

GSB /LACAF WORKSHOP, APRIL 2014
Modeling sugar cane productivity

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SUGAR CANE IS THE MOST PHOTOSYNTETHIC EFFICIENT CROP
MANY CHALLENGES STILL EXISTS FOR IT TO REACH ALL POTENTIAL
“GOOD PRACTICES” - TECHNOLOGICAL LEVEL
“quite”sustainable practices
COMPLETELY NEW PRODUCTION ENVIRONMENTS – NEW CHALLENGES AND SOLUTIONS

Different levels of yields

Defining factors

- CO2
- Solar radiation
- Temperature
- Genetics

Defining factors

+

Limiting factors

- **Water disposability**
- Nitrogen
- Nutrition and fertility
- Soil*

Defining factors

+

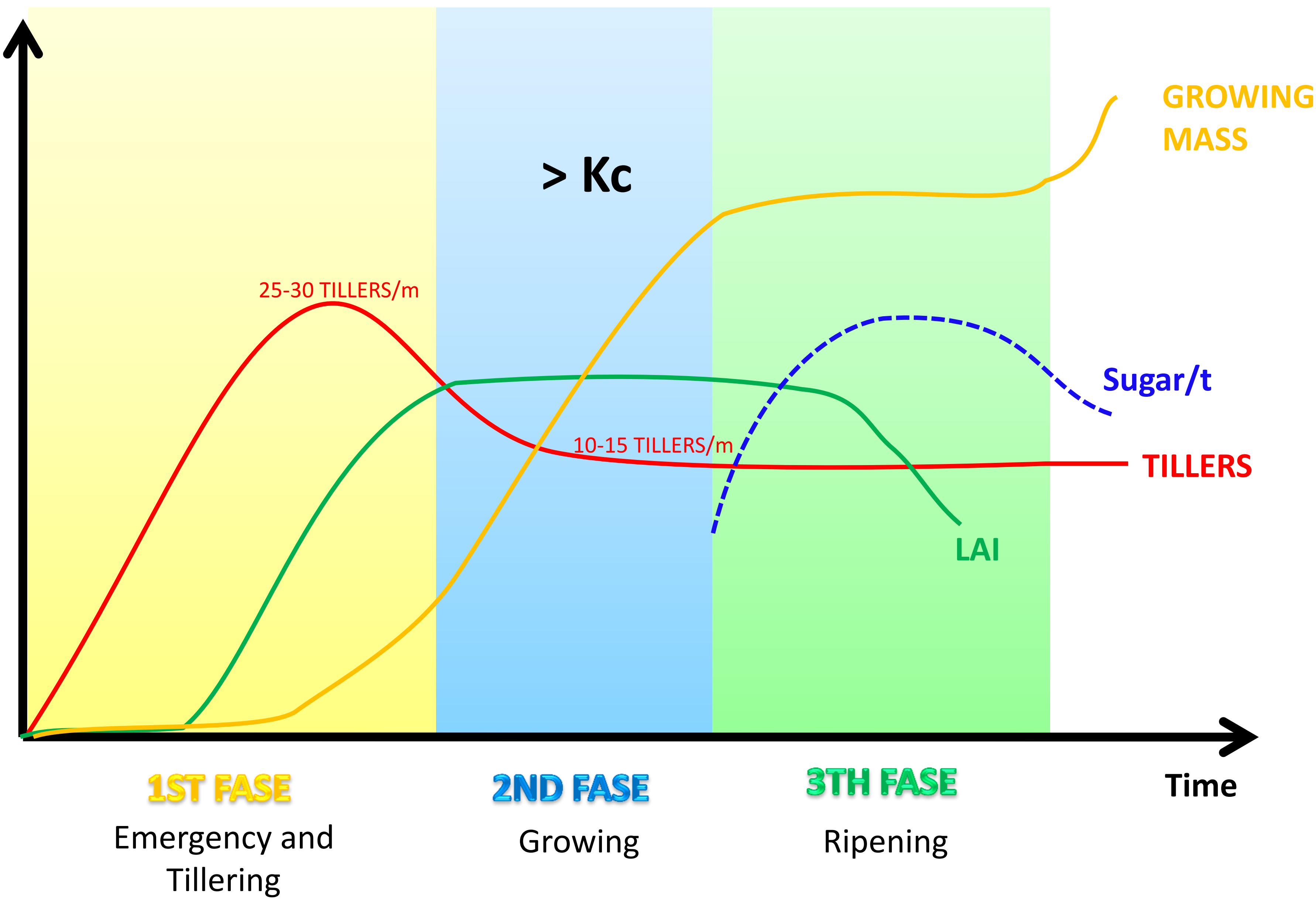
Limiting factors

+

Reducing factors

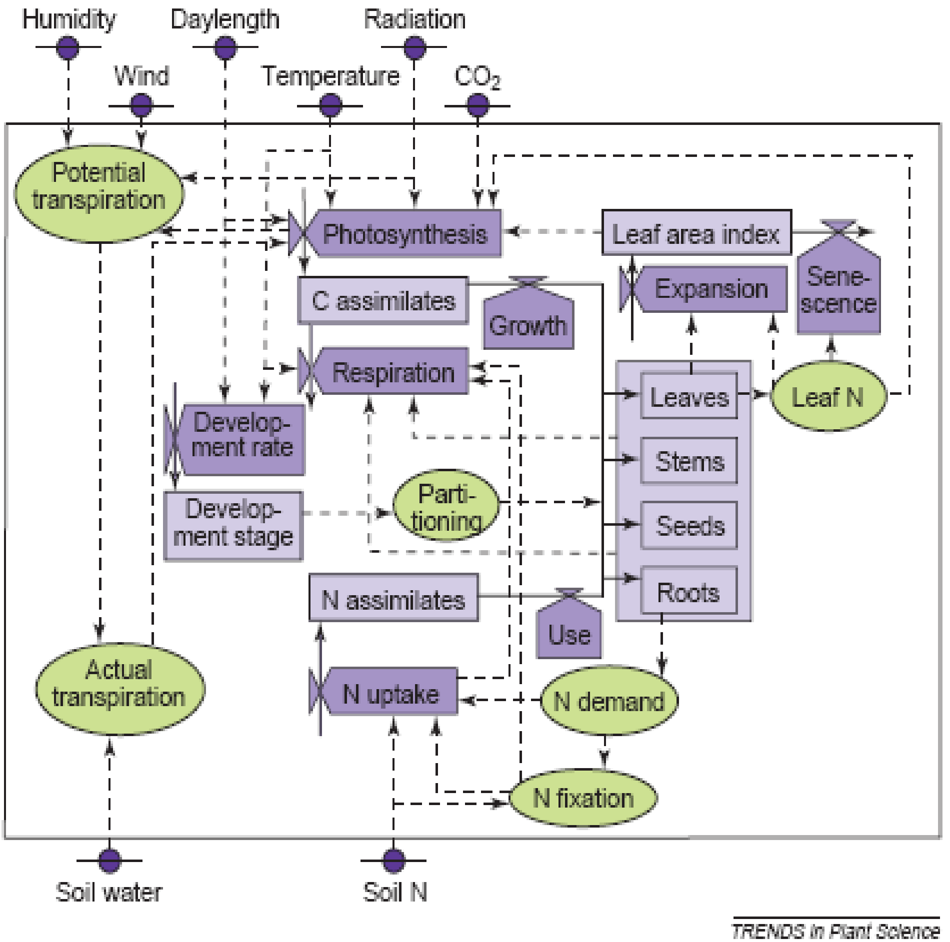
- Pests and diseases
- Weeds
- Toxic elements
- Soil*

Potential **Limited** **Actual**



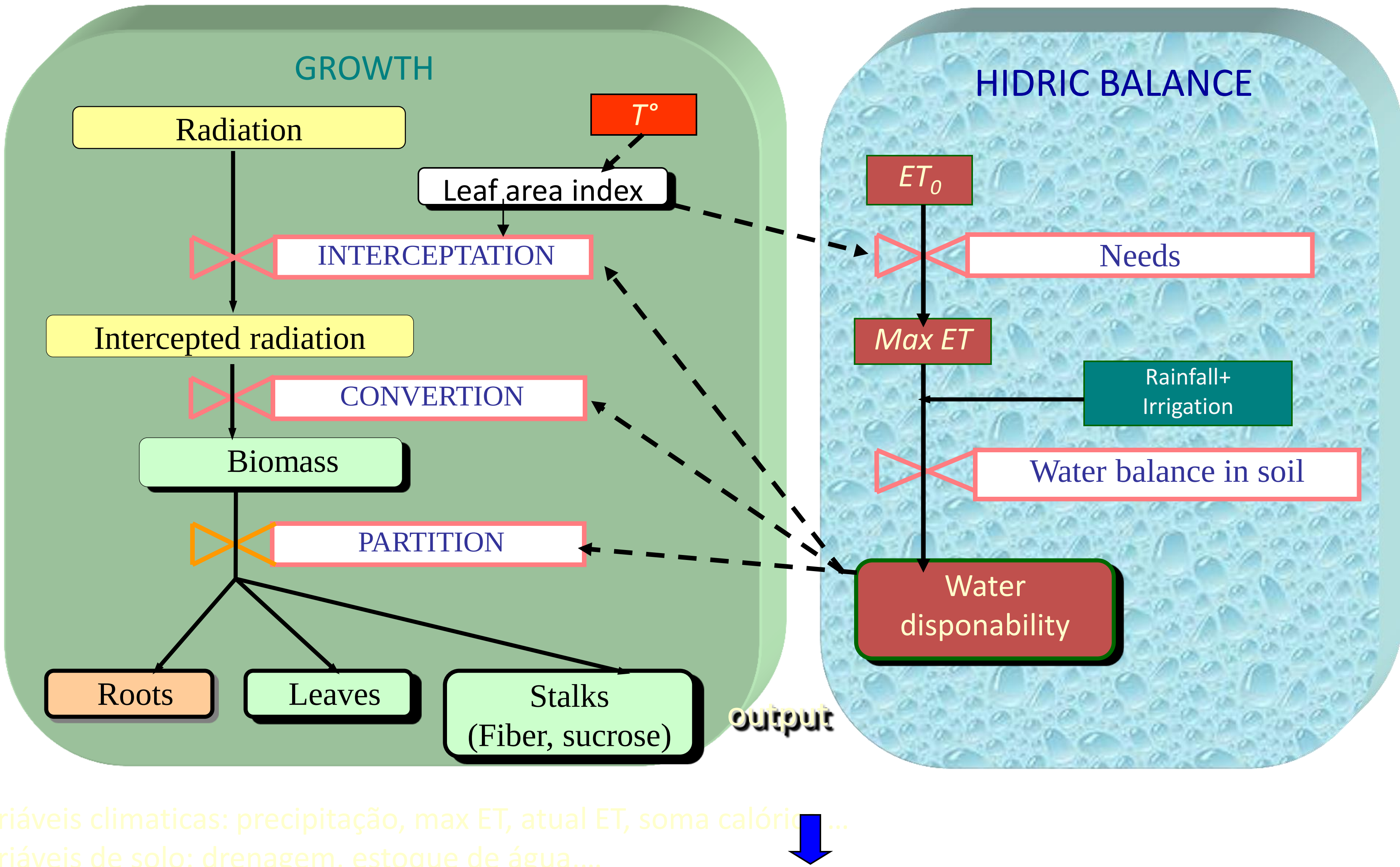
> Kc
GROWING MASS
25-30 TILLERS/m
Sugar/t
10-15 TILLERS/m
TILLERS
LAI
1ST FASE
Emergency and Tillering
2ND FASE
Growing
3TH FASE
Ripening
Time

Conceptual crop physiology model with environmental **inputs** and state and rate variables



Paul H. Moore

MOSICAS MODEL – IMPORTANCE OF **WATER DISPONABILITY**



Variáveis climaticas: precipitação, max ET, atual ET, soma calóri...

Variáveis de solo: drenagem, estoque de água,...

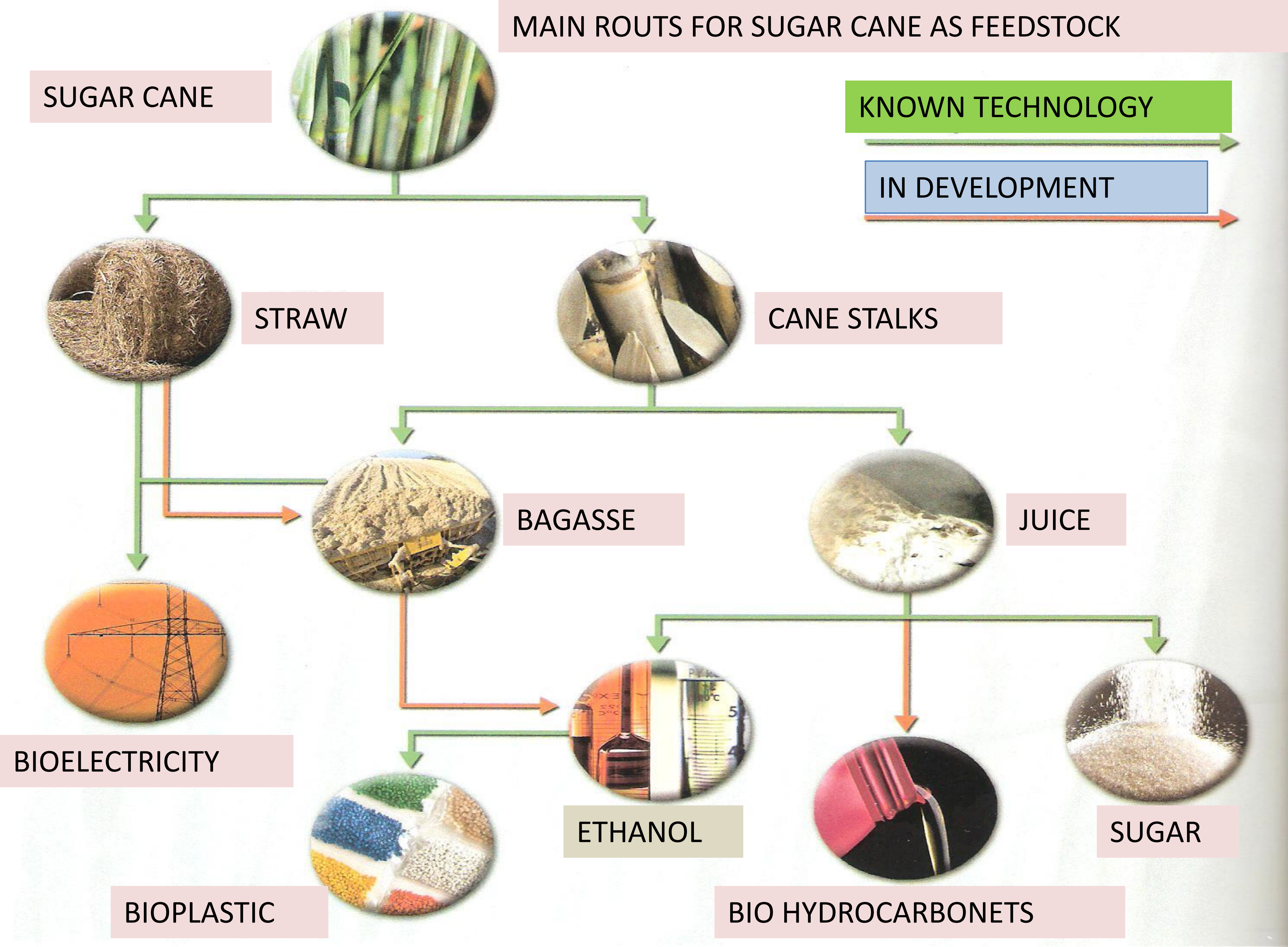
Variáveis de planta: área foliar, altura, biomassa e sacarose produzida, profund. raiz

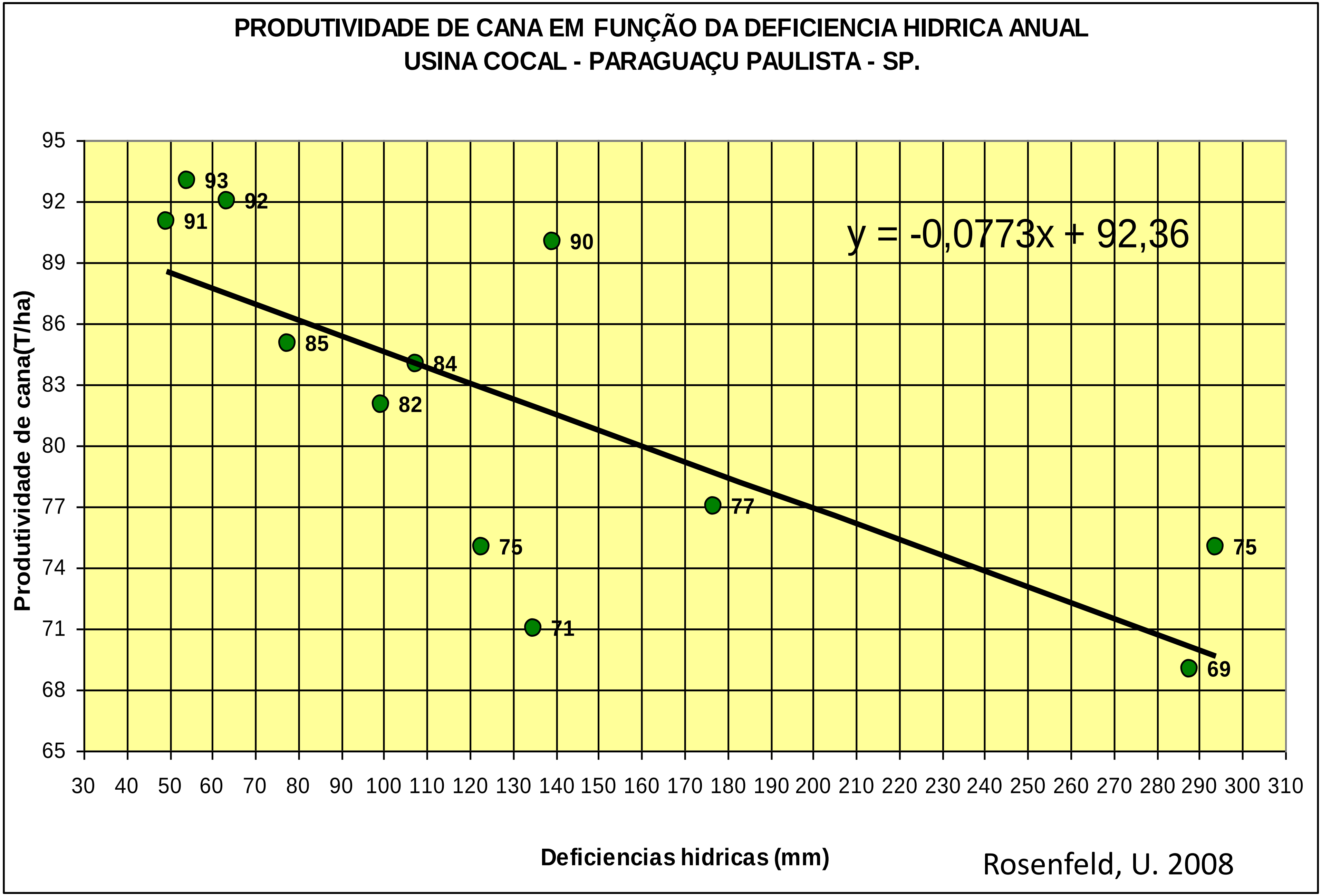
SOME KNOWLEDGE GAPS

- Field conditions
  - Includes average age (number of harvests)
- Varieties
  - new environmental condition and its responses
  - new diseases, pests and weeds
- Biological and integrated control of pests
- Improve mechanization of planting and harvesting (
- Improve LAND USE EFFICIENCY & WATER USE EFFIC

FILTERS

- LEGISLATION
- SOCIAL AND ENVIRONMENT IMPACTS
- NATURAL RESERVES
- SUITABILITY TO ENERGY CROP
  - TECHNICAL PARAMETERS RELATED TO:
    - CLIMATE
    - SOIL (PRODUCTION ENVIRONMENT)
- AVAIABLE AREA WILL BE OBTEINED DIVIDED IN 3 MAJOR GROUPS:
  - GOOD
  - AVERAGE
  - RESTRICTED (BAD)
- HISTORICAL DATA WILL DEFINE PARAMETERS MODELS


MAIN ROUTS FOR SUGAR CANE AS FEEDSTOCK
SUGAR CANE
KNOWN TECHNOLOGY
IN DEVELOPMENT
STRAW
CANE STALKS
BAGASSE
JUICE
BIOELECTRICITY
ETHANOL
SUGAR
BIOPLASTIC
BIO HYDROCARBONETS



PRODUTIVIDADE DE CANA EM FUNÇÃO DA DEFICIENCIA HIDRICA ANUAL
USINA COCAL - PARAGUAÇU PAULISTA - SP.
y = -0,0773x + 92,36
93
92
91
90
85
84
82
77
75
75
71
69
95
92
89
86
83
80
77
74
71
68
65
30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310
Produtividade de cana(T/ha)
Deficiencias hidricas (mm)
Rosenfeld, U. 2008

Simple Prediction Model

- Best estimate without data base = **average** yield
- **$Y = a + b\ GD - c\ WD$** + $(d\ P_{n-1})$

Where Y = Tons of cane per hectare

a, **b**, **c**, and **d** are parameters statistically determined

GD = degree days of all growth period

WD = Water deficit of all growth period (balance)

P_{n-1} = Productivity of previous harvest

Mathematic Model Application

- **A simple production model can express the importance of adequate water supply and the efficiency of radiation interception:**

Y = a + b GD – c HD

Where:

- **a , b , c are calculated parameters by stepwise algorithm for multiple linear regression. The "a" parameter may be average yield.**
- **GD = degree-day, calculated according to integration of hours with favorable temperature for growing**
- **HD = Hydric deficit calculated by hydric balance considering <u>water retention capacity of soil</u>.**
- **Simple tool that doesn't consider other production factors (limiting and reducing)**

POSSIBLE UPGRADES

- Use average yield as “a” parameter for each production system. Can be a technological parameter as “d” parameter if last yield is used.
- Stratification by production environment, number of harvesters, varieties…depends on data availability.
- Other crops can use the same concept.
- Application and validation of the model and further adjustments will be an obvious need and South Africa will play an important role.

Degree days calculation

- ✓ **BARBIERI et al. (1979)**:

For $TM>Tb>Tm$: $GDC=\left[\frac{(TM-Tb)^2 + (TM-25)^2}{2\,(TM-Tm)}\right] \cdot f$

For $Tb<Tm$: $GDC=\left[Tm-Tb + \frac{(TM-Tm)}{2} + \frac{(TM-25)^2}{2\,(TM-Tm)}\right] \cdot f$

where: $f = (N/24-N)^2$

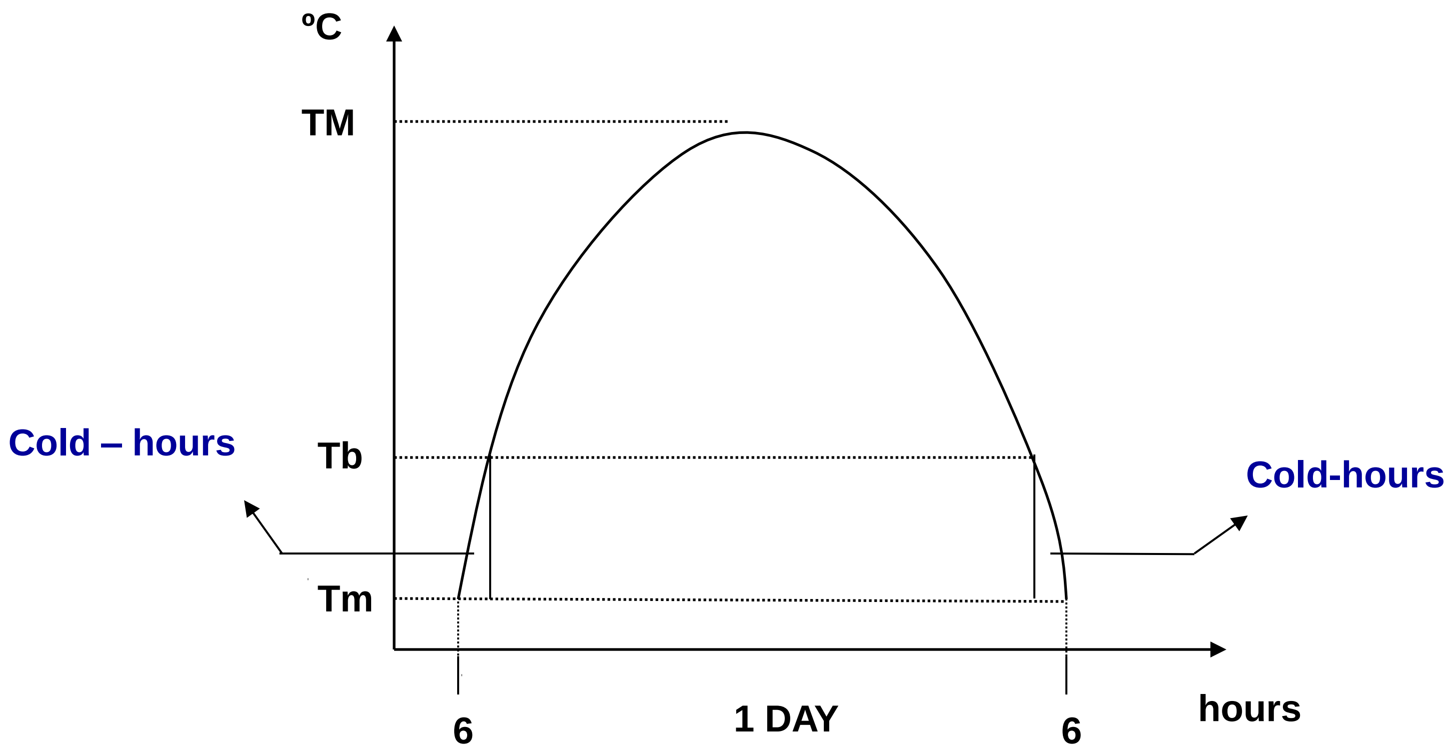
N = length of day in hours

Tm = minimum average monthly temperature (ºC)

TM = maximum average monthly temperature (ºC)

Tb = growth base temperature (ºC)

Negative Degree days (Scarpari & Beauclair, 2002) used to predict ripening process



For Tb > Tm:

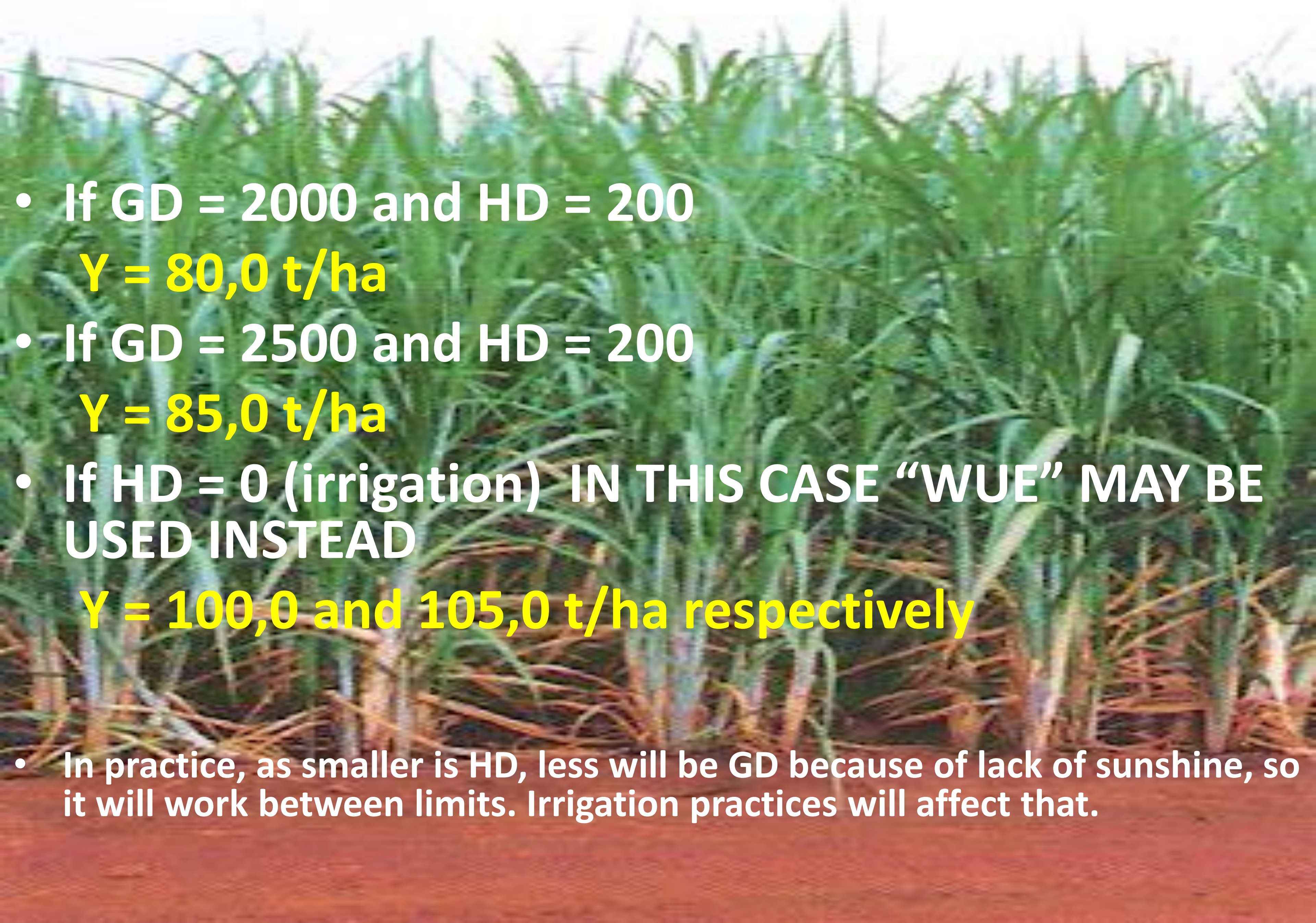
$$\text{Negative Degree- days} = \frac{(Tb - Tm)^2 \times \text{n.º days in month}}{2\,(TM - Tm)}$$

For Tb ≤ Tm: Negative degree-days = 0

Yields estimated

- Weather estimations for the rest of the growth period based in averages and scenarios
- Full environmental characterization for water balance – key information (weak point)
- EPIC database can be used and will improve timing.
- Restrains are supposed and assumed to be the same as in previous cycle. No new factor.
- To be precise, restrains have to be removed and limited factors to be increased.
- GOOD PRACTICES ARE NEEDED!

$$Y = 80{,}0 + 0{,}01\ GD - 0{,}1\ HD$$



- If GD = 2000 and HD = 200

  Y = 80,0 t/ha

- If GD = 2500 and HD = 200

  Y = 85,0 t/ha

- If HD = 0 (irrigation) IN THIS CASE “WUE” MAY BE USED INSTEAD

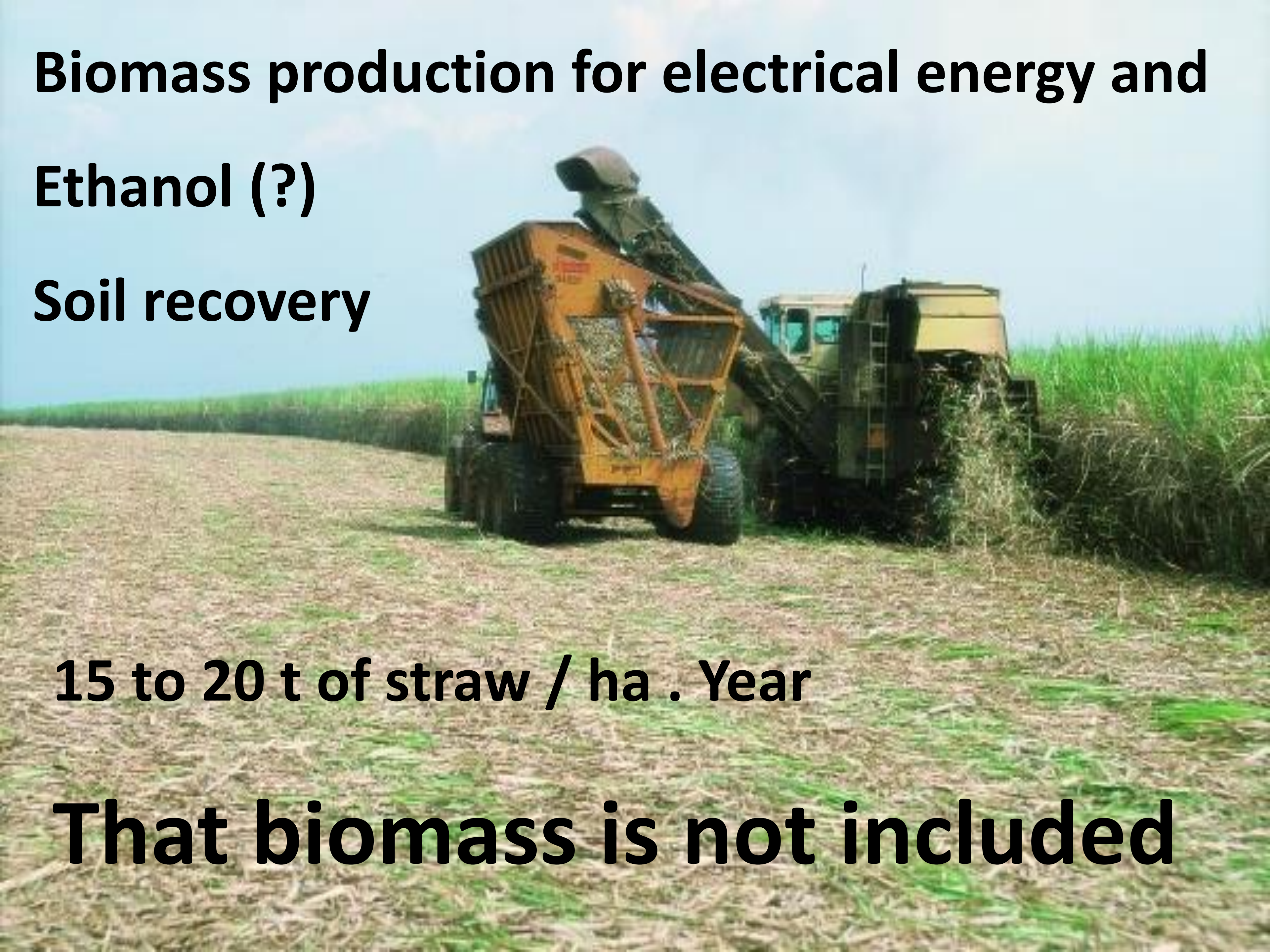
  Y = 100,0 and 105,0 t/ha respectively

- In practice, as smaller is HD, less will be GD because of lack of sunshine, so it will work between limits. Irrigation practices will affect that.

Biomass production for electrical energy and

Ethanol (?)

Soil recovery



15 to 20 t of straw / ha . Year

That biomass is not included

SWOT

STRONG – Easy tool to predict a potential productio
standard conditions.
WEAK – It does not consider particularities and can r
used as a management tool. Needs more field visits.
OPPORTUNITIES – Fast use and decisions can be mad
THREATS - Without validation and knowledge of rea

Conclusions

The simple production model can give us a base for future scenarios constructions and it can be updated as many times as needed with more data included.
It does have limitations that must be awarded by the user.

Sugar cane production as all other feedstock for biofuels needs investments in research to increase the knowledge for production in different conditions to be modeled.

Good practices pretends to include all already accumulated knowledge in liable and operational production systems, and it will be reflected at the parameters of the equations as efficiency measurements.

The project also pretends to bring new concepts and knowledge through the identification of knowledge gaps.


THANK YOU!
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