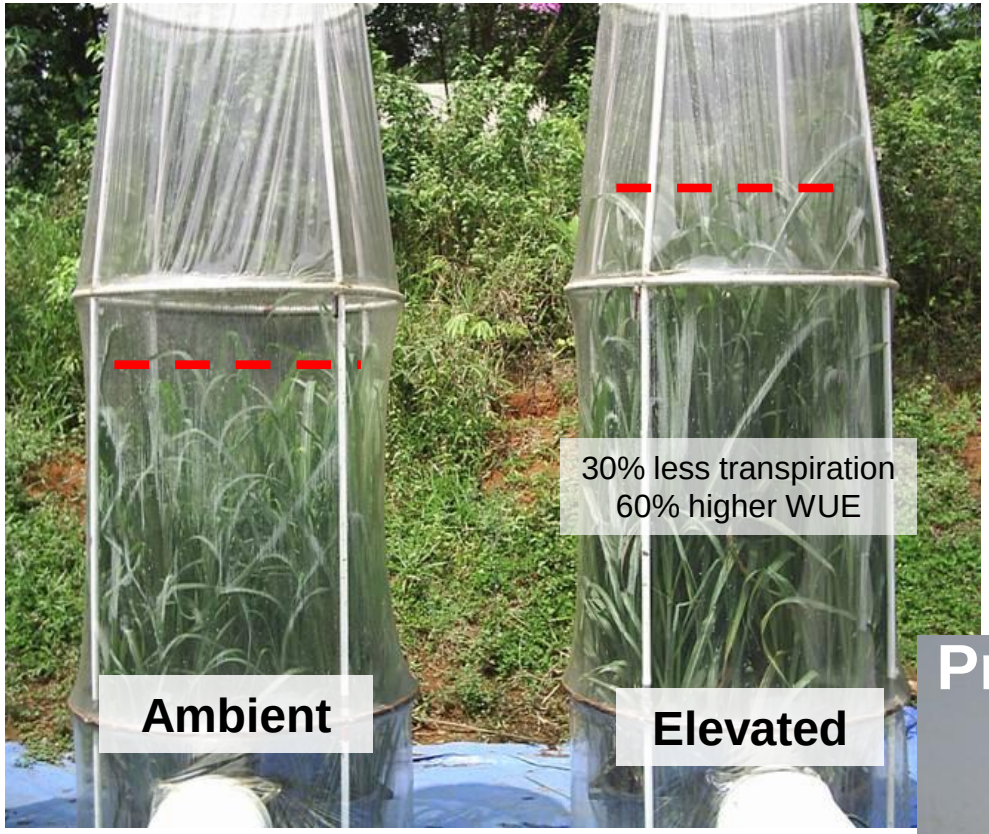
(hormonal regulation of carbohydrate metabolism)

Plant, Cell and Environment (2008) **31**, 1116–1127 doi: 10.1111/j.1365-3040.2008.01822.x

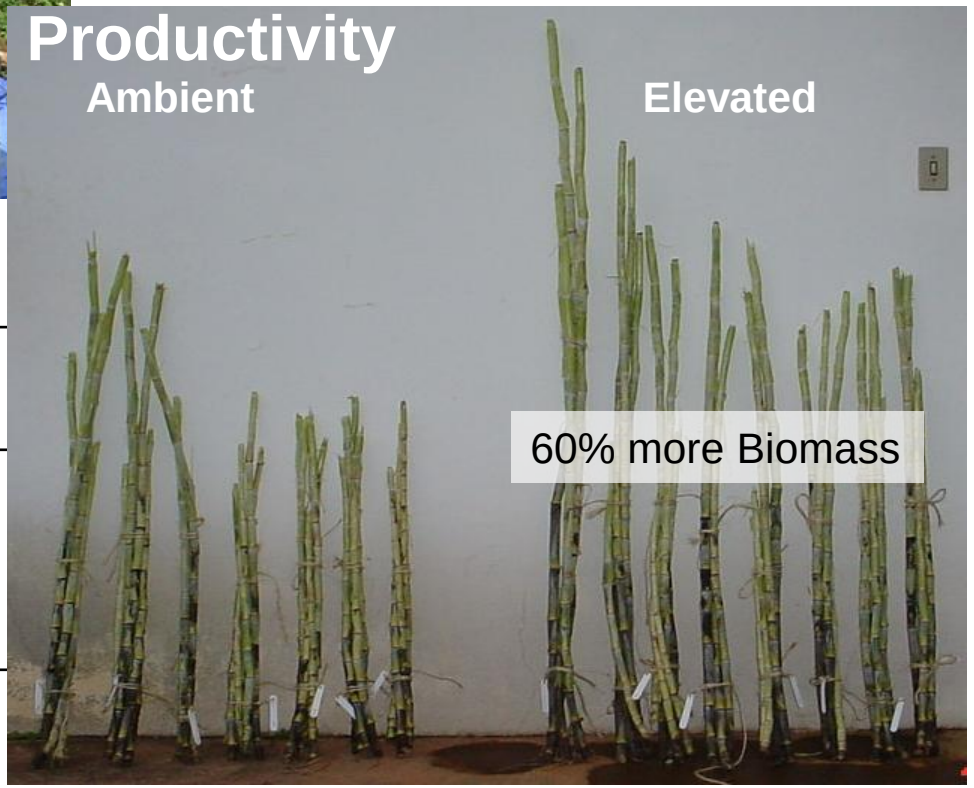
Elevated CO_2 increases photosynthesis, biomass and productivity, and modifies gene expression in sugarcane

AMANDA PEREIRA DE SOUZA[1], MARILIA GASPAR[1], EMERSON ALVES DA SILVA[1], EUGÊNIO CÉSAR ULIAN[4], ALESSANDRO JAQUIEL WACLAWOVSKY[2], MILTON YUTAKA NISHIYAMA JR.[2], RENATO VICENTINI DOS SANTOS[5], MARCELO MENOSSI TEIXEIRA[5], GLAUCIA MENDES SOUZA[3] & MARCOS SILVEIRA BUCKERIDGE[1]

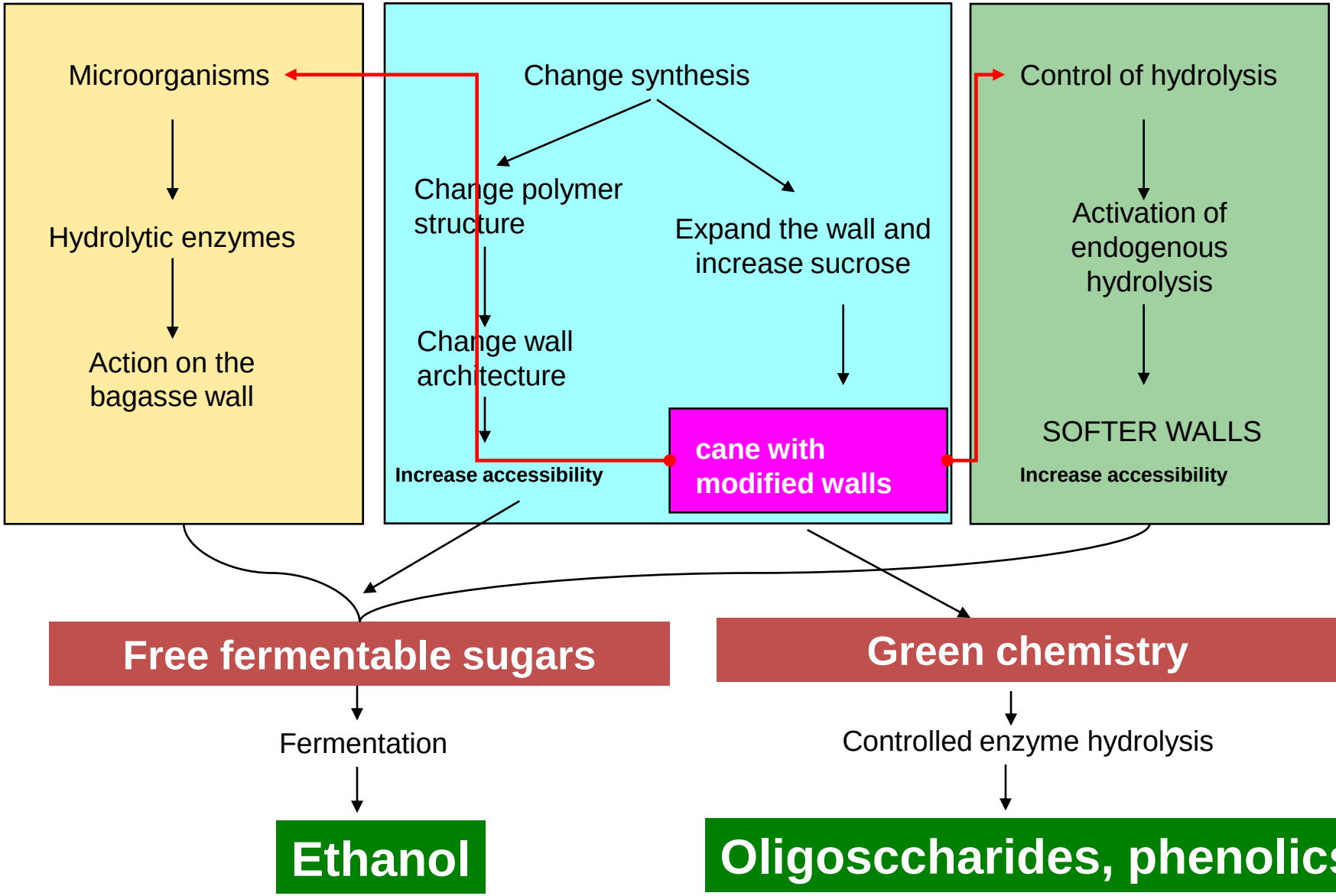
[1]Departamento de Botânica, Instituto de Biociências and [2]Departamento de Bioquímica, Instituto de Química, Universidade de São Paulo, São Paulo, Brazil, [3]Seção de Fisiologia e Bioquímica de Plantas, Instituto de Botânica, São Paulo, Brazil, [4]Centro de Tecnologia Canavieira, Piracicaba, Brazil and [5]Centro de Biologia Molecular e Engenharia Genética, Universidade Estadual de Campinas, Campinas, São Paulo, Brazil



	Fiber(% FW)	Sucrose (% FW)
Ambient	6.62 ± 0.13	2.18 ± 0.20
Elevated	7.13 ± 0.21	2.82 ± 0.14*



How to modify the wall to obtain energy and other valuable products?

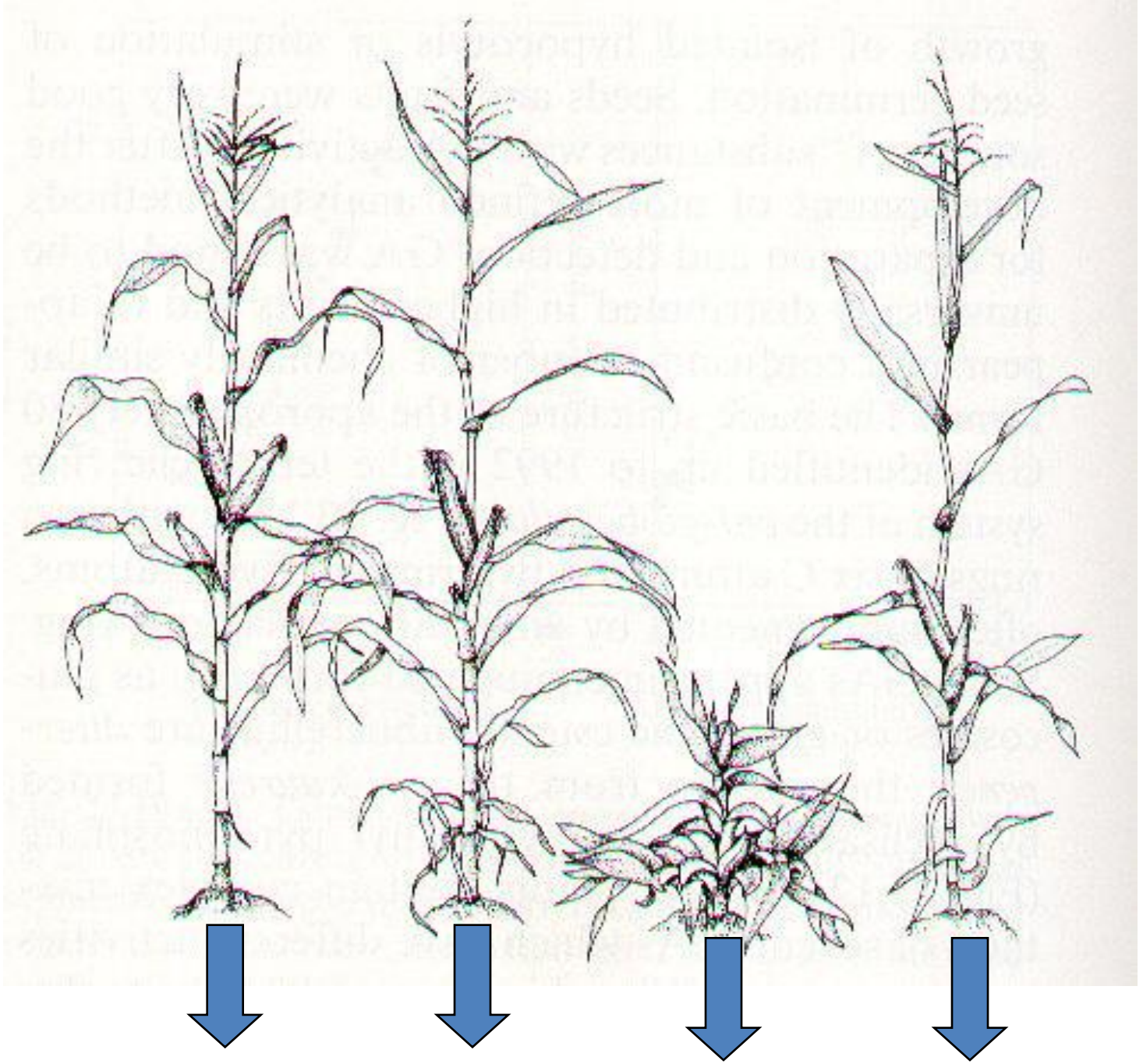


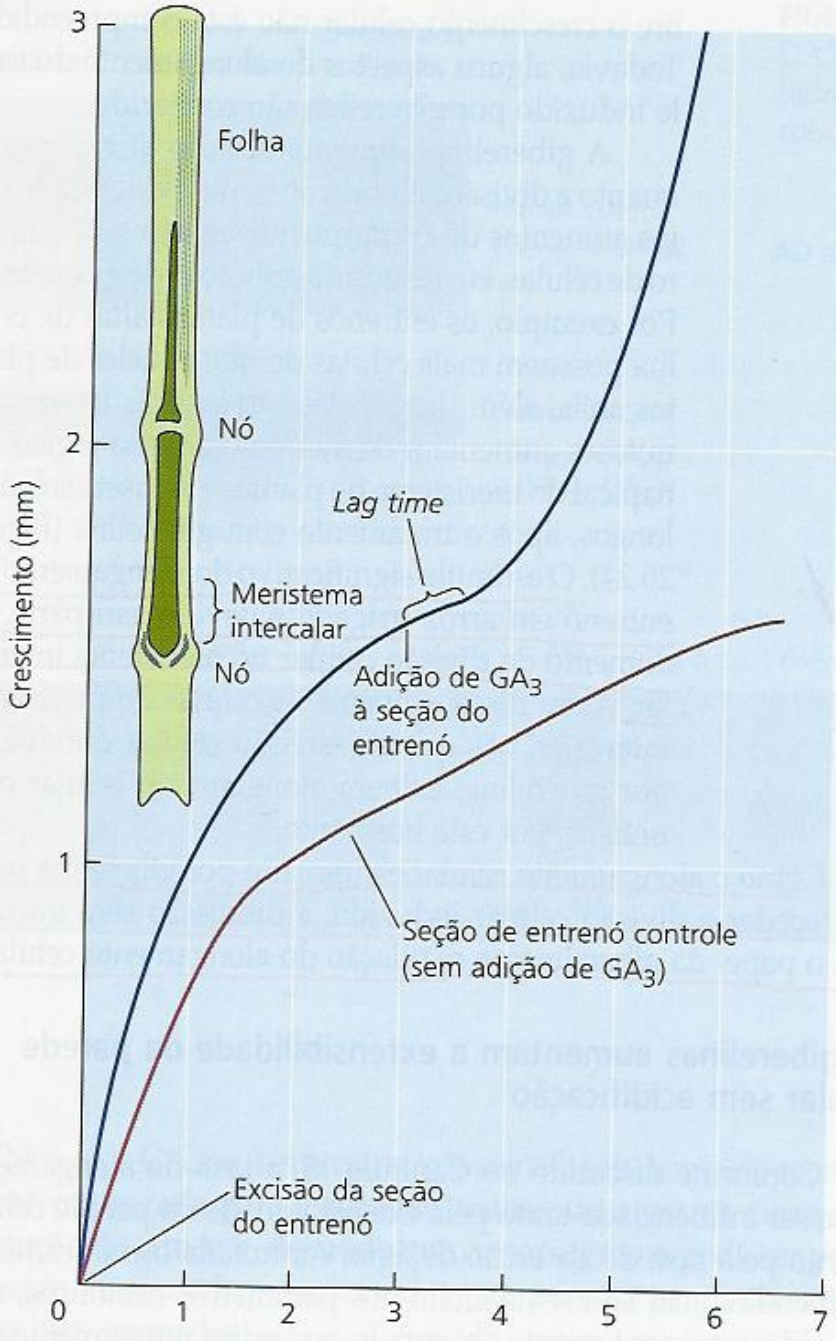
Gibberellin-responsive plants have better early growth

CSIRO PLANT INDUSTRY

Gibberellin responsive

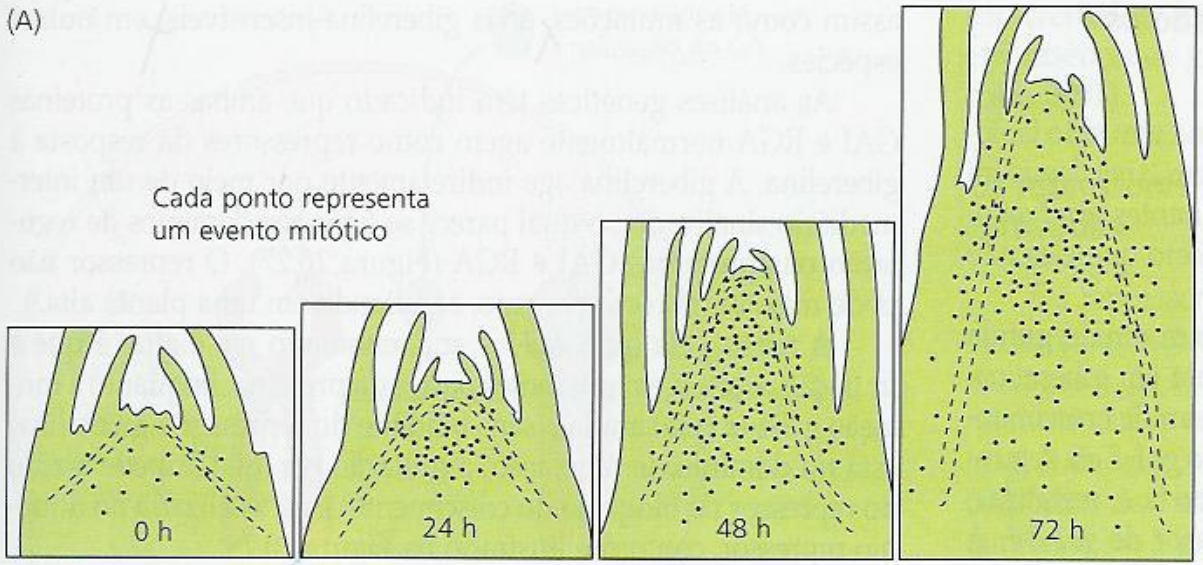
Gibberellin insensitive


wild
wild.+ GA3
Dwarf mutant
Dwarf + GA3



Effect of GA3 on development of the intercalar meristem of of rice

Giberelinas and cell division



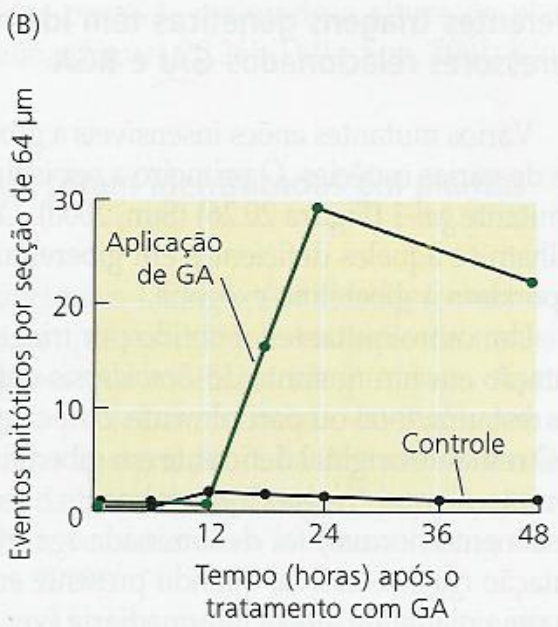


FIGURA 20.24 Aplicações de giberelina em plantas na forma de rosetas induzem o alongamento dos entrenós, em parte por aumentar a divisão celular. (A) Seções longitudinais através do eixo de *Samolus parviflorus* mostram um aumento na divisão celular após a aplicação de GA (cada ponto representa um evento mitótico em uma seção de 64 µm de espessura). (B) O número de eventos mitóticos com e sem GA em ápices caulinares de meimendro (*Hyoscyamus niger*) (Sachs, 1965).

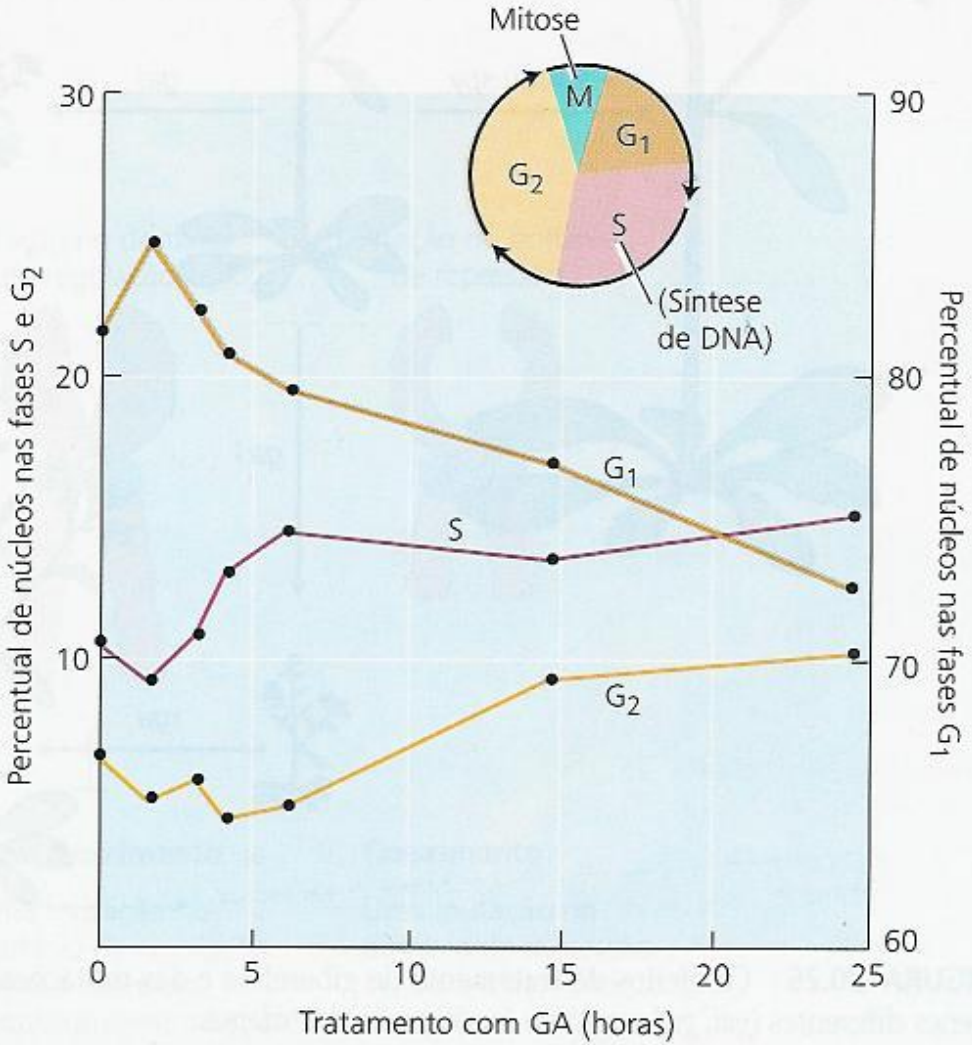
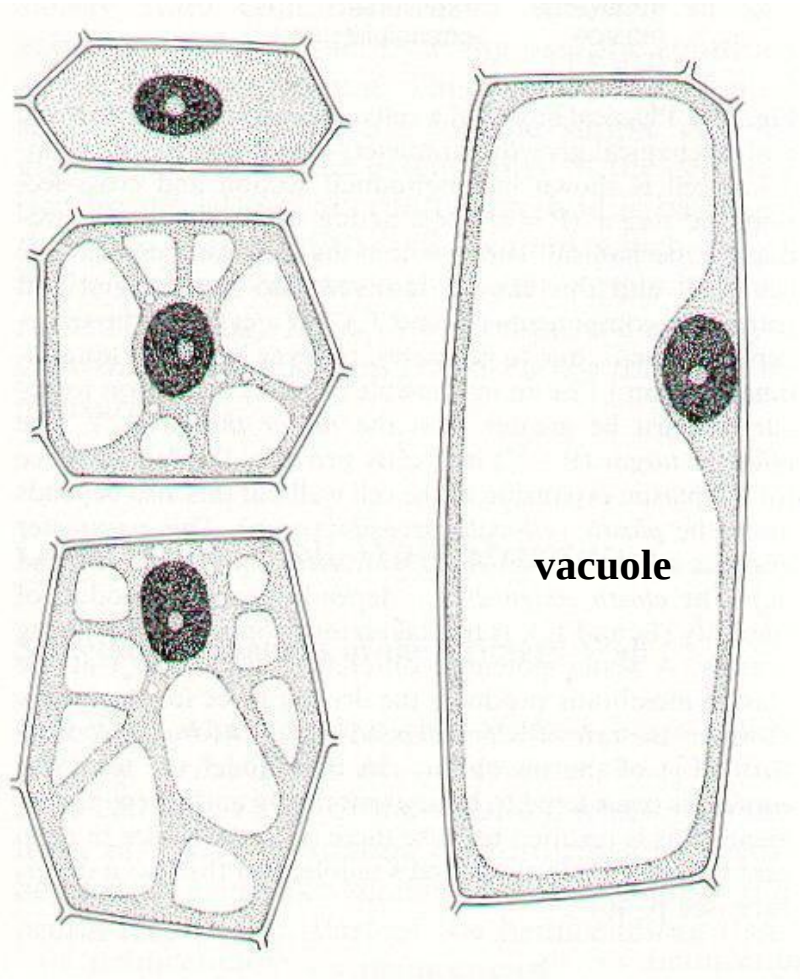


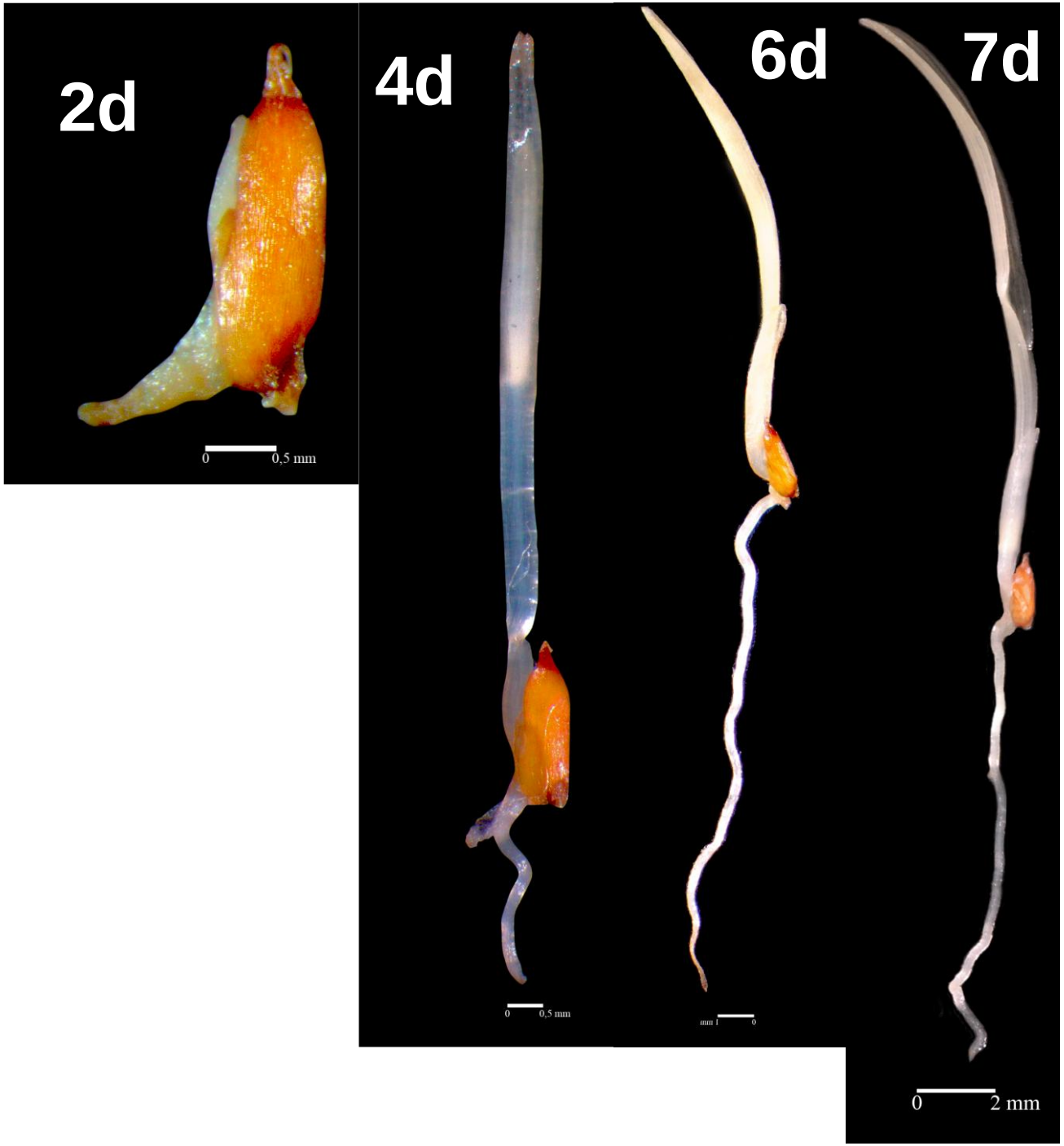
FIGURA 20.25 Mudanças no ciclo celular de núcleos do meristema intercalar de entrenós de plantas de arroz irrigado tratadas com GA_3. Observe que a escala para núcleos em G_1 está a direita do gráfico (Sauter e Kende, 1992).

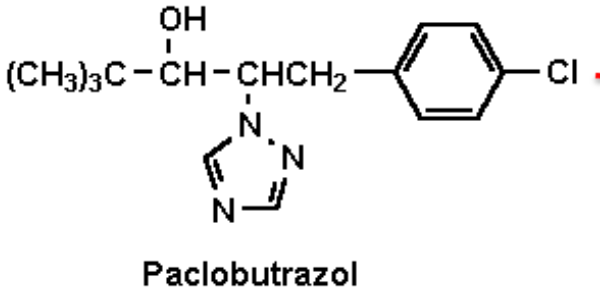
Giberelinas and the cell cycle

Meristematic cell

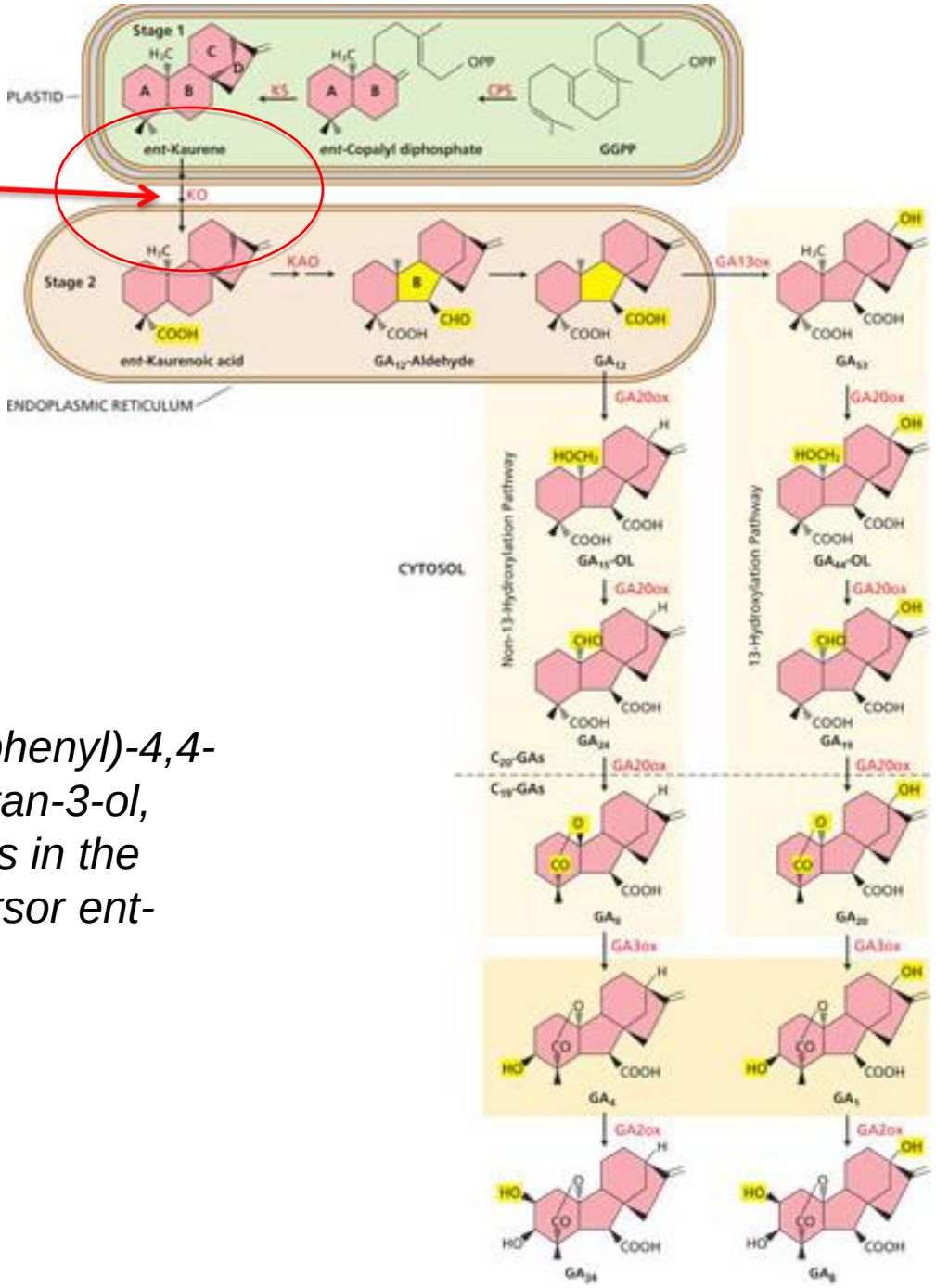


Mature cell


2d
0
0,5 mm
4d
0
0,5 mm
6d
7d
0
2 mm



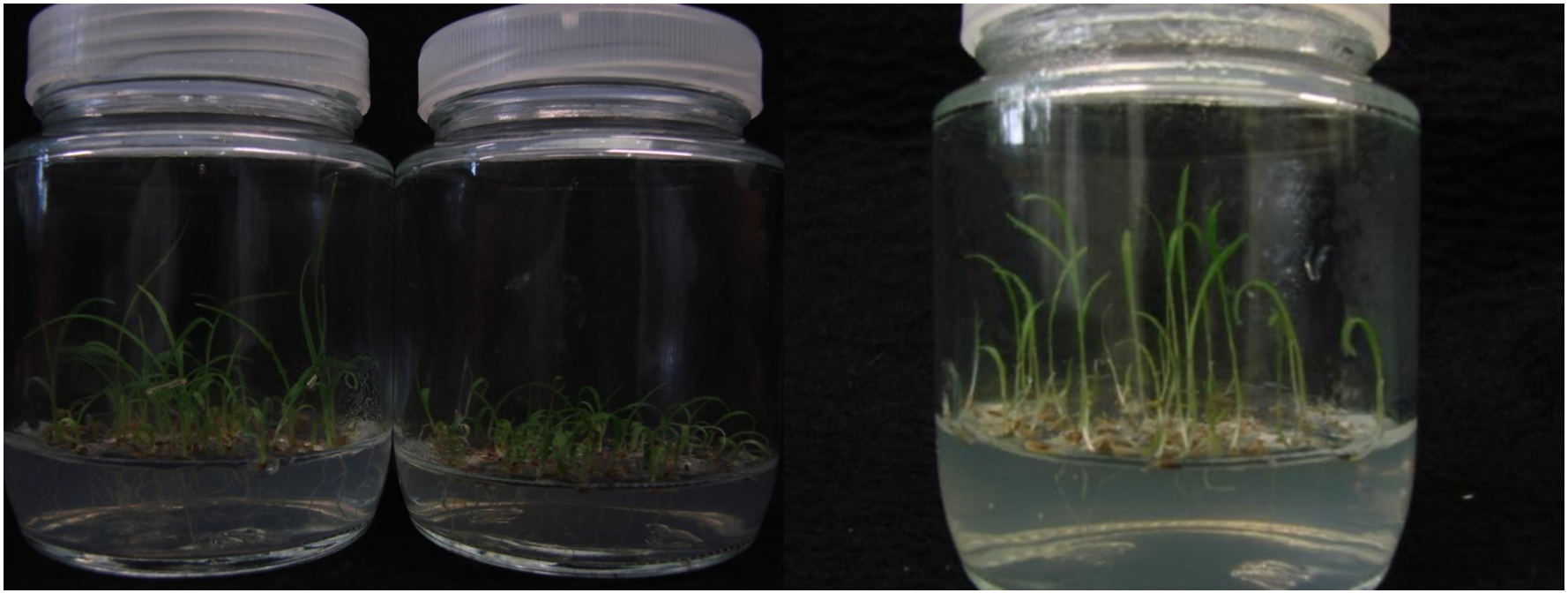
Paclobutrazol



(PP333) (*2RS, 3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)pentan-3-ol, inhibits specifically the three steps in the oxidation of the gibberellin-precursor ent-kaurene to ent-kaurenoic acid*

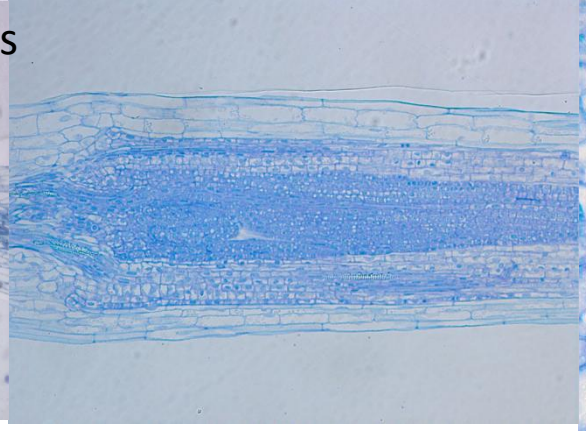
Material and Methods

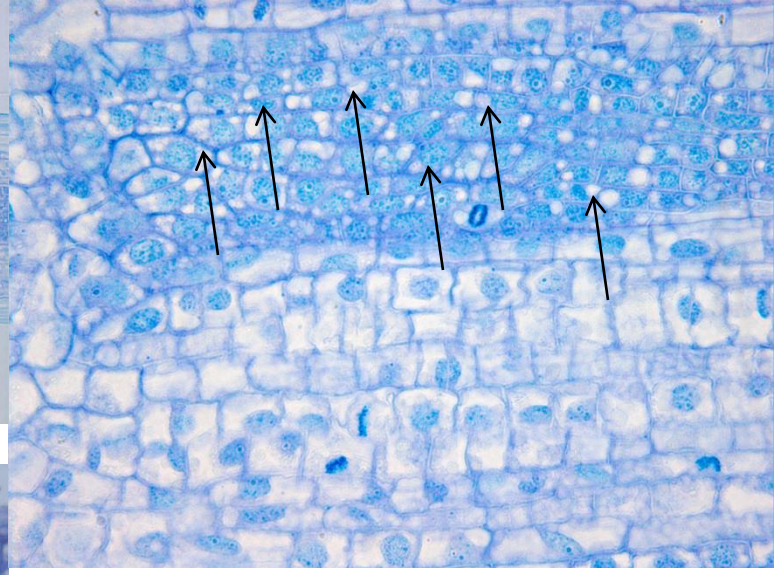
Seedlings were obtained from seeds (SP 87425 x SP 88813) donated by CTC – Sugarcane Tecnology Center (Piracicaba, SP)
Grown in MS culture medium in the presence of GA3

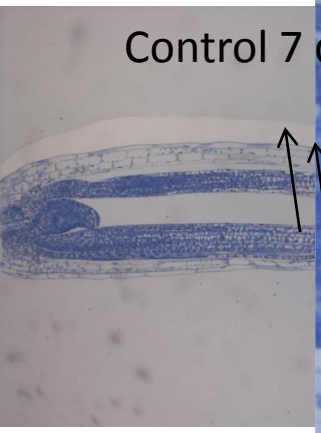


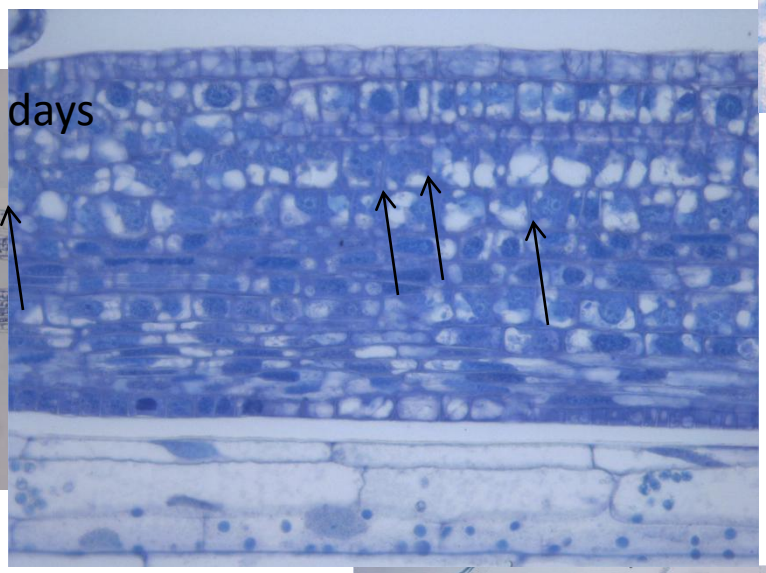
The plants were washed with distilled water, dehydrated with progressive concentrations of ethanol and fixed in Karnovisk.
The slides were stained with toluidine blue and analysed by light microscopy

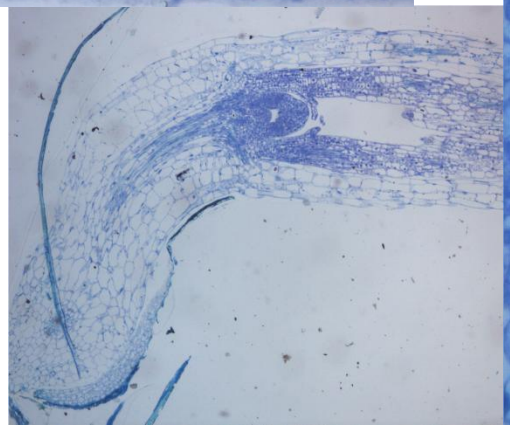

GA3 7 days

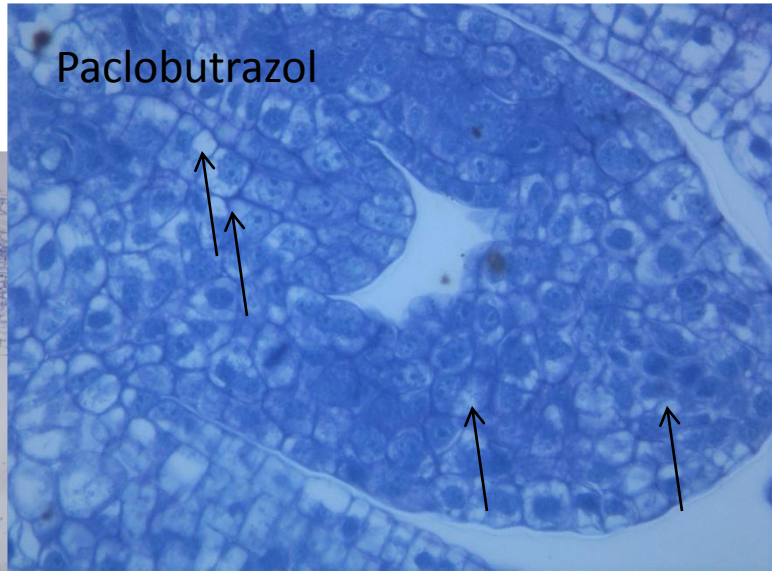





Control 7 days



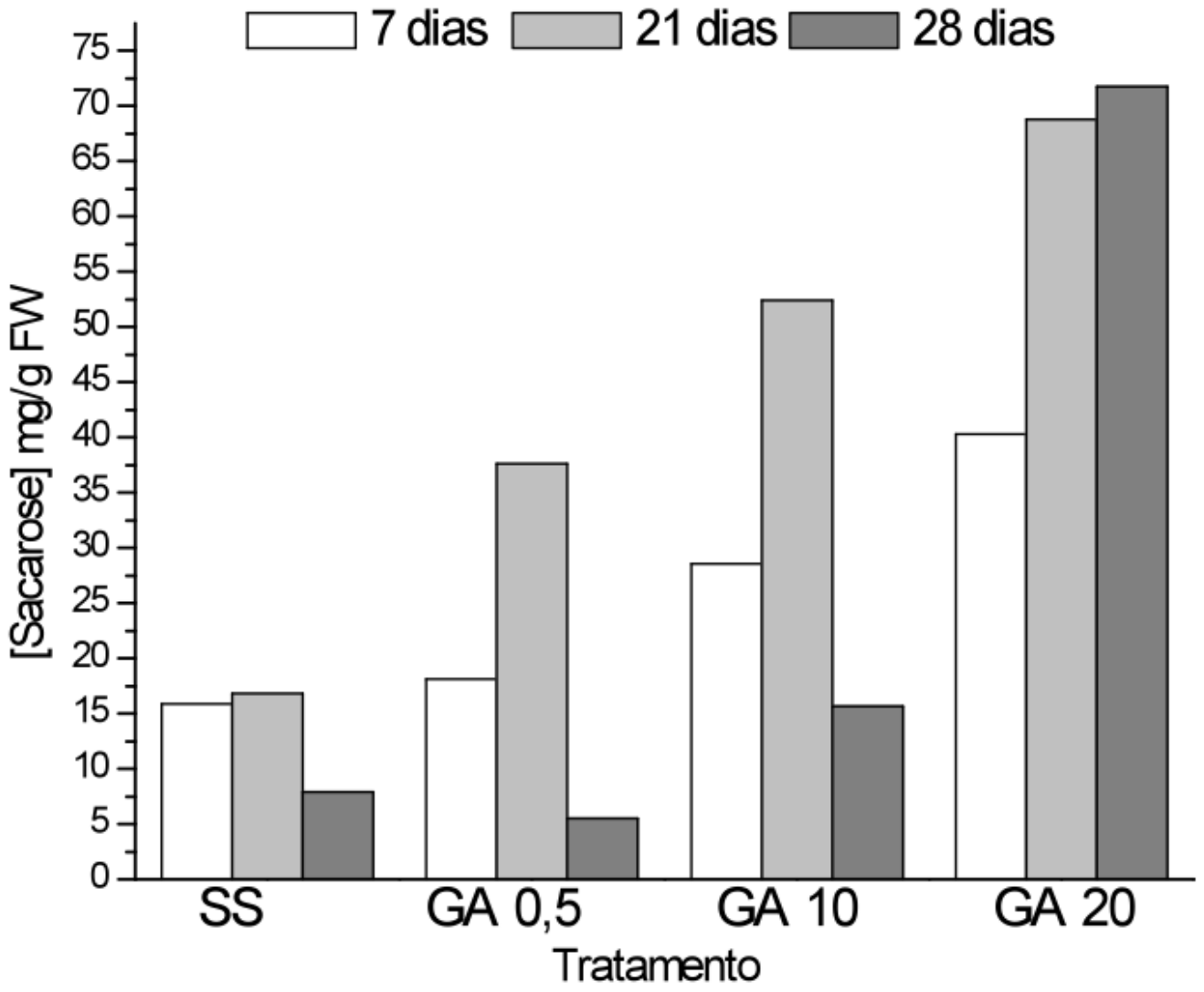


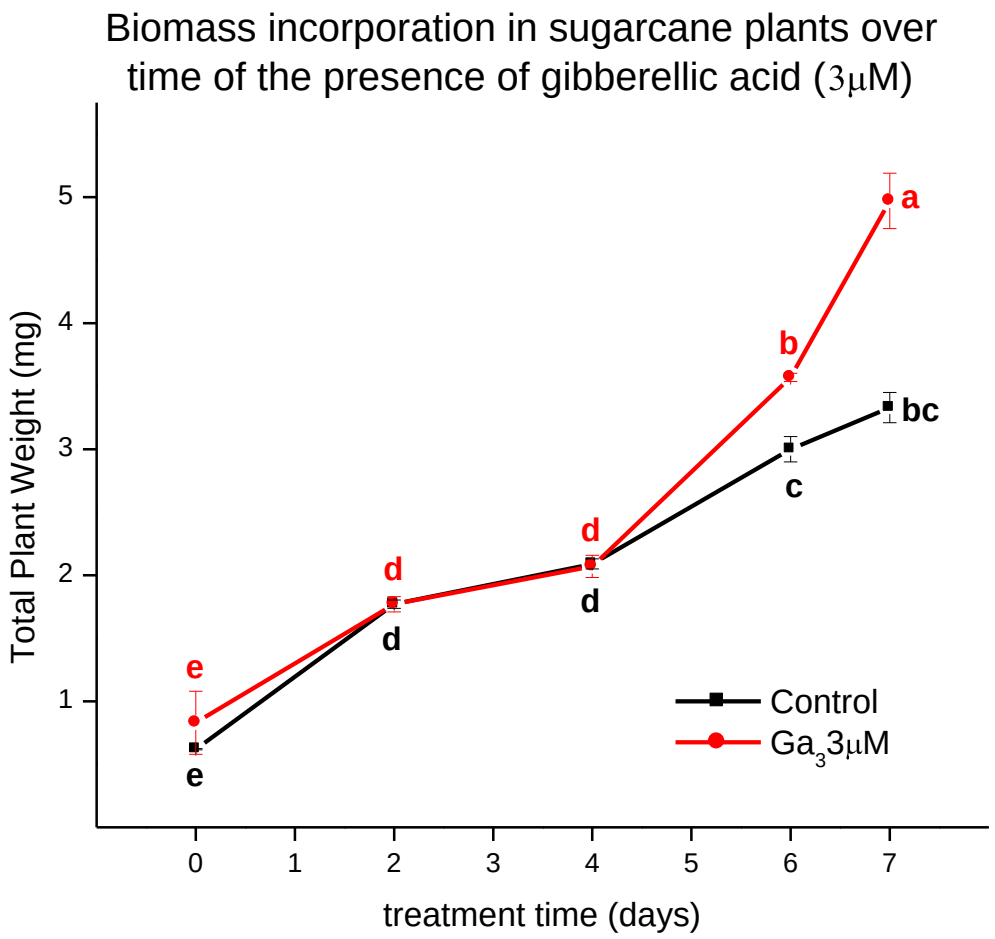

Paclobutrazol

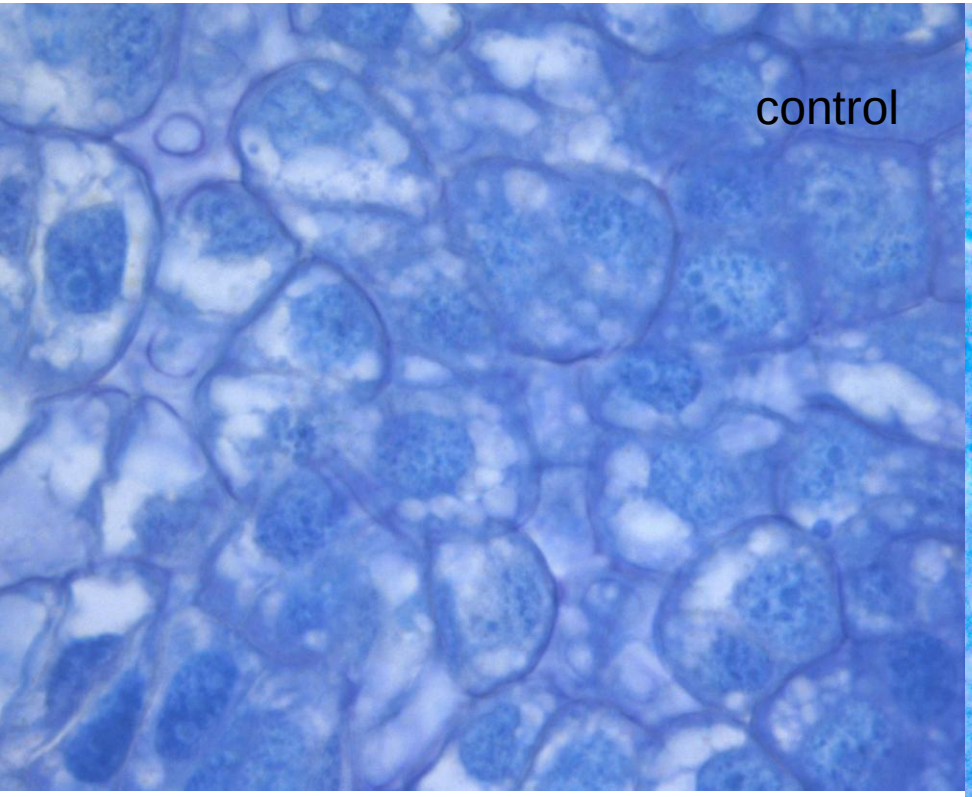
GA and seed germination

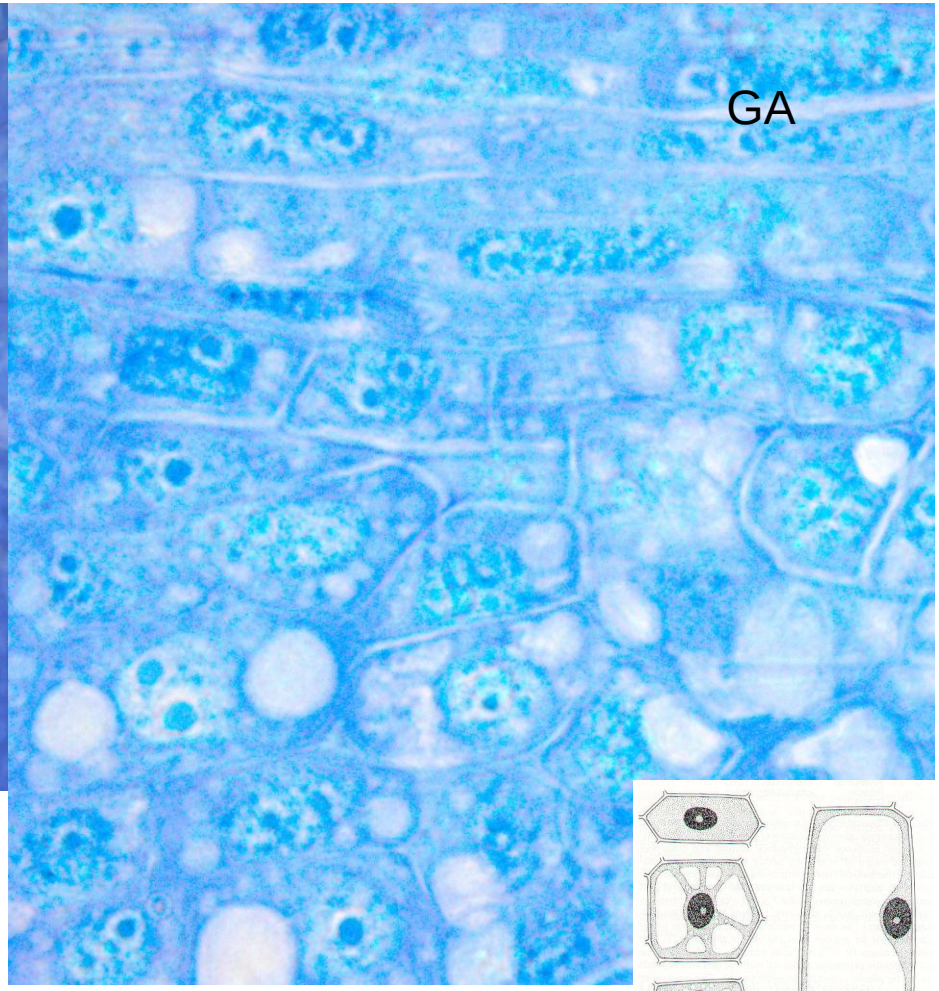
Germinated seeds(%)		
Tratament	(-) Paclobutrazol	(+) Paclobutrazol
Control	51,49±2 **e**	41,07±0 **d**
3 μM	38,78±2 **b**	17,78±2 **f**
30 μM	45,20±2 **c**	10,88±2 **gh**
60 μM	45,65±0 **a**	23,08±0 **h**

Effect of GA3 on sucrose content of sugarcane seedlings



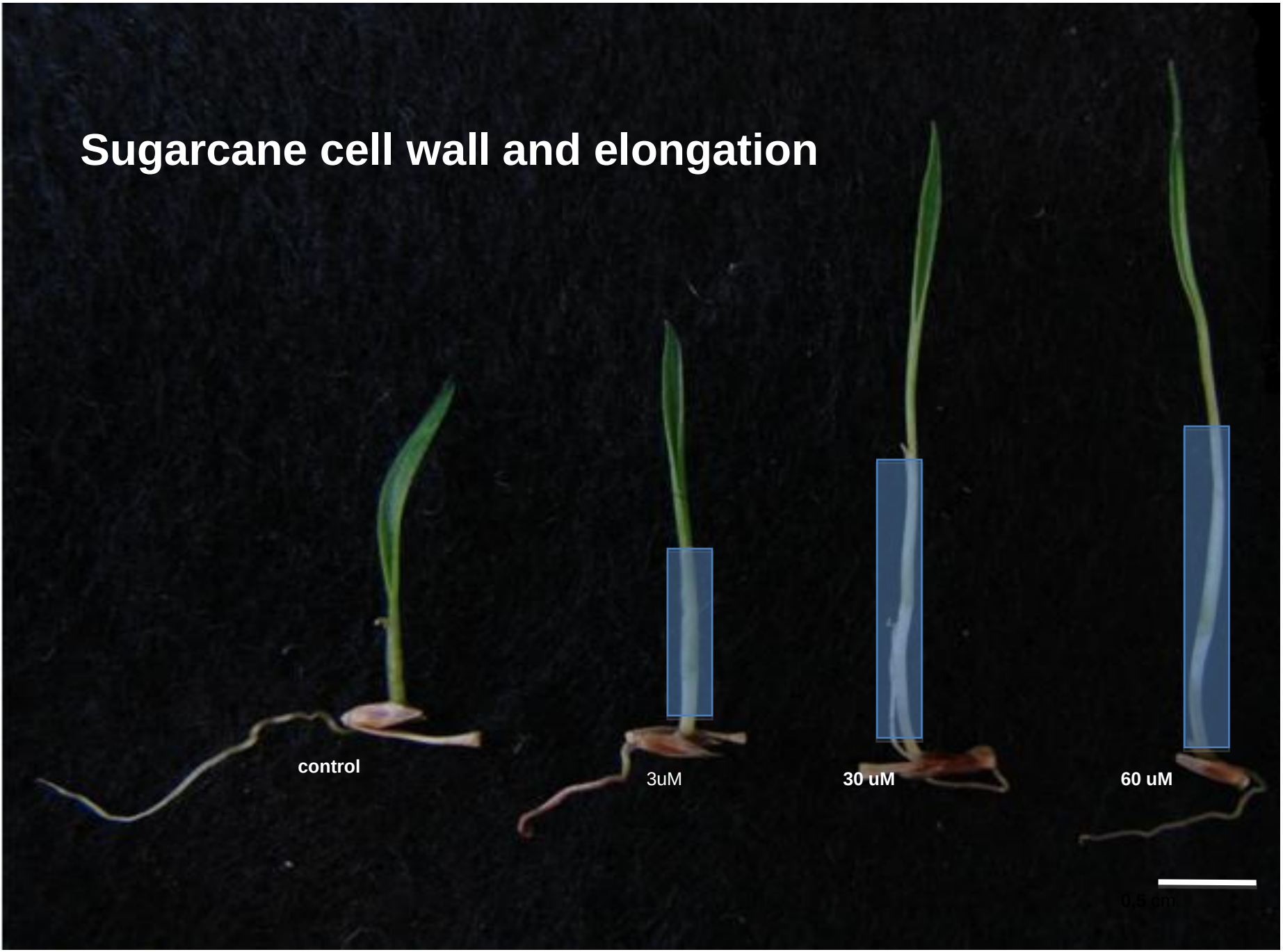

Biomass incorporation in sugarcane plants over time of the presence of gibberellic acid (3μM)
Total Plant Weight (mg)
treatment time (days)
Control
Ga3 3μM
a
b
bc
c
d
d
d
d
e
e

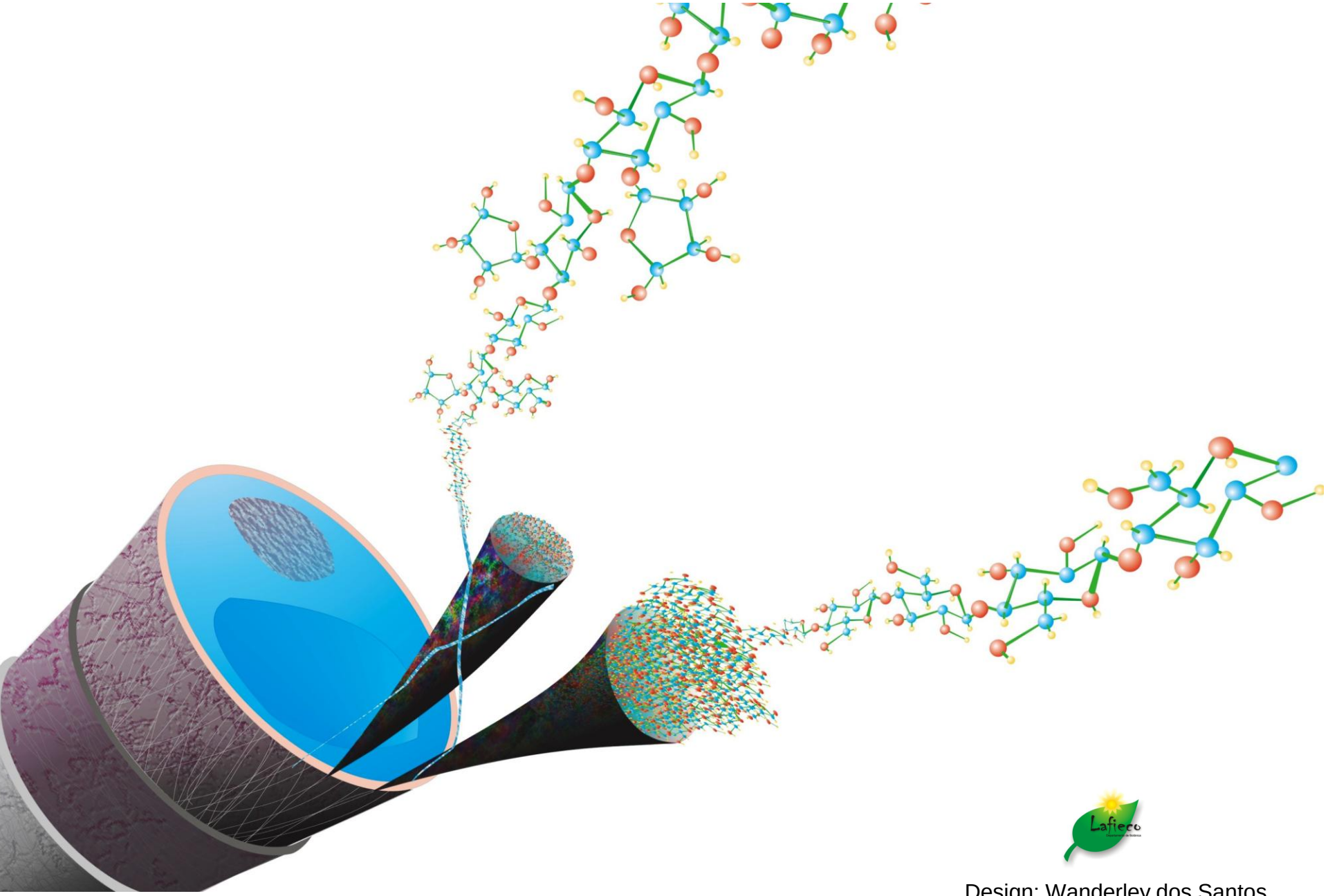




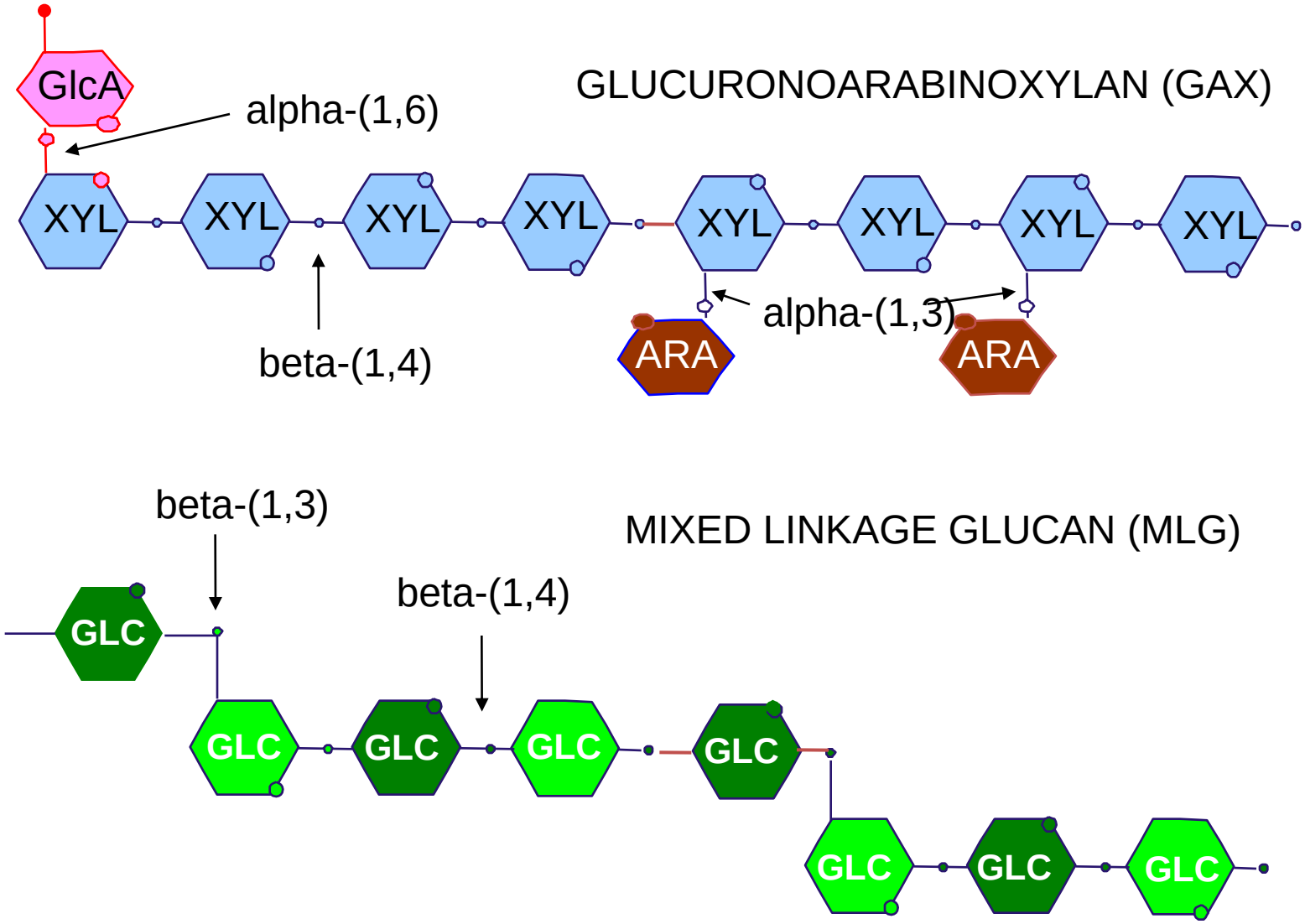
Vacuoles in meristematic cells of sugarcane seedlings 6 days old

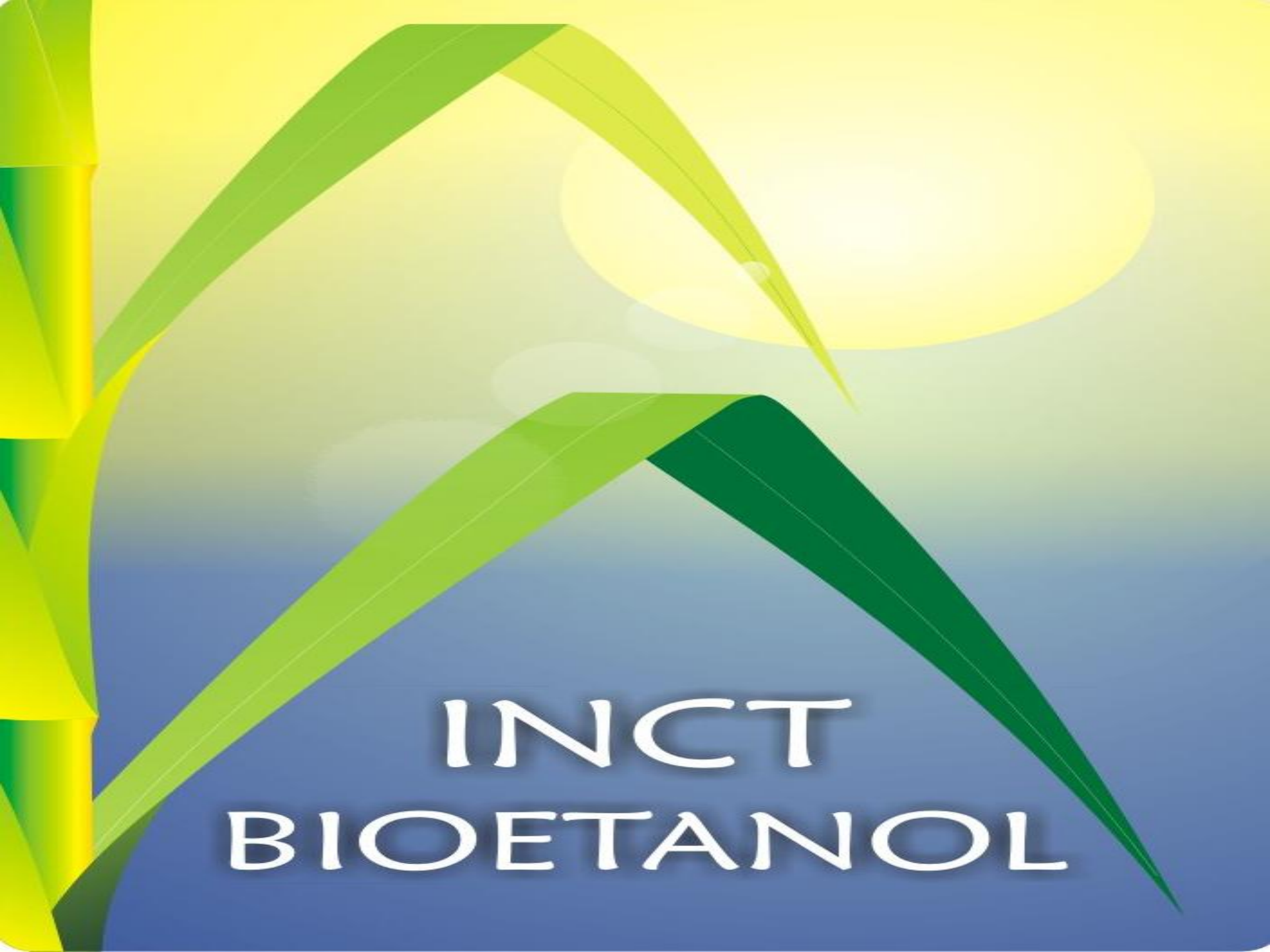
Sugarcane cell wall and elongation





Design: Wanderley dos Santos

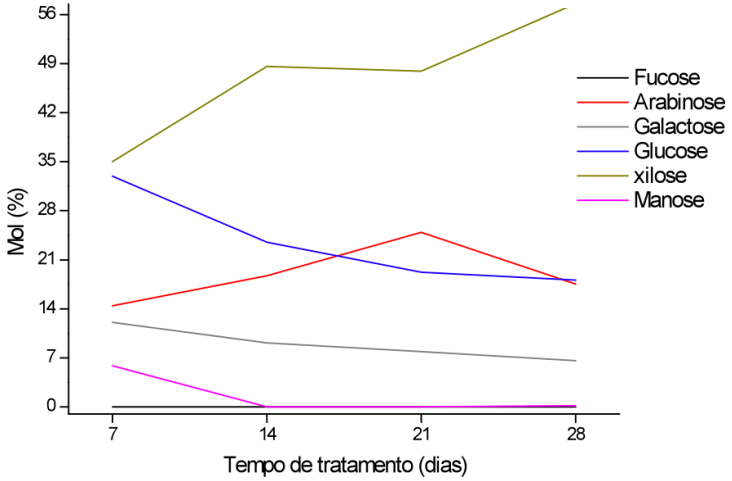

GlcA
alpha-(1,6)
GLUCURONOARABINOXYLAN (GAX)
XYL
XYL
XYL
XYL
XYL
XYL
XYL
XYL
beta-(1,4)
alpha-(1,3)
ARA
ARA
beta-(1,3)
MIXED LINKAGE GLUCAN (MLG)
beta-(1,4)
GLC
GLC
GLC
GLC
GLC
GLC
GLC


INCT
BIOETANOL

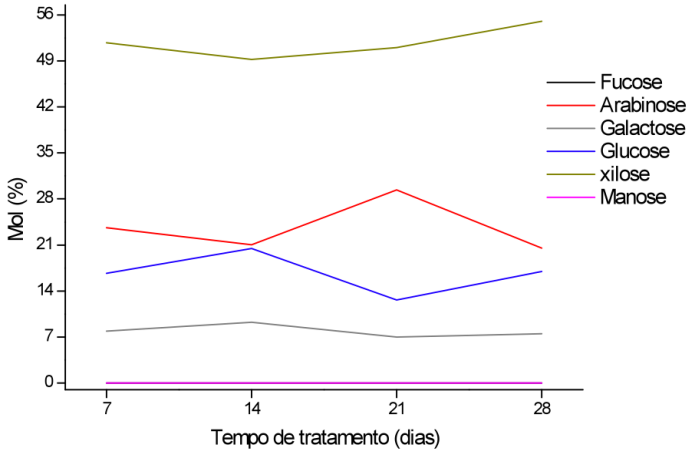
Sugar composition of sugarcane seedlings

INCT
BIOETANOL

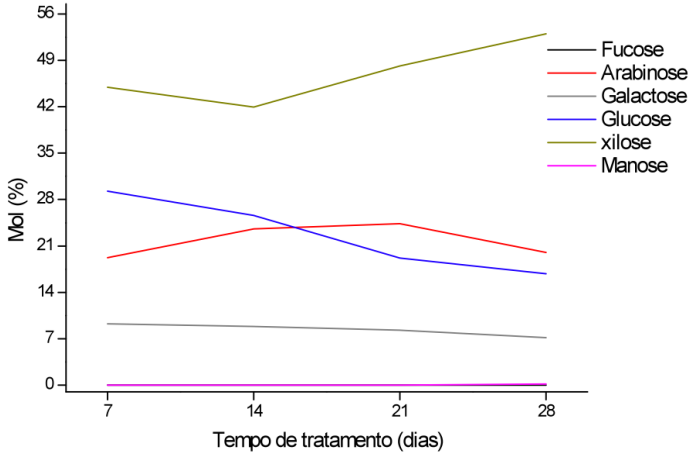
CONTROL



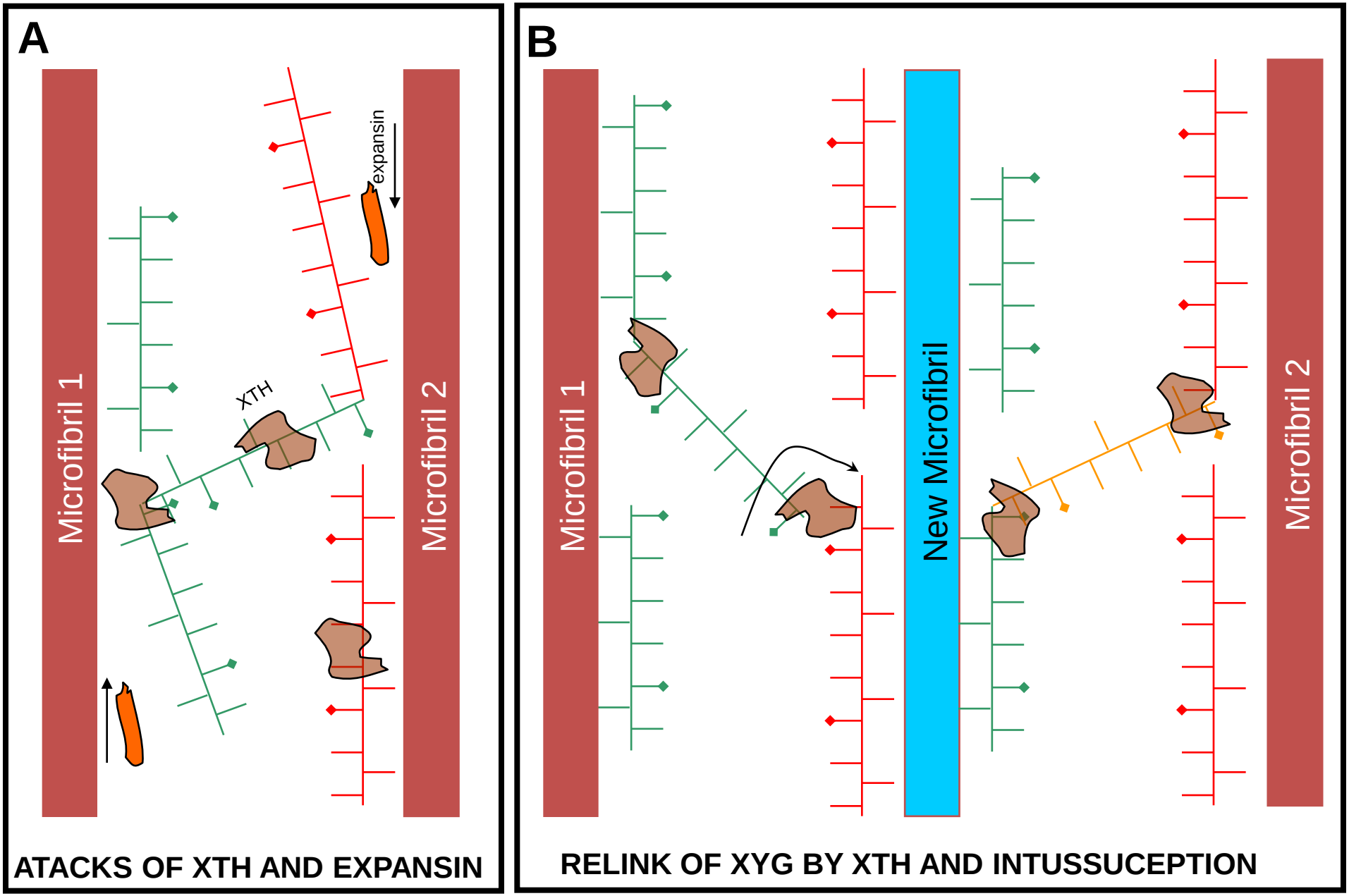
PACLOBUTRAZOL



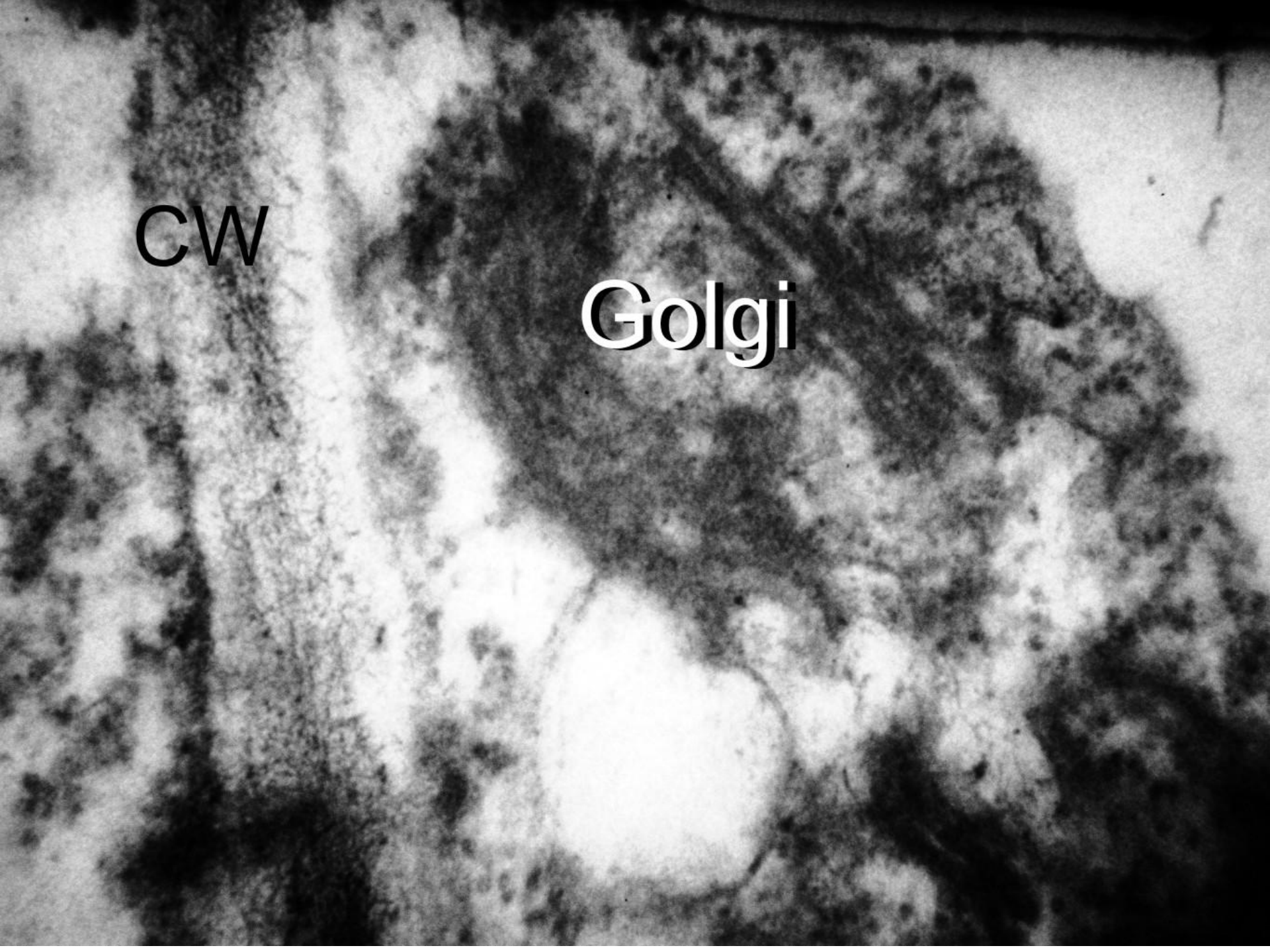
GA 3



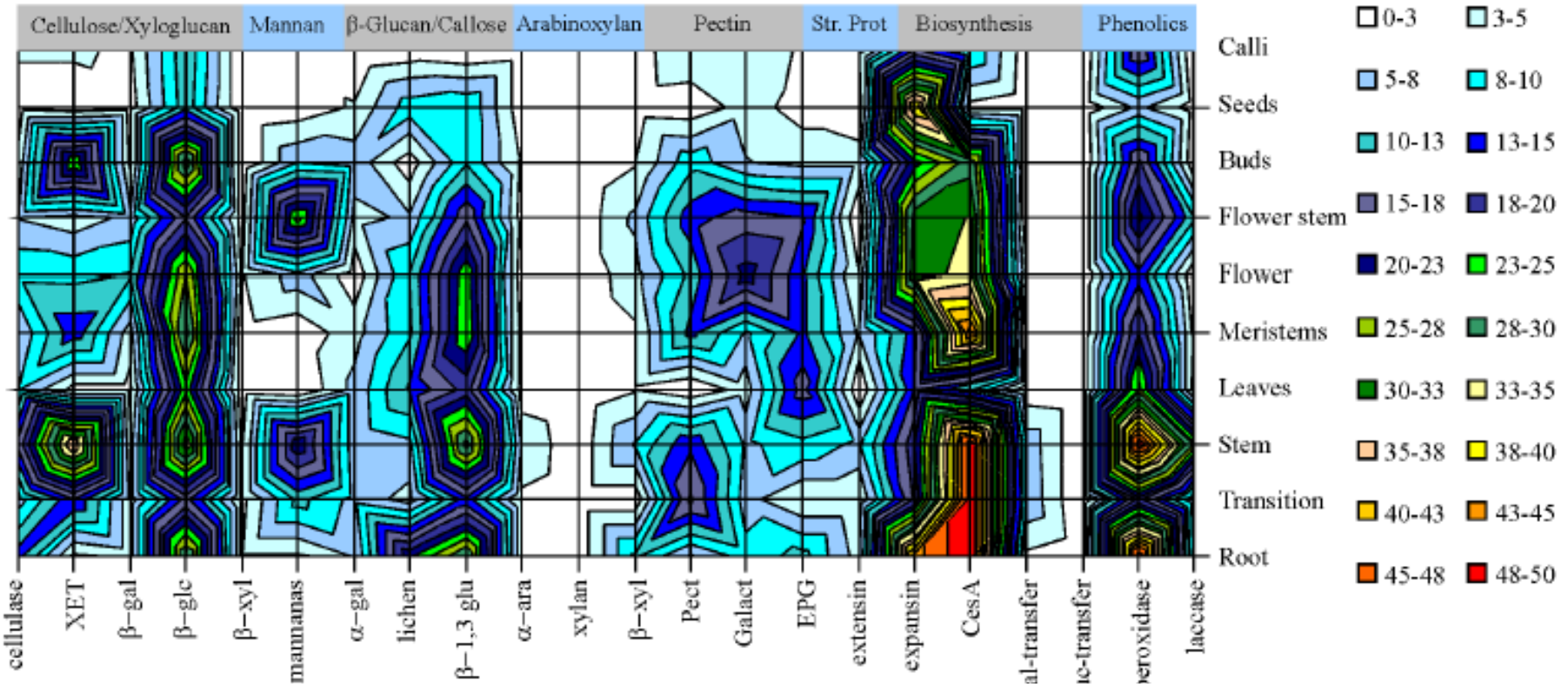
Changes in cell wall composition during Growth of sugarcane seedlings



Buckeridge et al. 2008. Parede Celular, Cap 9 in Kerbauy G.B. Fisiologia Vegetal. Guanabara Koogan


CW
Golgi

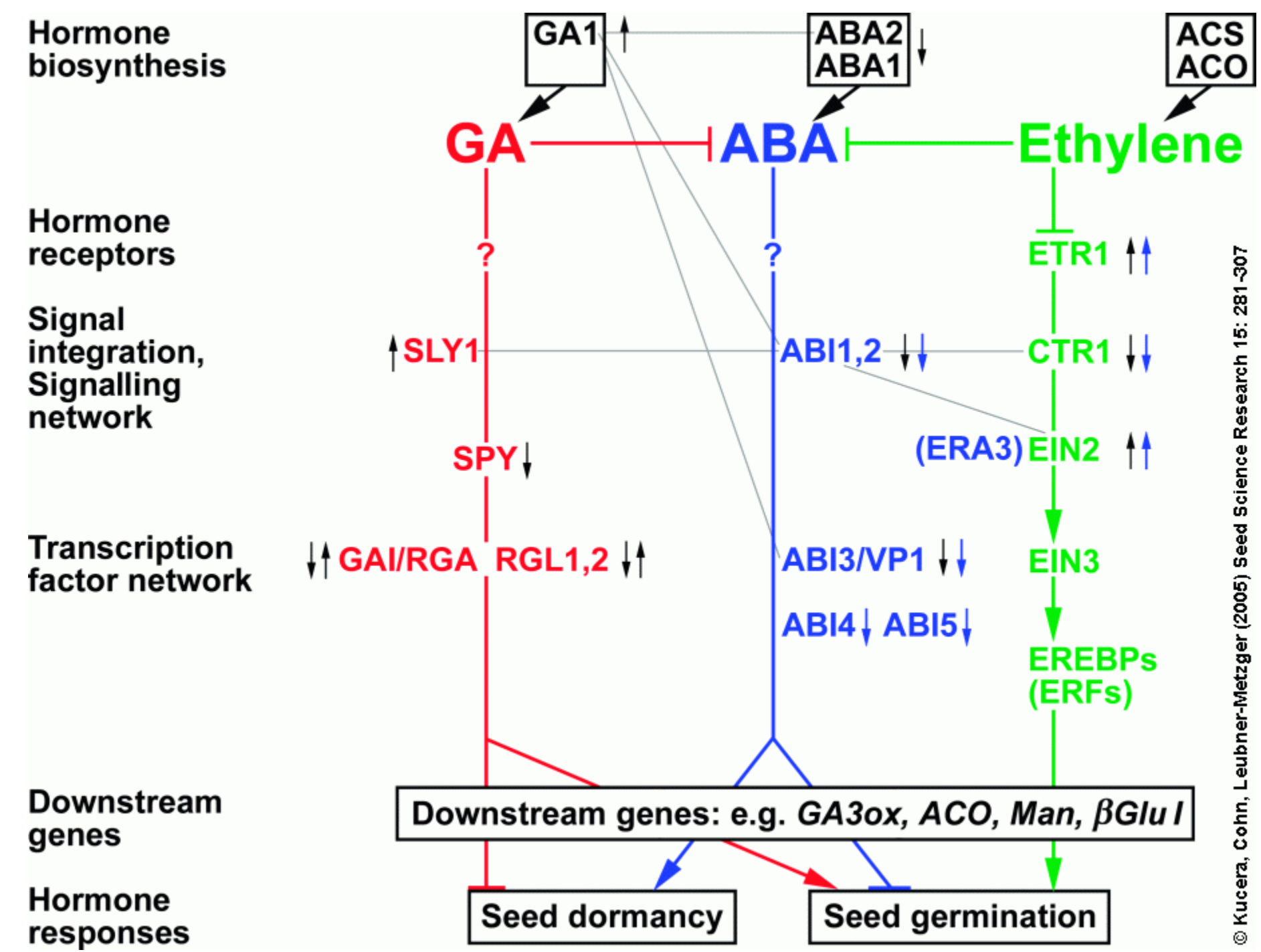
From 1999 to 2001, the SUCEST genome program produced 238,000 ESTs from various tissues of the sugar cane plant.



Since then we found:

1) 469 cell wall related genes in different cane tissues (*Lima et al. 2001, GMB*)

1) Determined the chemical composition and structure of the cell wall polymers of different sugarcane tissues


Hormone biosynthesis
GA1
ABA2
ABA1
ACS
ACO
GA
ABA
Ethylene
Hormone receptors
?
?
ETR1
Signal integration, Signalling network
SLY1
ABI1,2
CTR1
SPY
(ERA3)
EIN2
Transcription factor network
GAI/RGA
RGL1,2
ABI3/VP1
EIN3
ABI4
ABI5
EREBPs (ERFs)
Downstream genes
Downstream genes: e.g. GA3ox, ACO, Man, βGlu I
Hormone responses
Seed dormancy
Seed germination
© Kucera, Cohn, Leubner-Metzger (2005) Seed Science Research 15: 281-307

CONCLUSIONS

1) GA increases sucrose
2) GA induces changes in the wall (expansion?)
3) Seedling is a good model to study Carb Metabolism
4) Maybe a way to taget cell division
5) May be a way to targed cell wall biosynthesis
6) How can we connect this to other hormones?
7) Seedlings could be a good model for systems approach

INCT BIOETANOL

http://bioethanolbrazil.wordpress.com

Lafieco

BIOEN

FAPESP

THANK YOU

msbuck@usp.br

Andrea Brandão
Gilberto Kerbauy
Gregorio Ceccantini

Many thanks to
CTC (Sabrina)
Marcos Sanches

For the seeds!

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Lafieco

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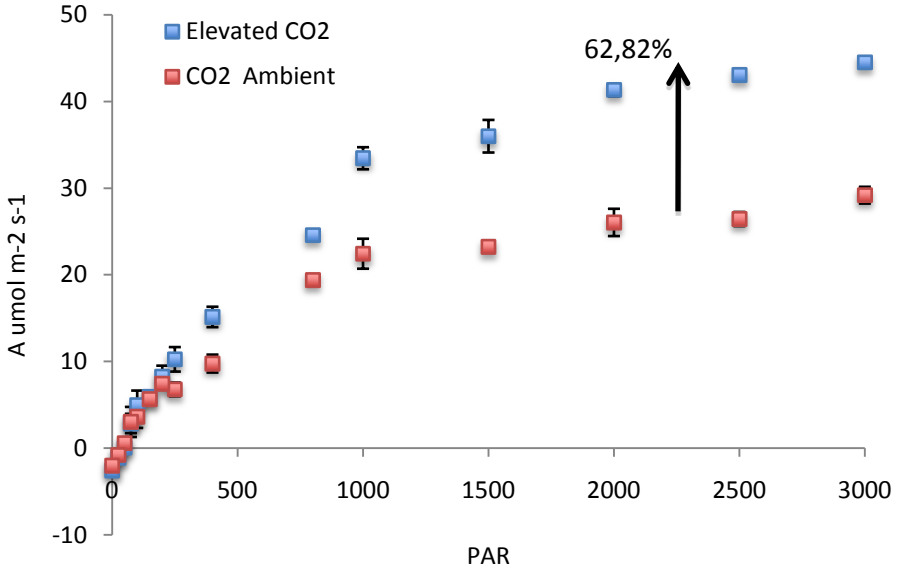
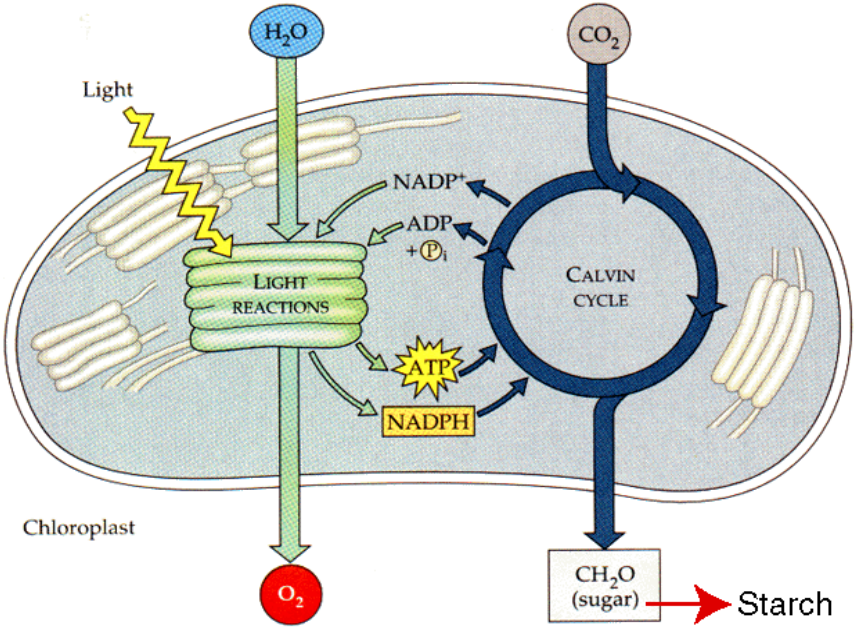
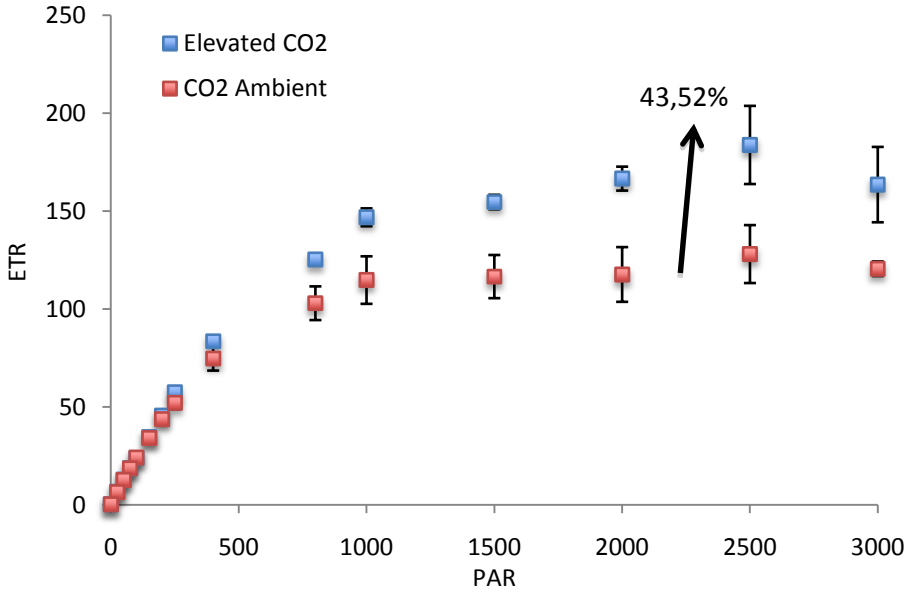
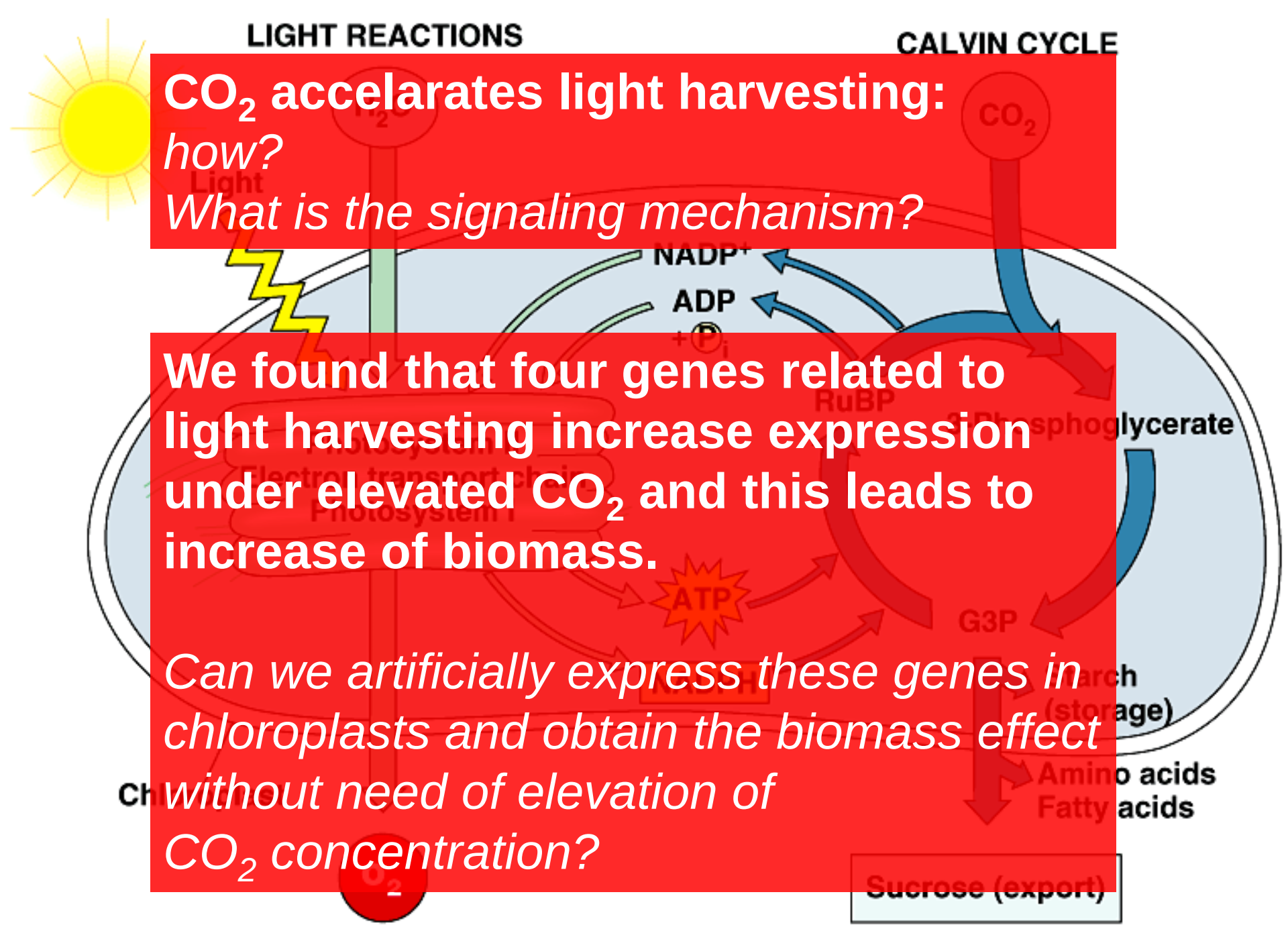






CO_2 assimilation and electron transport rate of sugarcane under elevated CO_2



CO_2 accelarates light harvesting:
how?
What is the signaling mechanism?

We found that four genes related to light harvesting increase expression under elevated CO_2 and this leads to increase of biomass.

Can we artificially express these genes in chloroplasts and obtain the biomass effect without need of elevation of CO_2 concentration?

% of shoots in the seedlings of sugarcane

Days	Control	Cont + PCZ	PCZ	3µM GA	GA
7	61,25±0,03 **c**	28,75±0,07 **d**	-54	83,33±0,17 **b**	+36
14	60,78±0,07 **c**	33,33±0,17 **d**	-45	87,84±0,17 **b**	+44
21	50,17±0,17 **c**	40±0,02 **d**	-20	82,22±0,44 **b**	+64
28	53,97±0,09 **b**	40±0,02 **c**	-26	83,93±0,6 **a**	+55