ENERGY CANE IN BRAZIL

SIZUO MATSUOKA
VIGNIS S.A.
www.vignis.com.br
sizuo.matsuoka@vignis.com.br

A BRIEF ON VIGNIS AND ITS ENERGY CANE

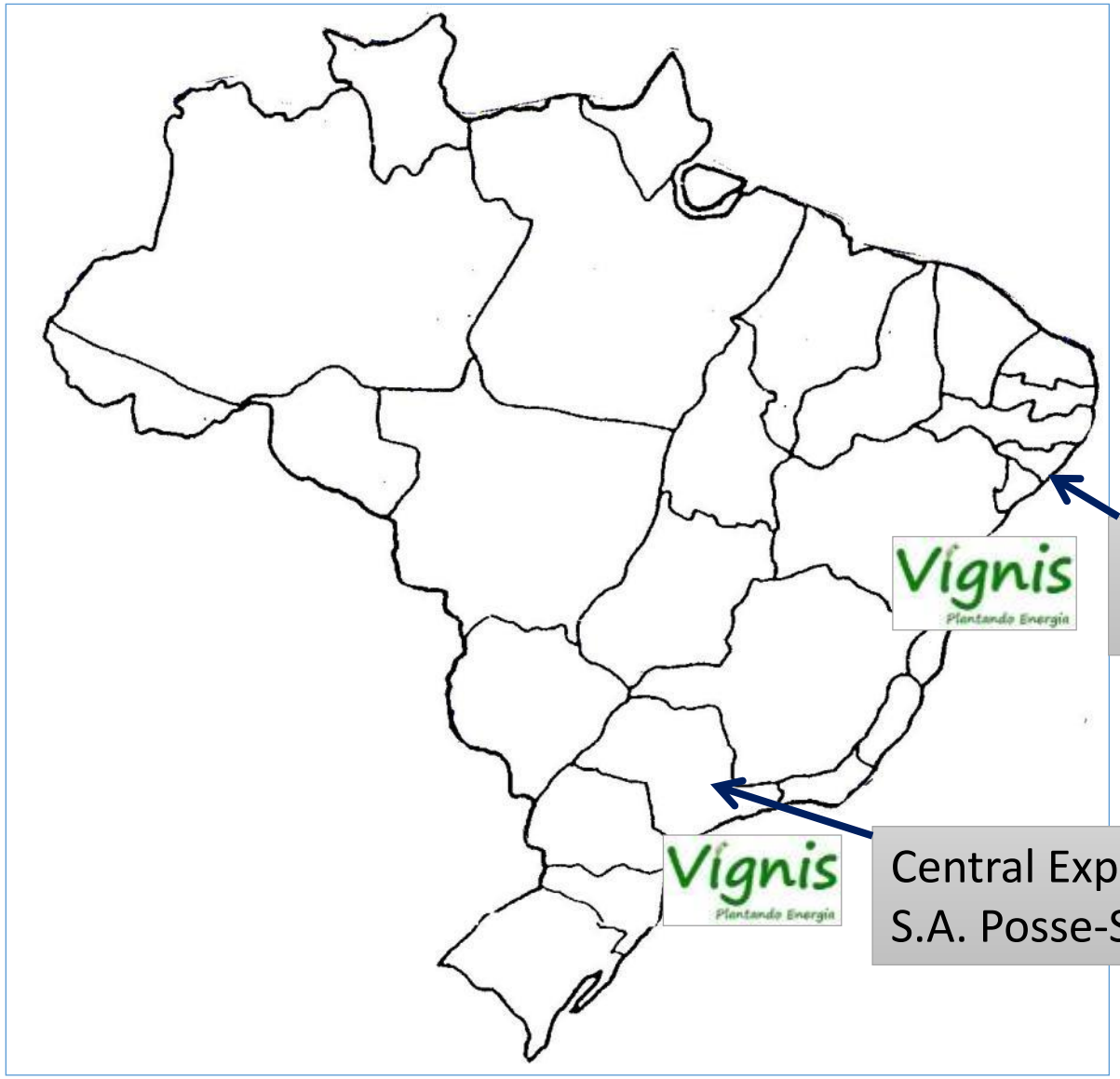
VIGNIS is a biotec company aimed at breeding ENERGY CANE.

A basic difference between ENERGY CANE and conventional sugar cane is its fiber content: it is higher in it, some two fold. One outstanding consequence of this is on the yield, more than two fold. ENERGY CANE also shows many other agronomic advantages.

Vignis' access to the market is through proprietary cultivars.

The feedstock is produced, harvested and delivered to the customer by the company itself.

VIGNIS' FACILITIES



Crossing Station
Maceió -AL

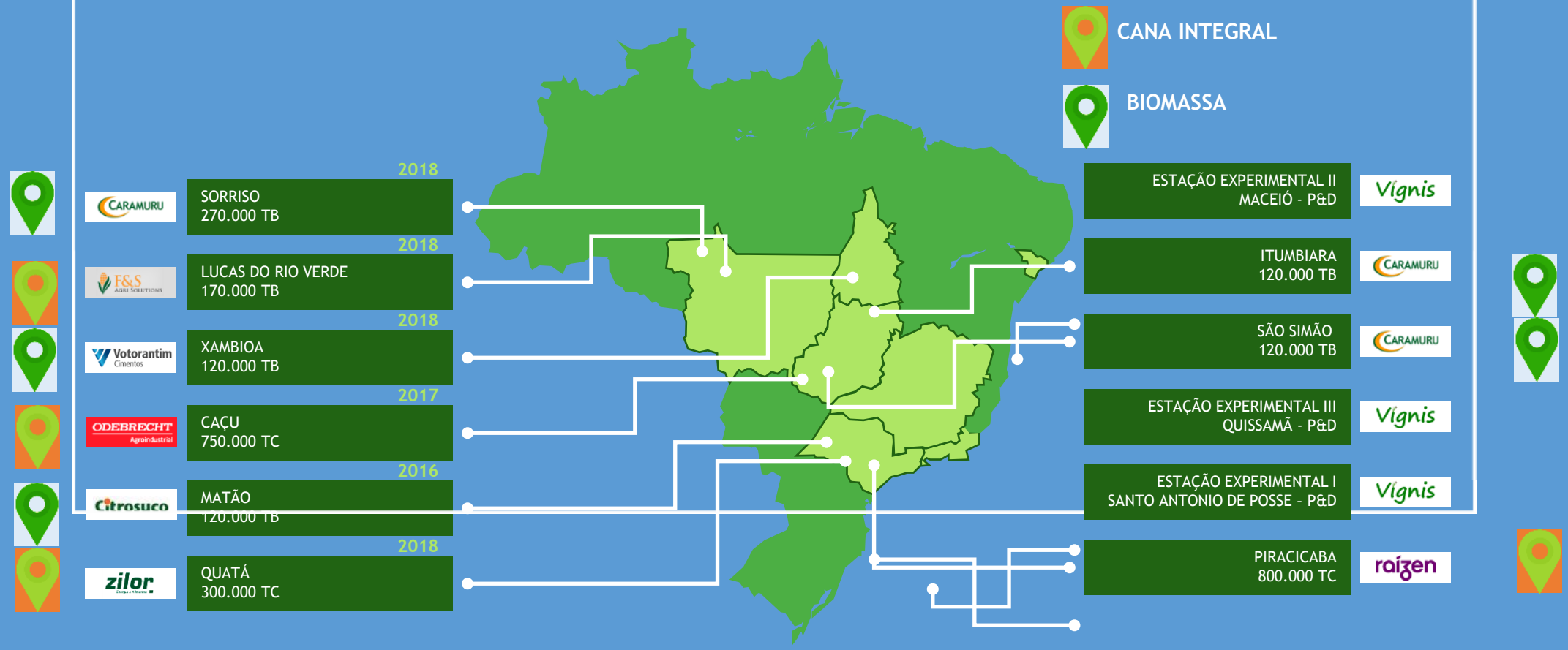
Central Experiment Station
S.A. Posse-SP

VIGNIS' EXPERIMENT STATION LOCATED AT SANTO ANTONIO DE POSSE-SP

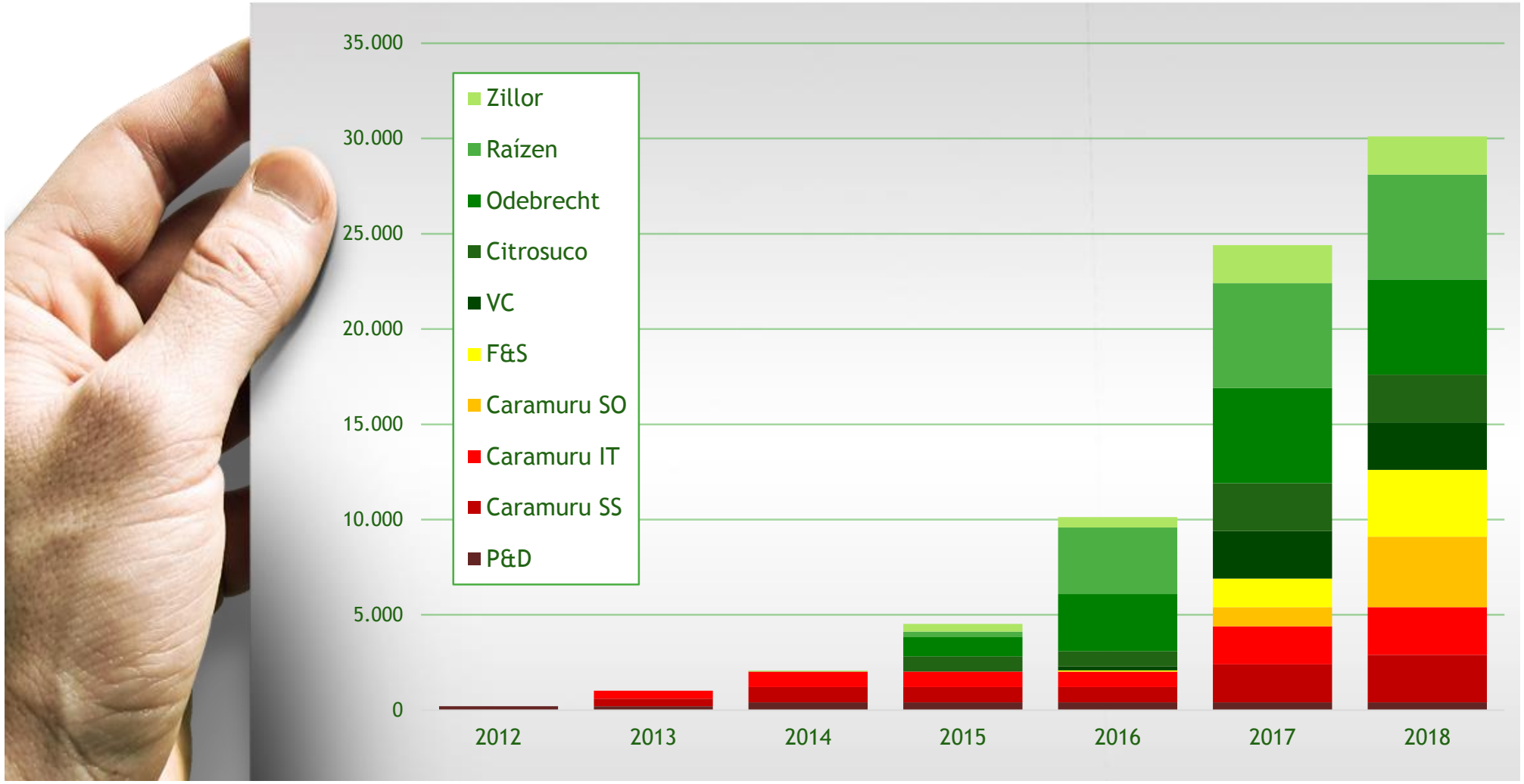
VIGNIS' CUSTOMERS

4.000.000 TONS OF FEEDSTOCK PER YEAR

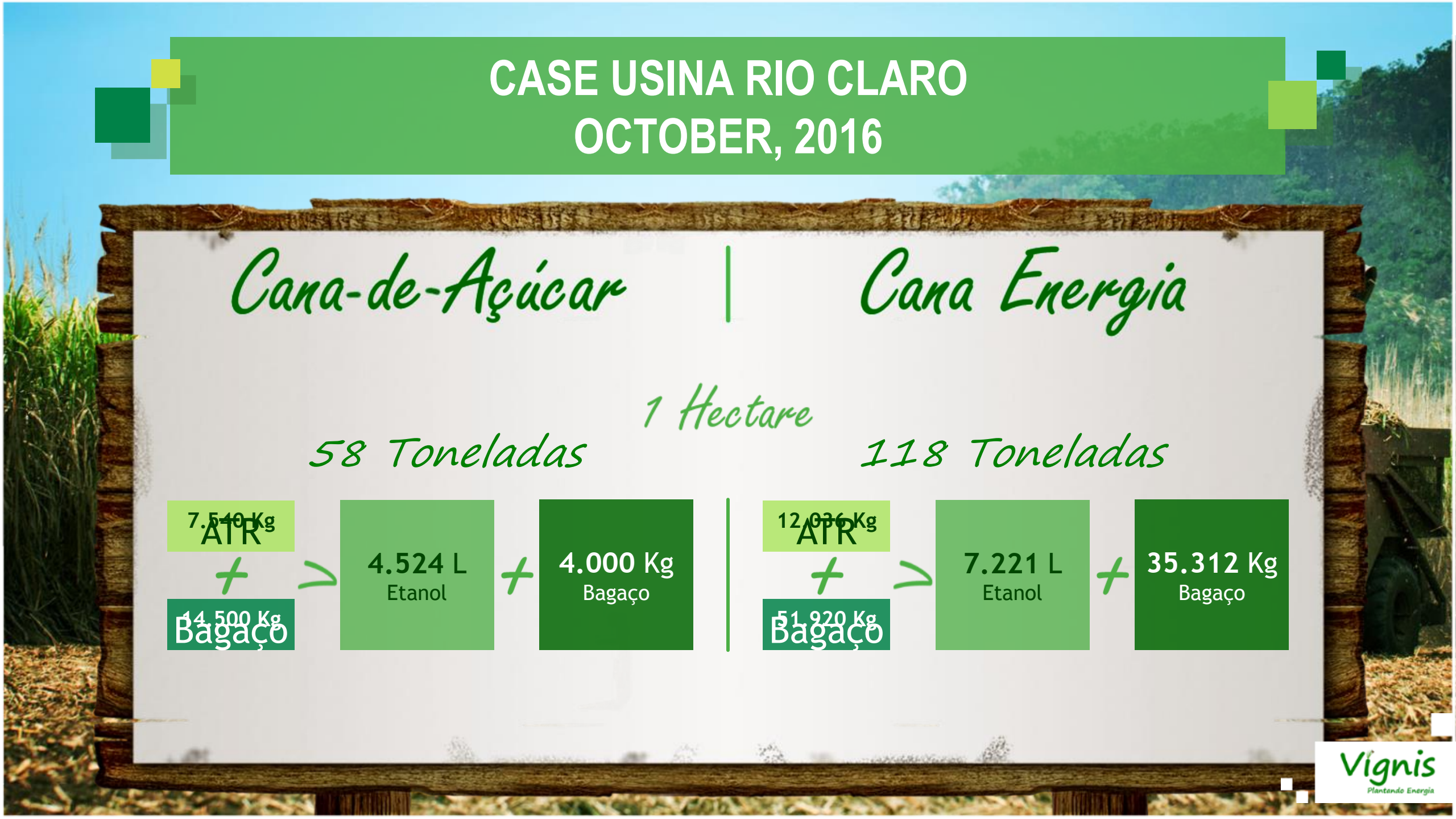
Vignis
Growing Energy



4.000.000 TONS OF ENERGY CANE PER YEAR



CASE USINA RIO CLARO
OCTOBER, 2016



VIGNIS PROTECTED CULTIVARS: 9 SO FAR

REPÚBLICA FEDERATIVA DO BRASIL
Ministério da Agricultura, Pecuária e Abastecimento
Serviço Nacional de Proteção de Cultivares

CERTIFICADO DE PROTEÇÃO DE CULTIVAR

Nº 20140129

Atendidas as disposições da Lei nº 9.456, de 25 de abril de 1997,
e do Decreto nº 2.366, de 5 de novembro de 1997,
e em vista da solicitação de proteção de cultivar

21806.000195/2013-15

concede-se à

VIGNIS PESQUISA E COMÉRCIO DE CANA-DE-AÇÚCAR LTDA.

do(a) BRASIL, o presente Certificado de Proteção de Cultivar de
CANA-DE-AÇÚCAR (*Saccharum* L.), denominada

VG1126

obtida com a participação do(s) melhorista(s)

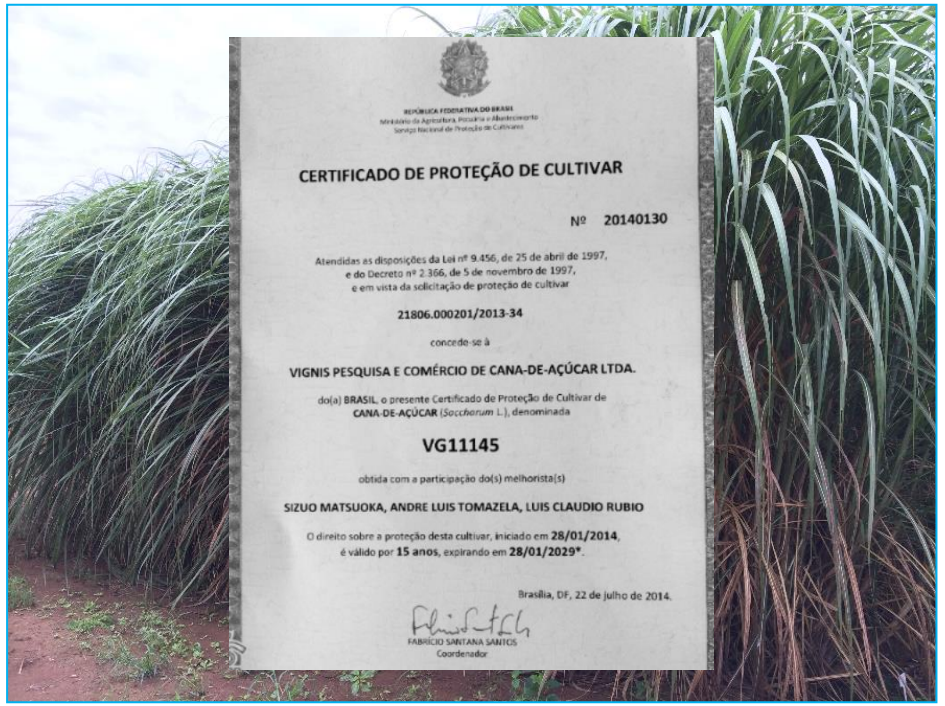
LUIS CLAUDIO RUBIO, SIZUO MATSUOKA, ANDRE LUIS TOMAZELA

O direito sobre a proteção desta cultivar, iniciado em **28/01/2014**,
é válido por **15 anos**, expirando em **28/01/2029***.

Brasília, DF, 22 de julho de 2014.

FABRÍCIO SANTANA SANTOS
Coordenador

VG1126



REPÚBLICA FEDERATIVA DO BRASIL
Ministério da Agricultura, Pecuária e Abastecimento
Serviço Nacional de Proteção de Cultivares

CERTIFICADO DE PROTEÇÃO DE CULTIVAR

Nº 20140130

Atendidas as disposições da Lei nº 9.456, de 25 de abril de 1997,
e do Decreto nº 2.366, de 5 de novembro de 1997,
e em vista da solicitação de proteção de cultivar

21806.000201/2013-34

concede-se à

VIGNIS PESQUISA E COMÉRCIO DE CANA-DE-AÇÚCAR LTDA.

do(a) BRASIL, o presente Certificado de Proteção de Cultivar de
CANA-DE-AÇÚCAR (*Saccharum* L.), denominada

VG11145

obtida com a participação do(s) melhorista(s)

SIZUO MATSUOKA, ANDRE LUIS TOMAZELA, LUIS CLAUDIO RUBIO

O direito sobre a proteção desta cultivar, iniciado em **28/01/2014**,
é válido por **15 anos**, expirando em **28/01/2029***.

Brasília, DF, 22 de julho de 2014.

FABRÍCIO SANTANA SANTOS
Coordenador

VG11145

HOW ENERGY CANE IS OBTAINED

Sugar cane breeding is an ongoing process more than 100 years old: commercial varieties are hybrids from crosses between *Saccharum officinarum* and *S. spontaneum*, or landraces, followed by sucessive backcross to the first species.

Saccharum officinarum

Tropical
Sugary
Low resilience

Saccharum barberi/sinense

After several backcrosses

Modern sugar cane cultivars

Saccharum spontaneum

Sub-tropical
Fibrous
High resilience

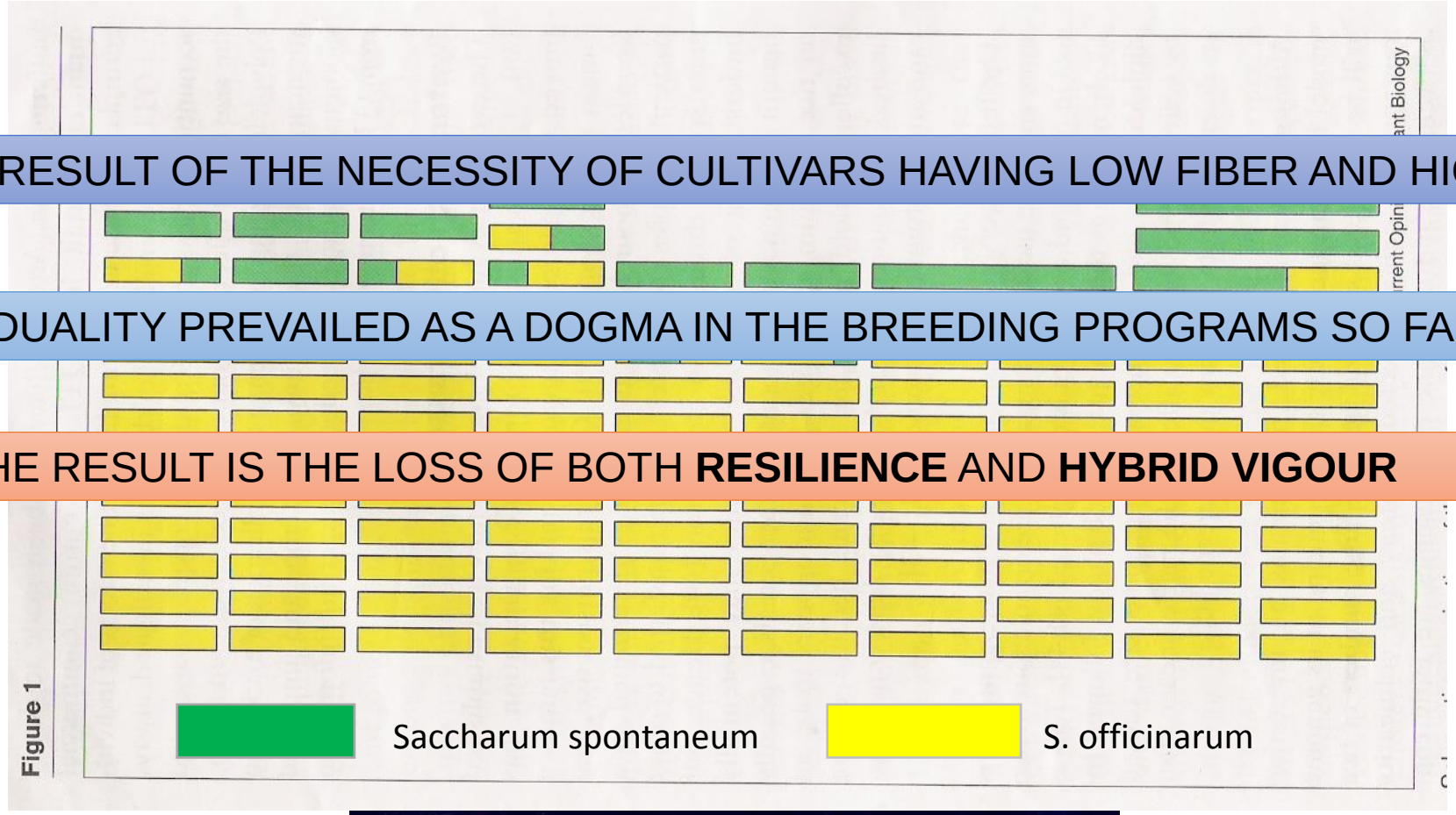
Prevalence of *S. officinarum* chromosomes

GENOMIC COMPOSITION OF MODERN SUGAR CANE VARIETIES

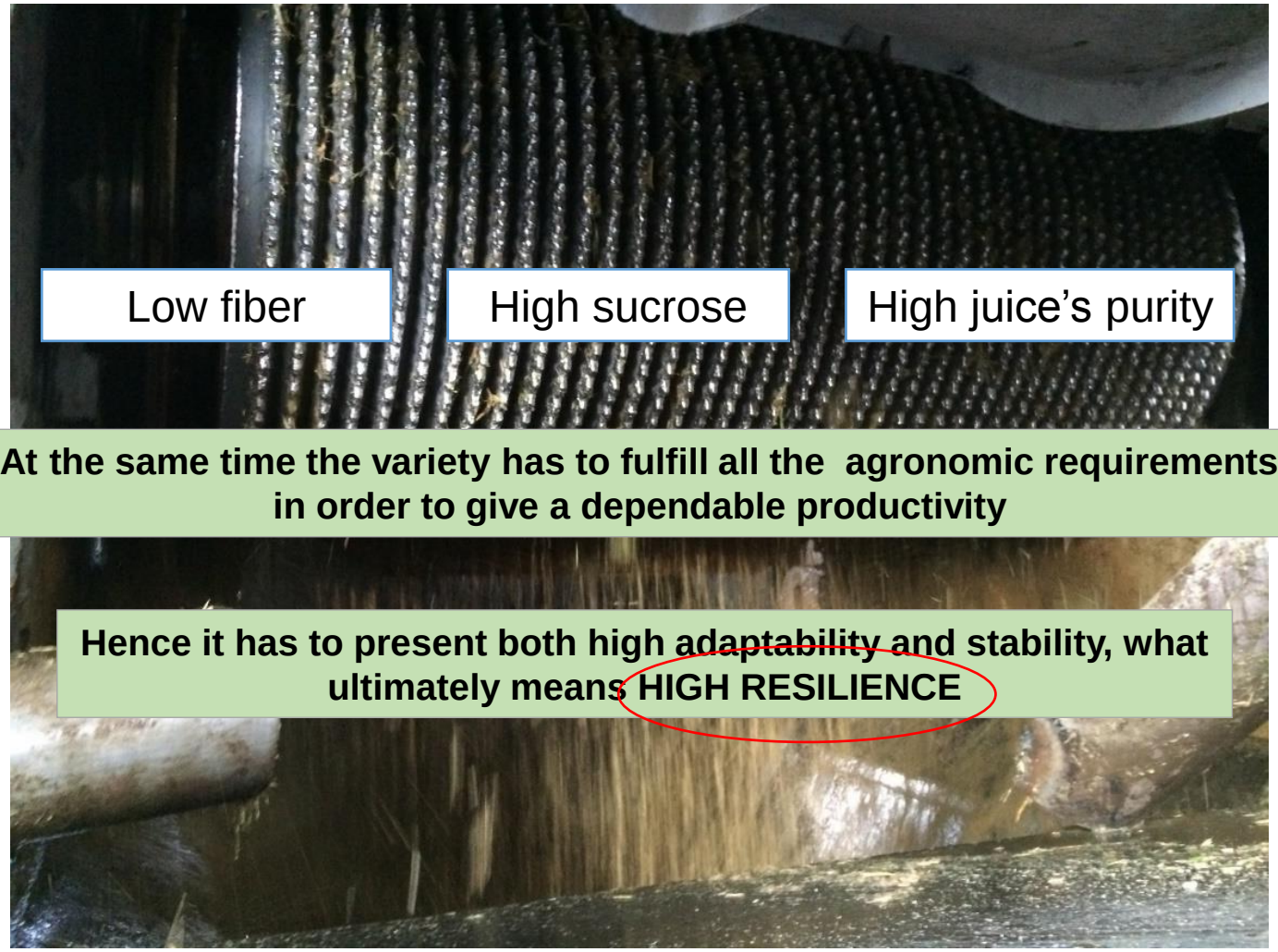
THIS IS A DIRECT RESULT OF THE NECESSITY OF CULTIVARS HAVING LOW FIBER AND HIGH SUCROSE

THIS DUALITY PREVAILED AS A DOGMA IN THE BREEDING PROGRAMS SO FAR

THE RESULT IS THE LOSS OF BOTH **RESILIENCE** AND **HYBRID VIGOUR**



THE INDUSTRY REQUIREMENTS IMPOSED THE GENOMIC COMPOSITION OF MODERN SUGAR CANE VARIETIES



At the same time the variety has to fulfill all the agronomic requirements in order to give a dependable productivity

Hence it has to present both high adaptability and stability, what ultimately means HIGH RESILIENCE

The tradeoff HIGH SUGAR and LOW FIBER represents a STRONG LIMITATION ON YIELD. If BIOMASS is the target instead (high fiber), the result is a plant with high HYBRID VIGOR and HIGH RESILIENCE

Vignis
Growing Energy

Saccharum officinarum

Saccharum spontaneum

Fibrous energy cane cultivars

UNLIKE CONVENTIONAL SUGAR CANE, ENERGY CANE HAS PREVALENCE OF *S. spontaneum* GENOME, HENCE **HIGHER RESILIENCE**

This change to a fibrous cane brings together many distinct and advantageous characteristics.
Two of them are higher hybrid vigor, and higher resilience.

Vignis
Growing Energy

Sugar cane

Energy cane

RATOONING IS ANOTHER OUTSTANDING DIFFERENCE BETWEEN SUGAR CANE AND ENERGY CANE

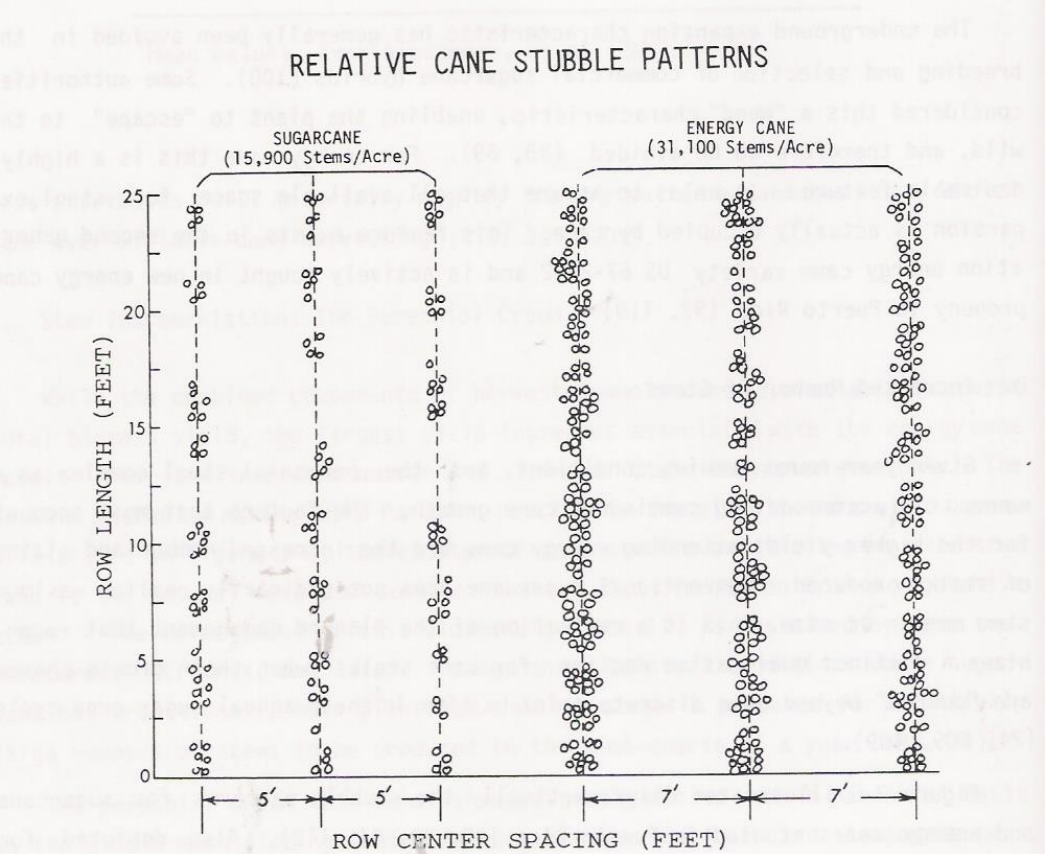
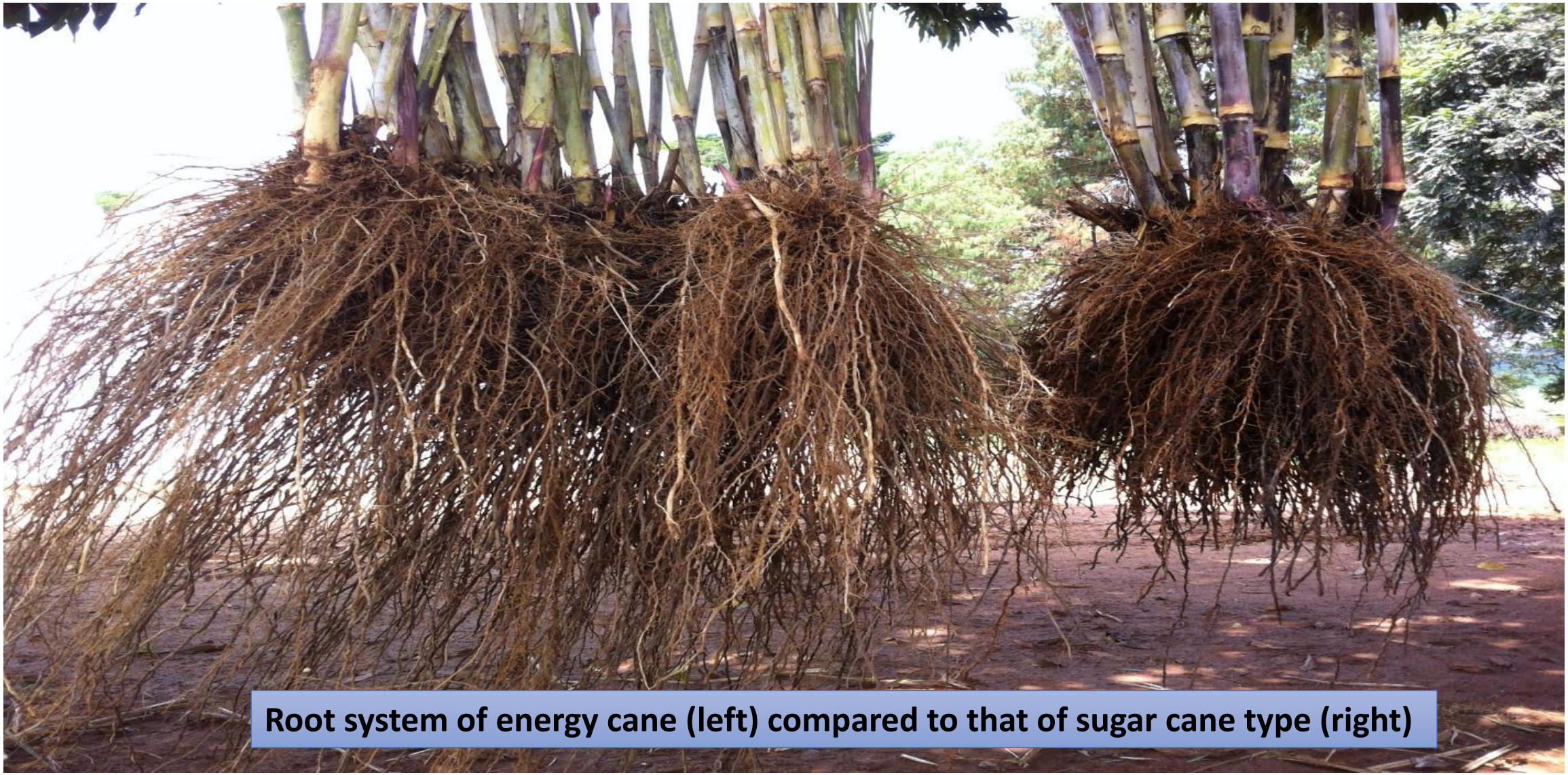


Fig. 3-3. Schematic diagram of stubble patterns in freshly-harvested sugarcane and energy cane. These patterns are based on stubble counts and observations performed in the Lajas Valley and at Hatillo, Puerto Rico, between 1978 and 1982 (92). As illustrated, the stubbles for sugarcane (15,900 stems per acre) and energy cane (31,100 stems per acre) are oversized and represent approximately half the number that would be found under actual field conditions. The higher numbers for energy cane result from increased stems within the row (wider stools and shorter distances between stool centers). These features more than compensate for the greater distance between rows of energy cane. Diagram by A. G. Alexander.

ANOTHER OUTSTANDING CHARACTERISTIC OF ENERGY CANE IS IT'S VIGOROUS ROOT SYSTEM

Vignis
Growing Energy



Root system of energy cane (left) compared to that of sugar cane type (right)

ENERGY CANE'S ROOT SYSTEM IS NOT ONLY VIGOROUS BUT ALSO BEARS RHIZOME, AN ORGAN NON-EXISTENT IN SUGAR CANE. RHIZOME IS IMPORTANT TO THE PLANT WITHSTAND STRESSFUL CONDITIONS.

Vignis
Growing Energy

ROOT SYSTEM - ESSENTIAL TO ANY PLANT

BENEFICIAL CONTRIBUTION OF ABUNDANT, PROFOUND AND PERMANENT ROOT SYSTEM OF ENERGY CANE

1. HIGHER LONG LASTING SEQUESTER OF CARBON
2. INCREASED SEQUESTER OF NUTRIENTS (N, P, etc.): INCREASED PLANT EFFICIENCY ON GROWTH AND LEACHING AVOIDMENT
3. HIGH SOIL EROSION CONTROL
4. BETTERMENT OF SOIL PHYSICAL AND CHEMICAL PROPERTIES
5. BETTERMENT OF SOIL BIOLOGICAL PROPERTY
6. RESCUE OF DEGRADED SOILS
7. RESCUE OF NATURAL LOW QUALITY SOILS
8. INCREASED WATER INFILTRATION AND STORAGE

SOME OUTSTANDING ECOLOGICAL CHARACTERISTICS OF ENERGY CANE

Vignis
Growing Energy

COMPLETE GROUND COVERAGE

Avoid raindrops hitting directly the soil surface, thus protecting it against erosion, one of the most hazardous effect of agriculture.

C4 PERENNIAL GRASS

The most photosynthetically efficient amongst all cultivated plants: its high productivity of biomass allows a highly positive C balance.

ABUNDANT FASCICULATED ROOTS

Greater water infiltration, thus avoiding surface water flow and consequente rill and gully erosion; more efficient water and nutrient foraging.

40 cm Arable layer

DEEP ROOT SYSTEM

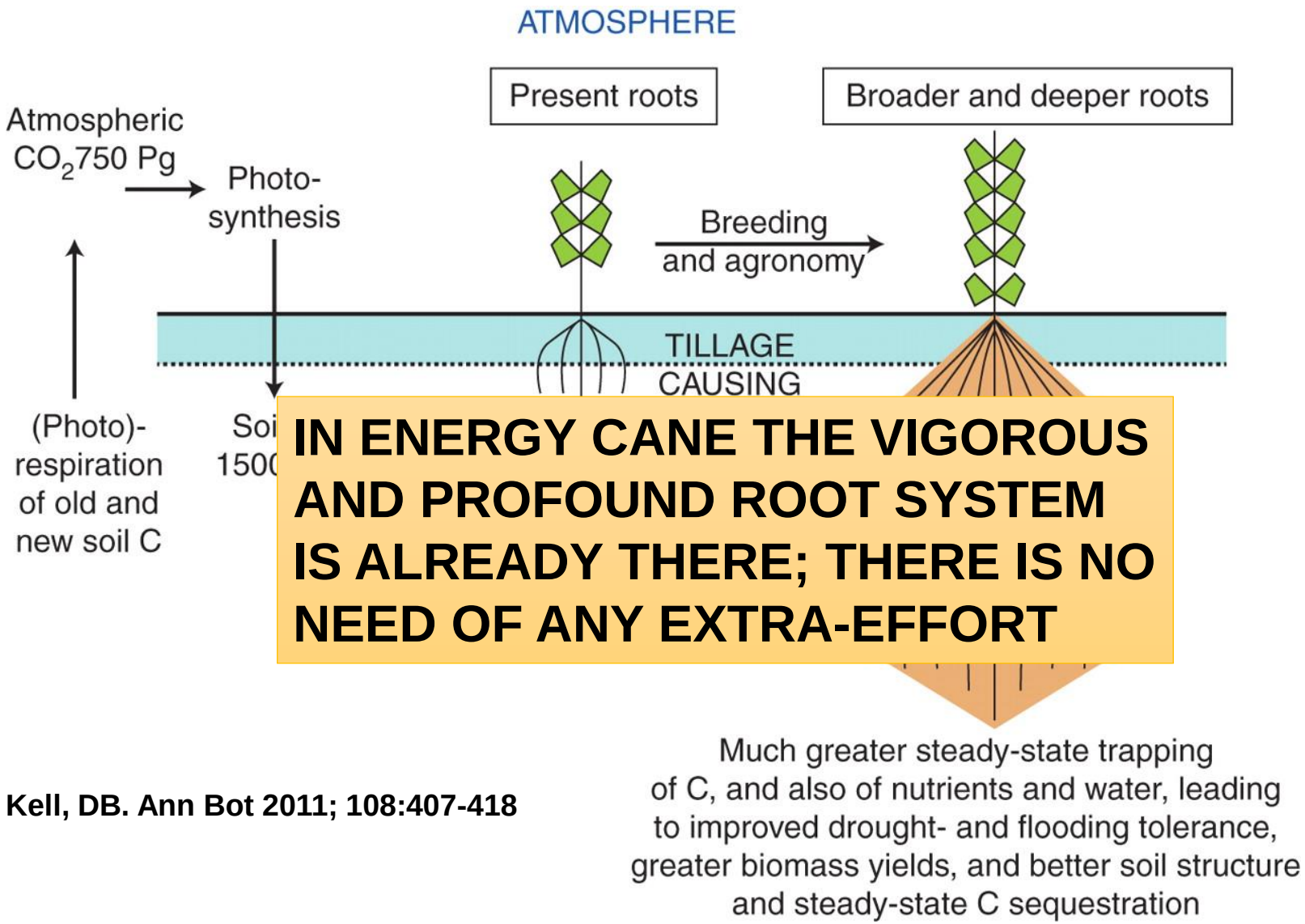
Favors water infiltration and tolerance to drought; also results in higher C sequestration (untransient).

RHIZOME

Tolerance to stresses; longer number of ratoons and, thus, less tillage (which is one of the main causative of soil erosion).

RHIZOME

POTENTIAL TO INCREASE AGRONOMIC AND ECOLOGYCAL ATTRIBUTES OF PLANTS THROUGH BREEDING FOR LARGER ROOT SYSTEM OF PERENNIALS

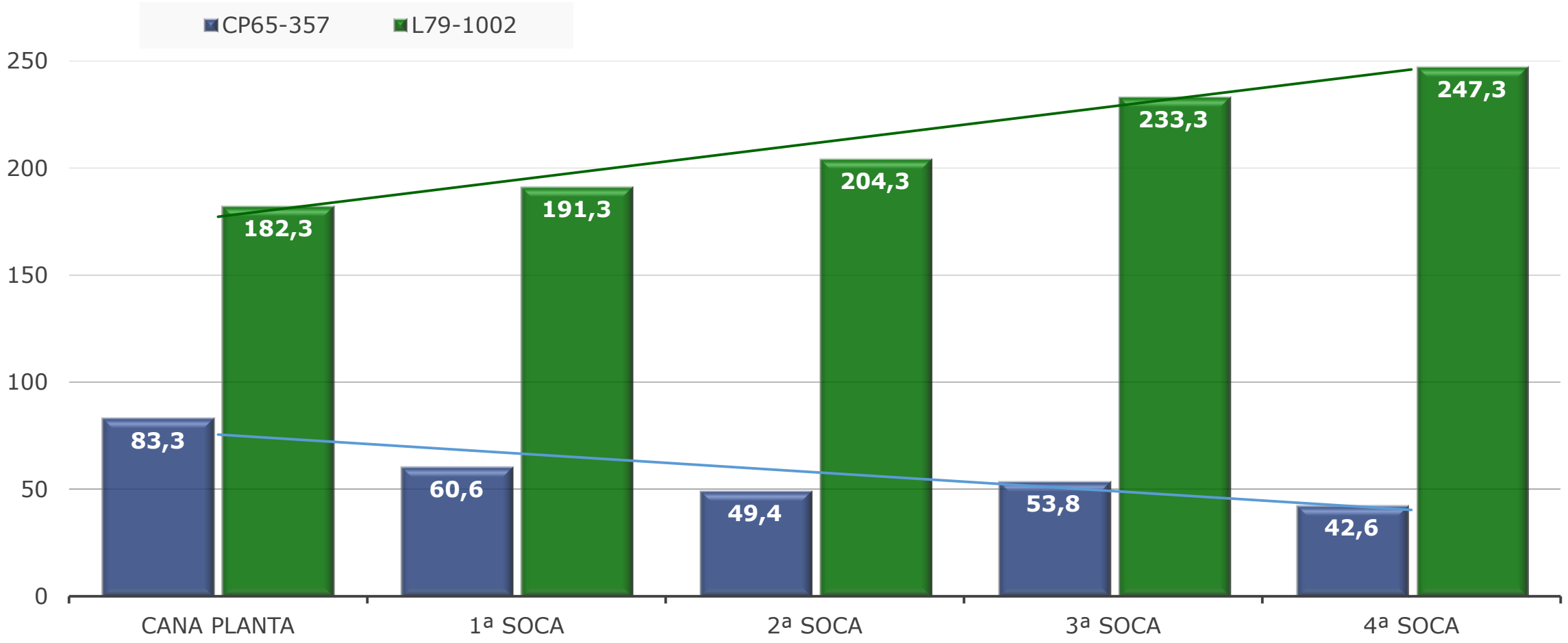


IN ENERGY CANE THE VIGOROUS AND PROFOUND ROOT SYSTEM IS ALREADY THERE; THERE IS NO NEED OF ANY EXTRA-EFFORT

Kell, DB. Ann Bot 2011; 108:407-418

COMPARISON OF RATOON PERFORMANCE: UNLIKE SUGAR CANE (CP65-357) ENERGY CANE (L79-1002) INCREASES PRODUCTIVITY IN THE RATOONS

Vignis
Growing Energy



BISCHOFF, K.P. ET AL. 2008. J. PLANT REGISTRATIONS, V.2 (3):211-217

COMPARISON BETWEEN SUGAR CANE AND VIGNIS' ENERGY CANE

Vignis
Growing Energy

Sugar cane

Productivity

Total biomass: 100 (Ton/ha)
Sugar (135 TRS): 13.5 (Ton/ha)
Bagasse (12.5% fiber): 25 (Ton/ha)

Energy cane

Productivity

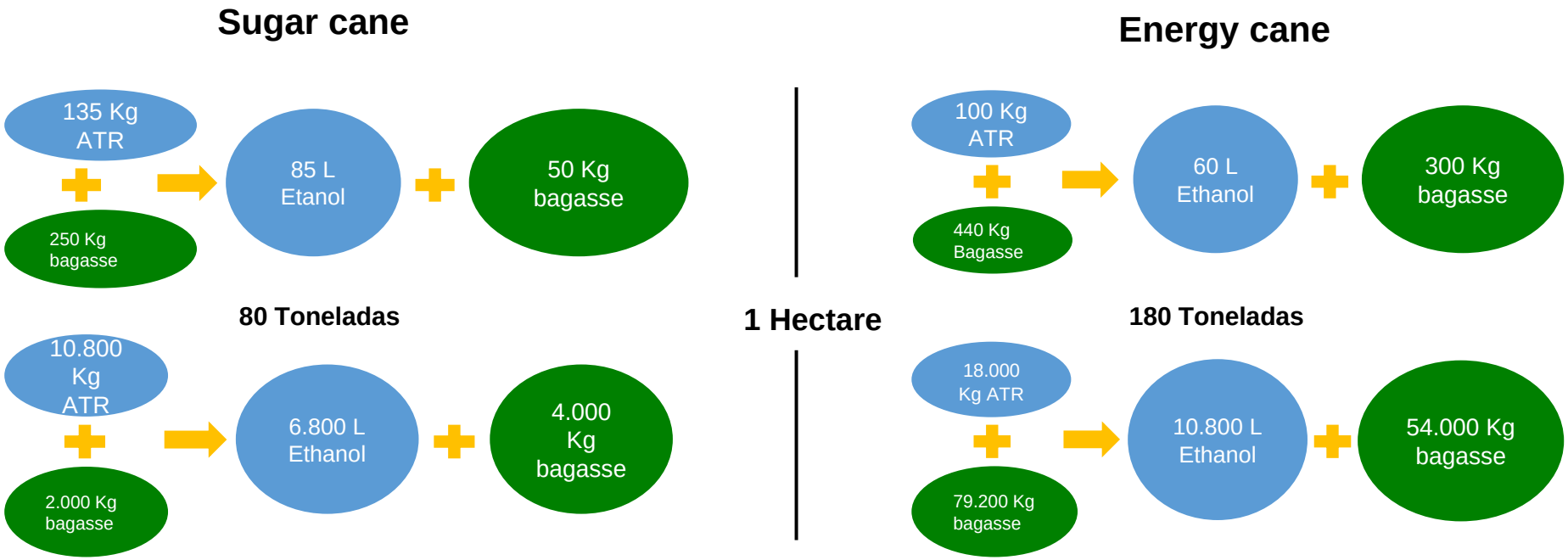
Total biomass: 220 (Ton/ha)
Sugar (115 TRS): 25.3 (Ton/ha)
Bagasse (18% fiber): 79.5 (Ton/ha)

Energy cane

Productivity

Total biomass: 185 (Ton/ha)
Sugar (93 TRS): 17.2 (Ton/ha)
Bagasse (26% fiber): 96.2 (Ton/ha)

ENERGY CANE PRODUCES MORE SUGAR AND FIBRE PER AREA THAN SUGAR CANE



FEEDSTOCKS FOR BIOFUELS

Vignis
Growing Energy

MAIN PROPOSED FEEDSTOCKS
1. AGRICULTURAL WASTES
2. SURPLUS AGRI-PRODUCTS
3. MUNICIPAL WASTES
4. WOOD CHIPS and other residues
5. GRAIN, STARCH & SUGAR CROPS
6. DEDICATED CROPS

DEDICATED CELLULOSIC CROPS
1. PLANTED FORESTS
2. COPPICES
3. GRASS PLANTS

MAIN PROPOSED GRASSES
1. MISCANTHUS
2. SWITCHGRASS
3. SORGHUM
4. ELEPHANT GRASS
5. ENERGY CANE
6. OTHERS

WHY ENERGY CANE BIOMASS

Vignis
Growing Energy

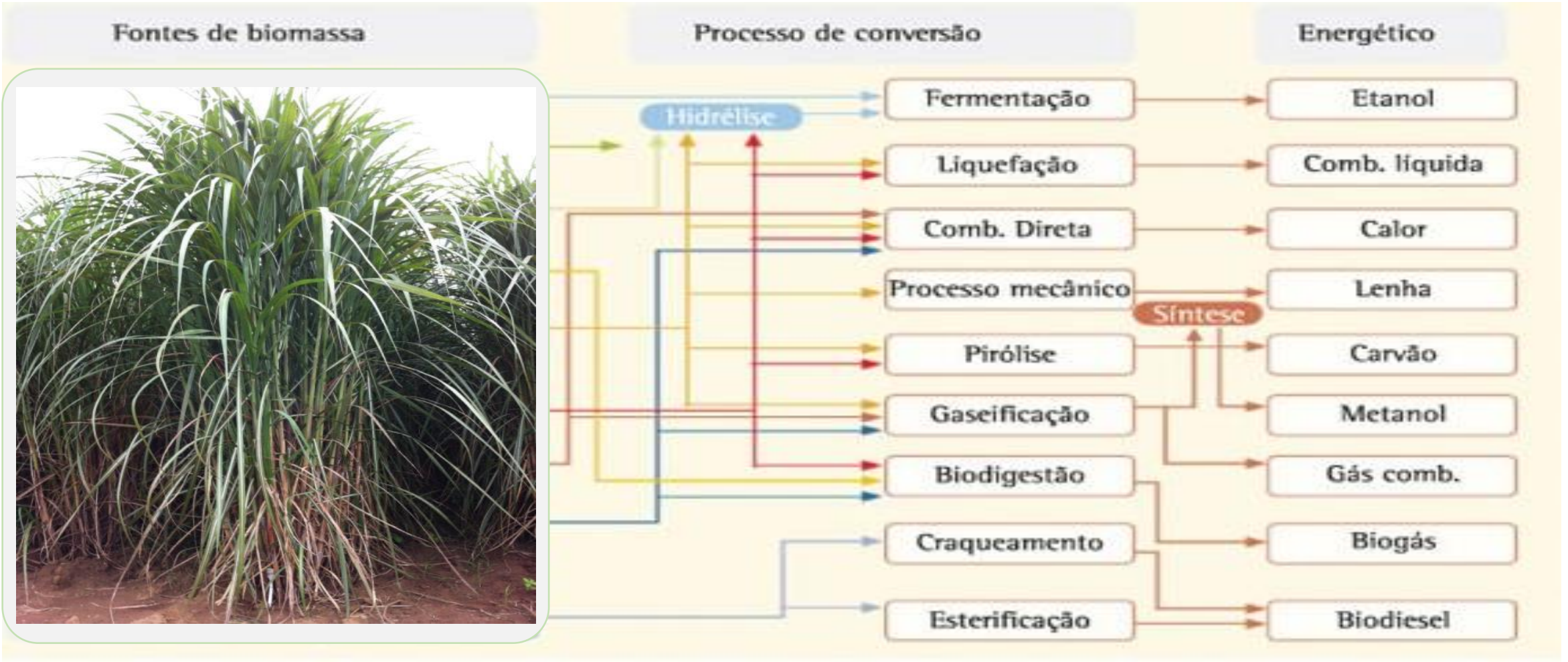
- ✓ **The most productive biomass crop plant**
- ✓ Year-round availability of feedstock
- ✓ Just-on-time supply of feedstock
- ✓ Crop tailored to local climatic and soil conditions
- ✓ Crop resistant to local pest and diseases
- ✓ A well-known crop system: management, harvesting and delivery
- ✓ Environmentally sustainable crop
- ✓ No competition with food production or other economic feedstocks: grown on marginal or degraded lands
- ✓ Possibility of exploiting cold region as well as dry region
- ✓ Available a well-known breeding technology and basic germplasm as well

Vignis
Growing Energy

COMPOSITION OF ENERGY CANE COMPARED TO SUGAR CANE

	Energy cane	Sugar cane
Humidity	64,0	71,0
Fixed C	15,1	15,9
C	47,0	45,8
H	6,1	6,2
N	0,4	0,4
Ash	2,6	2,1
S	0,1	0.08
O	43,7	45,5
GCV	18,8	18,4
NCV	17,5	17,1
Cellulose	23,2	20,6
Lignin	18,3	13,8
Hemicellulose	24,8	20,9
Acetil group	1,9	1,6
Extractives	23,6	36,9

VIGNIS' BIG BREEDING PROGRAM ALLOWS THE DEVELOPMENT OF PLANTS TAILORED TO EACH DEMAND



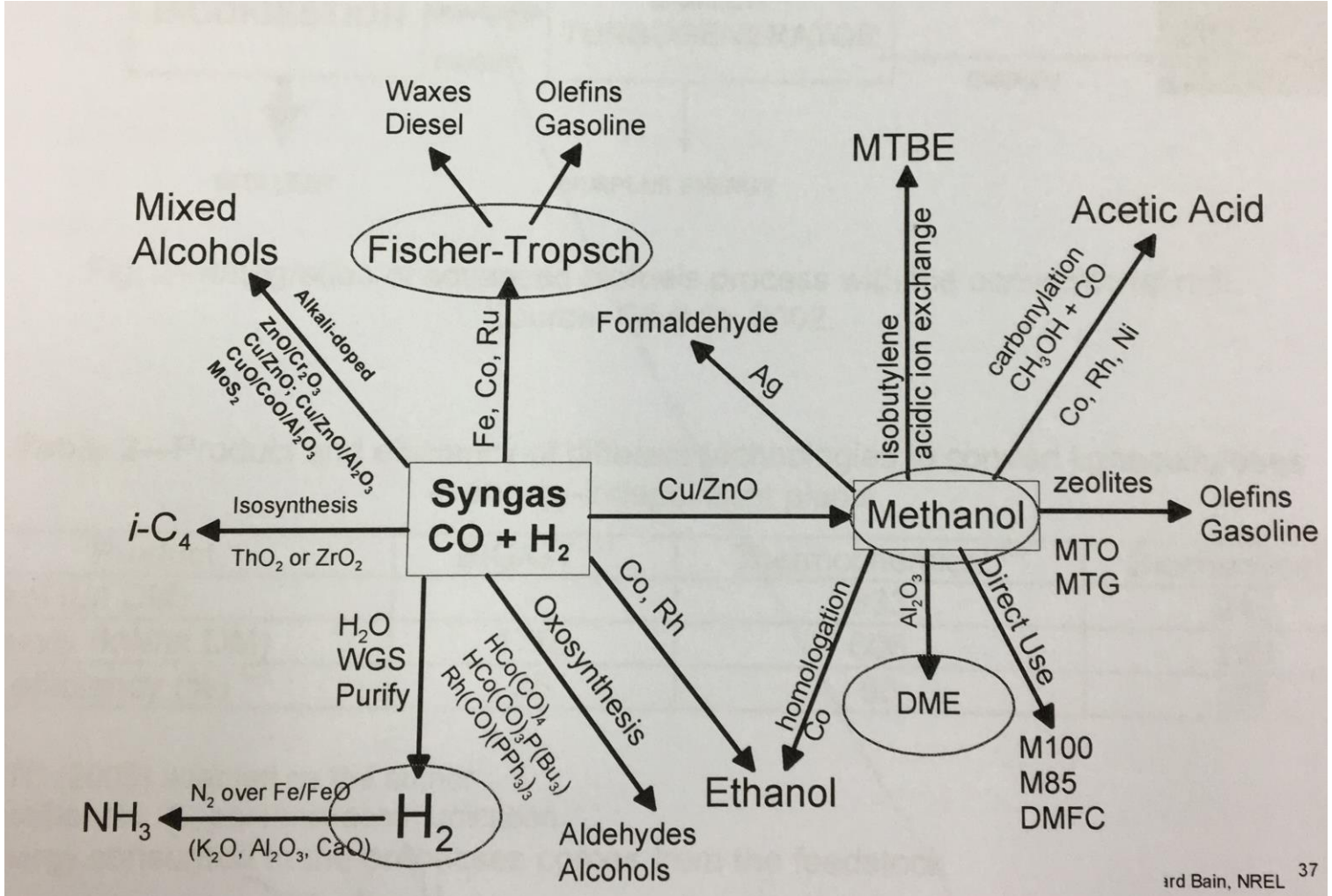
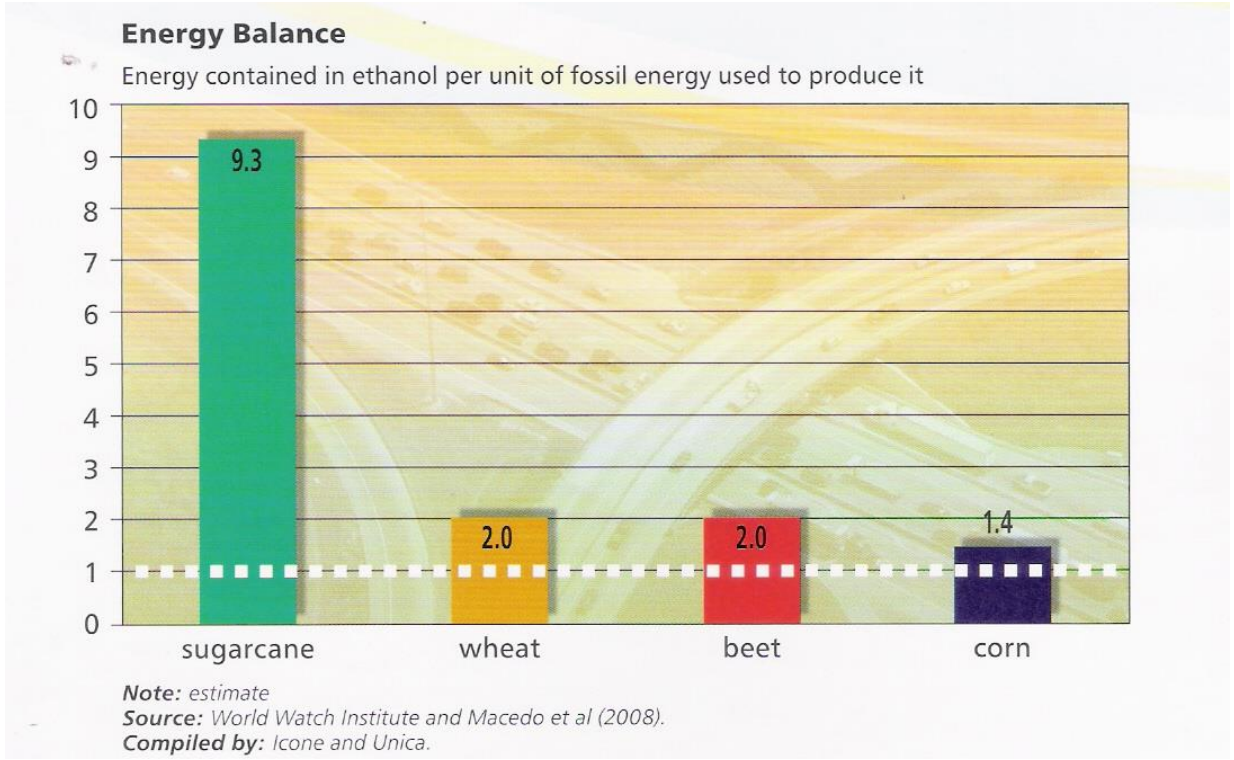
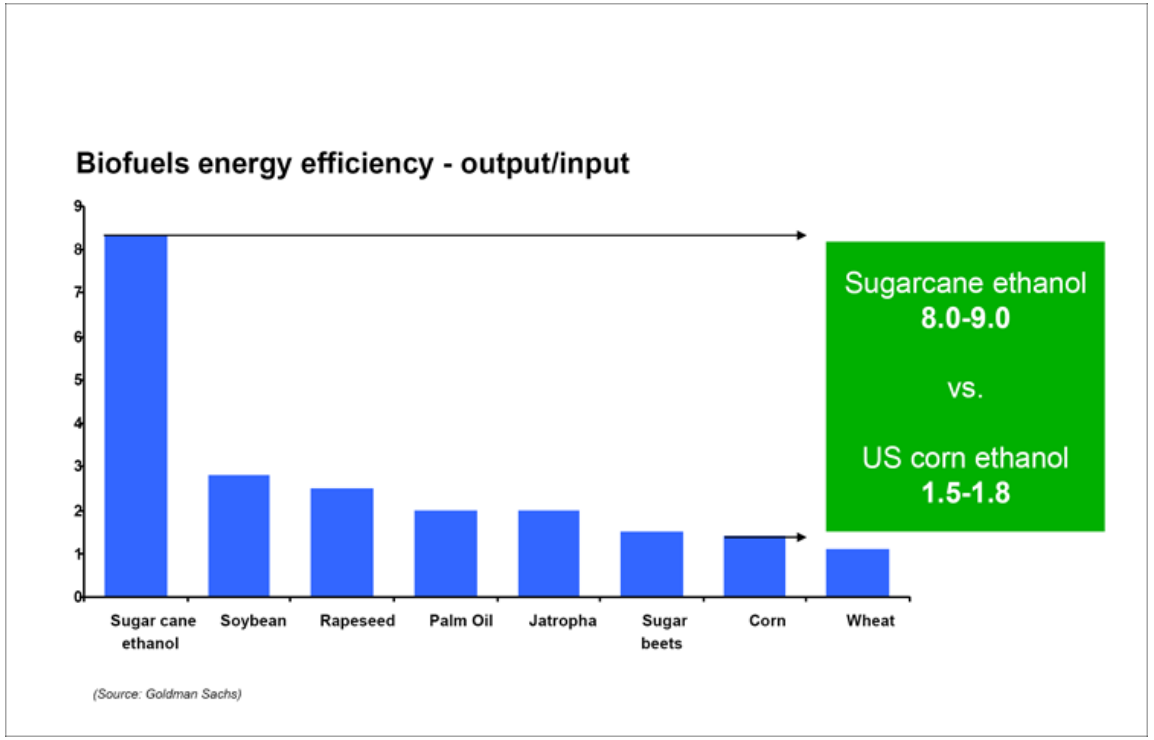


Fig. 1—Overall view of alternatives to process syngas into several final products. Source: (Larson, 2007).

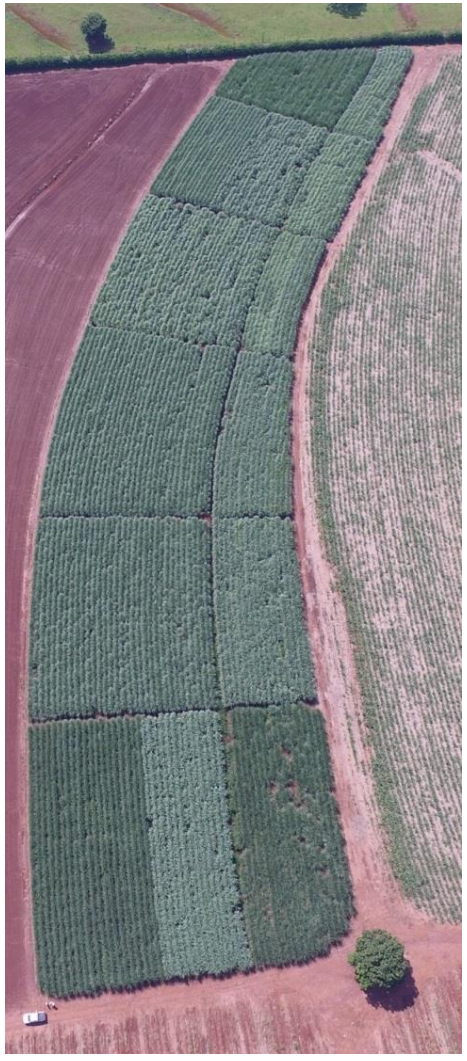
BIOFUELS' ENERGY BALANCE AND EFFICIENCY





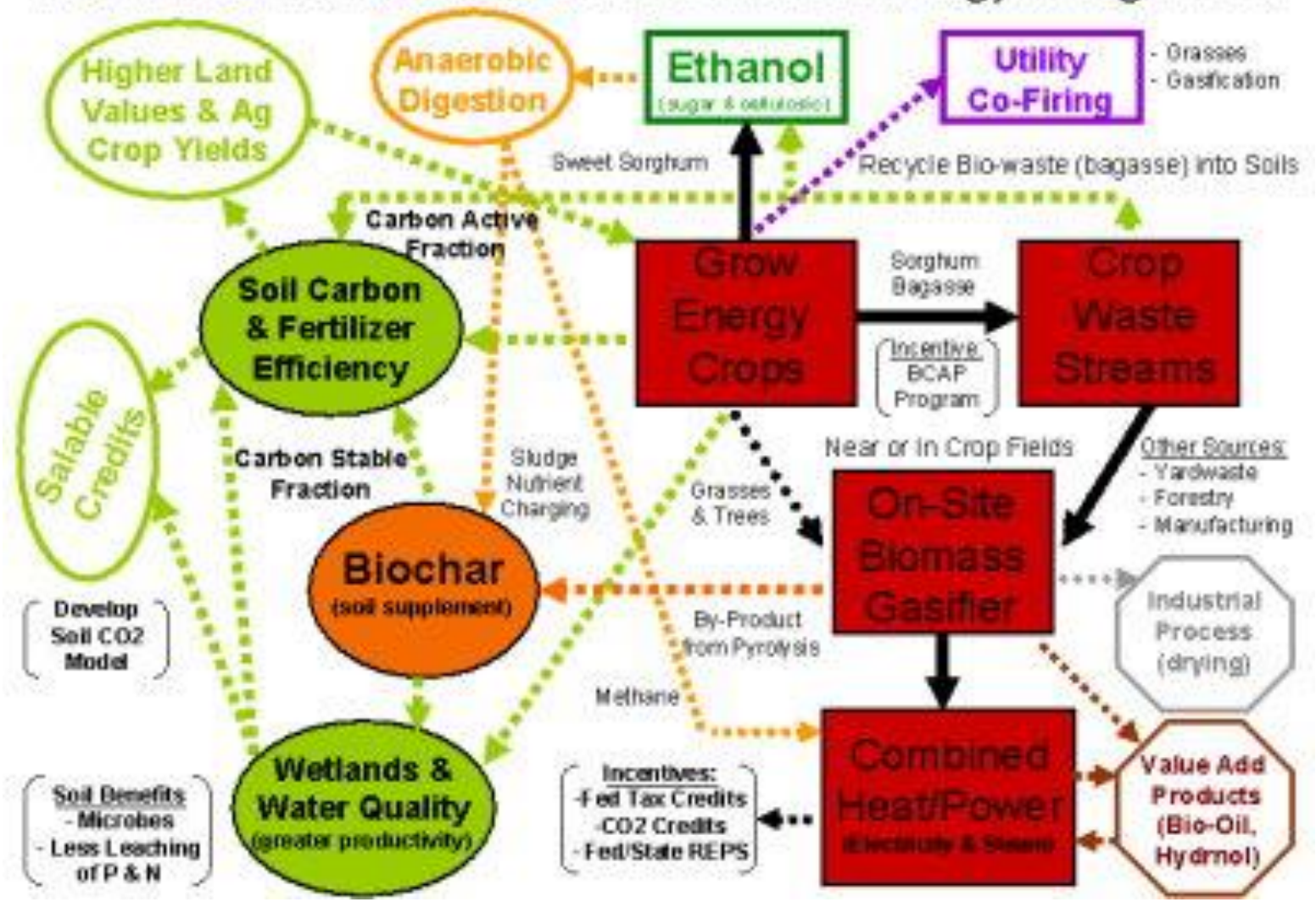
ENERGY CANE:
MOST PRODUCTIVE DEDICATED ENERGY CROP, AND MOST PROFITABLE, MANAGEABLE, SUSTAINABLE AND ENVIRONMENTAL-FRIENDLY OF KNOWN BIOMASS

Vignis
Growing Energy



Vignis
Growing Energy

Land Use and Renewable Biomass Energy Integration



PRODUCTS AND SUB-PRODUCTS FROM A SUGARCANE BIOREFINERY

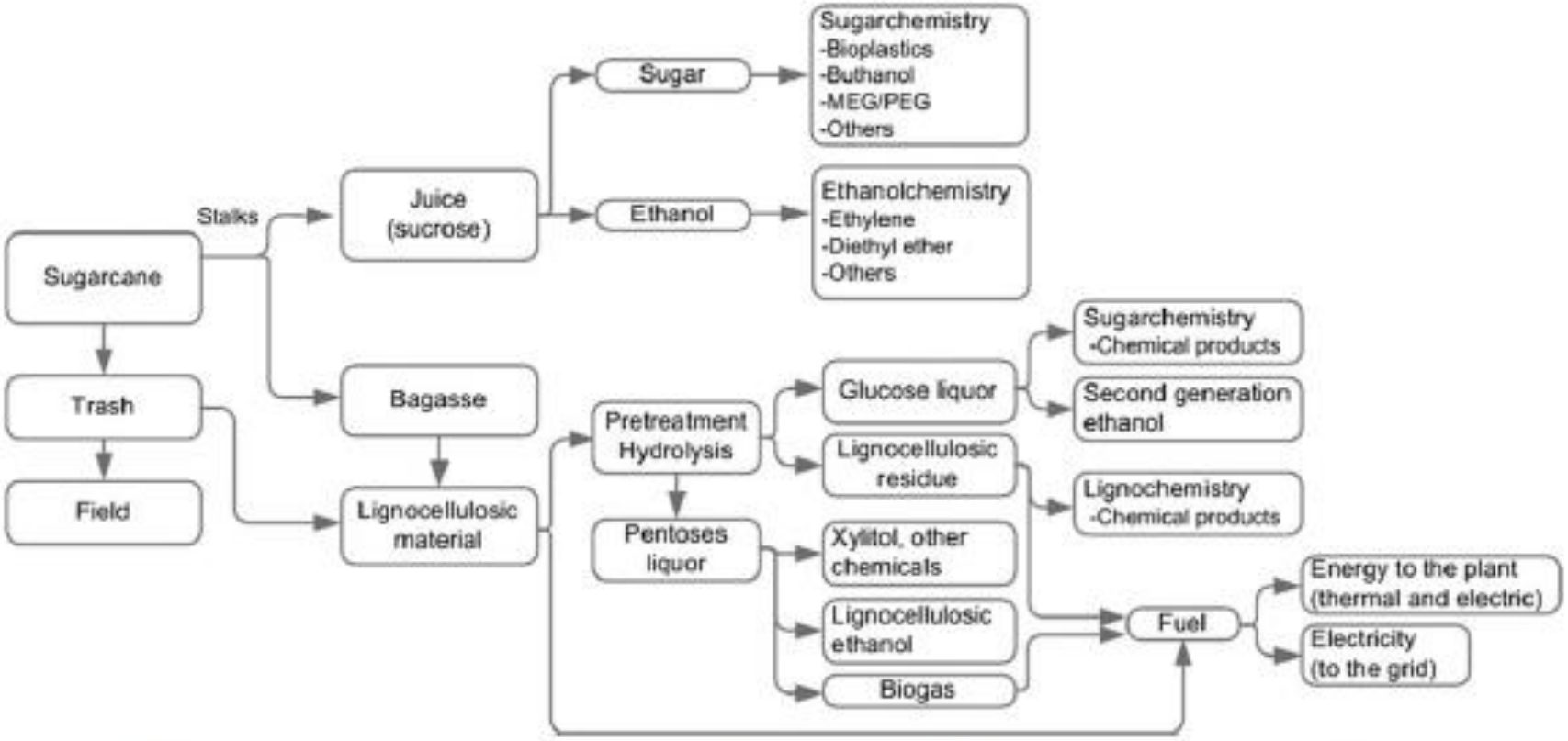
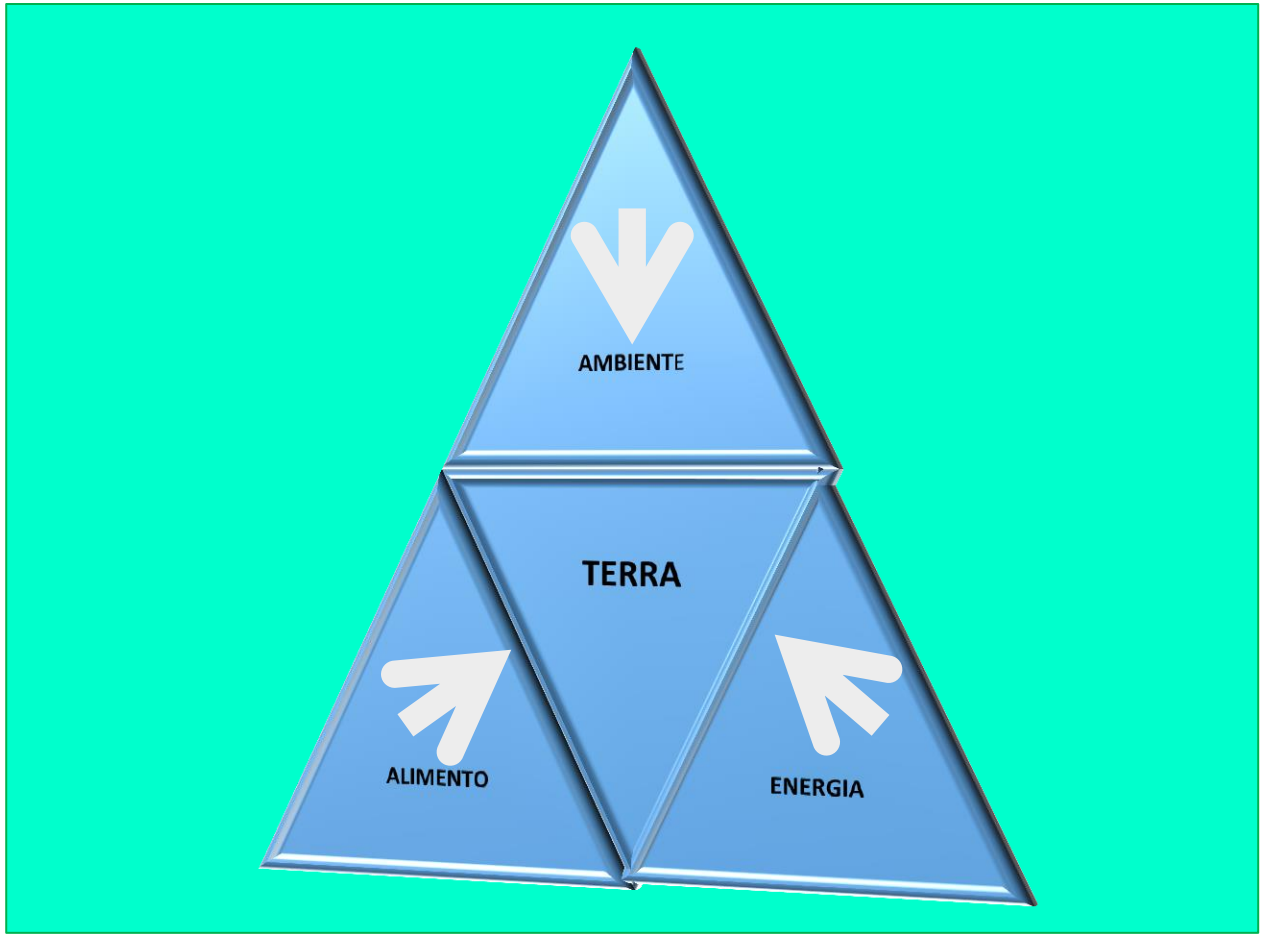


Fig. 3 – Simplified process scheme of a conceptual future sugarcane biorefinery.

Lago *et al.*, 2012.

BRAZIL'S SUGAR CANE ZOONING

BRASIL	CLASSES DE APTIDÃO	AREAS APTAS POR TIPO DE USO DA TERRA POR CLASSE DE APTIDÃO (HÁ)				
		Pecuaria	Agropecuaria	Agricultura	Pecuaria + Agropecuaria	Pecuaria + Agropecuaria + Agricultura
AREAS TOTAIS	Alta	11,3 Milhoes	600 Mil	7,3 Milhoes	11,9 Milhoes	19,2 Milhoes
	Media	22,8 Milhoes	2,01 Milhoes	16,3 Milhoes	24,8 Milhoes	41,2 Milhoes
	Baixa	3,04 Milhoes	483 Mil	731 Mil	3,5 Milhoes	4,2 Milhoes
	Alta + Media	34,1 Milhoes	2,6 Milhoes	23,7 Milhoes	36,7 Milhoes	60,4 Milhoes
	Alta + Media + Baixa	37,2 Milhoes	3,09 Milhoes	24,4 Milhoes	40,3 Milhoes	64,7 Milhoes


AMBIENTE
TERRA
ALIMENTO
ENERGIA