OAK RIDGE NATIONAL LABORATORY

GSB - LACAF

BIOEN FAPESP

GSB Workshop

12 – 13 June 2013

NUTRITIONAL REQUIREMENTS FOR SUSTAINABLE BIOFUEL PRODUCTION

IAC INSTITUTO AGRONÔMICO 125 anos

Heitor Cantarella

BIOFUEL: Plant Nutrition & Sustainability

- Issues of interest
  - Nutrient supply
  - Nutrient use efficiency
  - Long term soil preservation

Nutrient Supply

- Nutrient requirement & Availability at Regional and World Scale
  - Food vs Fuel
  - Cost of fertilizers as demand increases (large biofuel production scenario)
  - Is nutrient supply a constraint?

Fertilizer supply & Food security:

P Plateau theory

Phosphate peak theory has been rejected by the fertilizer industry

The story of phosphorus: Global food security and food for thought

Dana Cordell [a,b,*], Jan-Olof Drangert [a], Stuart White [b]

Global Environmental Change 19 (2009) 292–305

Contents lists available at ScienceDirect

Global Environmental Change

Nutrient Use Efficiency:
Sustainable Biofuel

- Sustainability requirements for biofuels are more rigorous than for food production
- Environmental Aspects
  - Energy balance and GHGs
  - Pollution because of excess nutrient (in certain ecosystems)
  - Efficient use (biomass-energy/unit nutrient)
    - Recycling
      - Choice of crops
      - Management options

Sustainability & Biofuel

On the ground of sustainability issues, the feasibility of large-scale biofuel production has been questioned recently in Europe and North America

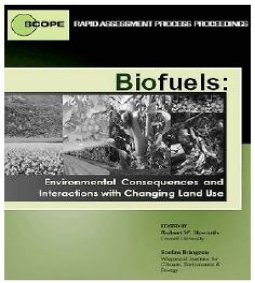
*Land availability/ILUC
*Food X Fuel
*LCA: energy & environmental balances

Renewable Fuel Standard

2011

POTENTIAL ECONOMIC AND ENVIRONMENTAL EFFECTS OF

U.S. Biofuel Policy



Biofuels: Environmental Consequences and Interactions with Changing Land Use

Leopoldina
Nationale Akademie der Wissenschaften

2012

Statement

Bioenergy – Chances and Limits

N Fertilizer, GHG, and Energy Balance (Example of Sugarcane)

- High energy consumption in manufacture (53 MJ/kg N; 1,400 m^3/t NH_3) and high environmental impact due to N_2O emission in the field
  - 3.2 + 5.1 = 8.3 kg CO_2eq/kg N

- N fertilizer & Energy or GHGs balance in sugarcane
  - 25% of whole field energy (Boddey et al. 2008)
  - 30% of C emission agric: 23% total emissions (Galdos et al. 2010)
  - 40% of total GHG emission (Lisboa et al. 2011)

Environmental problems:

need to increase nutrient use efficiency

Our Nutrient World

The challenge to produce more food and energy with less pollution

Sutton et al, 2013

Target for 2020: increase full chain nutrient use efficiency by 20%: savings of 20 Mt Nr.

nature geoscience
ARTICLES
PUBLISHED ONLINE: 30 AUGUST 2009 | DOI: 10.1038/NGEO608

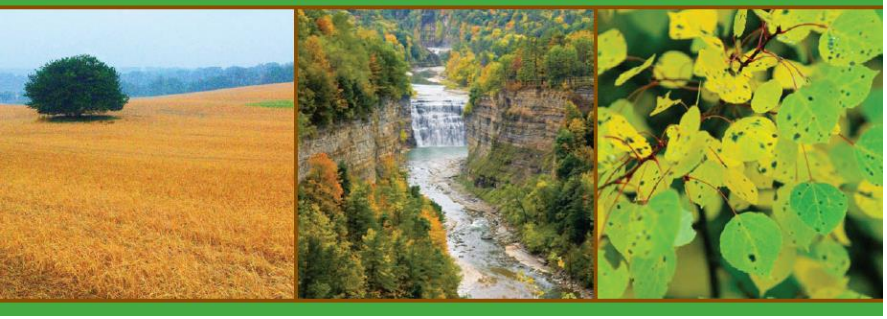
The contribution of manure and fertilizer nitrogen to atmospheric nitrous oxide since 1860

Eric A. Davidson

2011

Reactive Nitrogen in the United States: An Analysis of Inputs, Flows, Consequences, and Management Options

A REPORT OF THE EPA SCIENCE ADVISORY BOARD



- -20% (1 Mt N/yr) flow of N_R to surface waters and oceans
  - 25% increase in N uptake by crops
  - -20% use of artificial N_R (fertilizer N) in agriculture (2.4 Mt N/yr) without yield reduction

Suitable bioenergy crop

- **Successful crop: cost-competitive & environmentally sound replacement for fossil fuel**
  - **High yields**
  - **Relatively low nutrient use (recycling is part of this)**
  - **Good environmental indicators**

How different crops use nutrients to produce energy?

- Biomass/energy yield efficiency
- Easiness of recycling nutrients
  - Topography may be an important constraint
    - Crops that can be cultivated in irregular landscapes
  - Nutrient use efficiency of biofuel production: Crops
    - Annual crops (maize)
    - Temperate grasses (miscanthus)
    - Semi-perennial crop (sugarcane)
    - Tropical trees (eucalyptus)
    - Temperate trees

Estimate fertilizers used for biofuel crops

(Million t N, P_2O_5, K_2O): Data from BR and USA are for ethanol

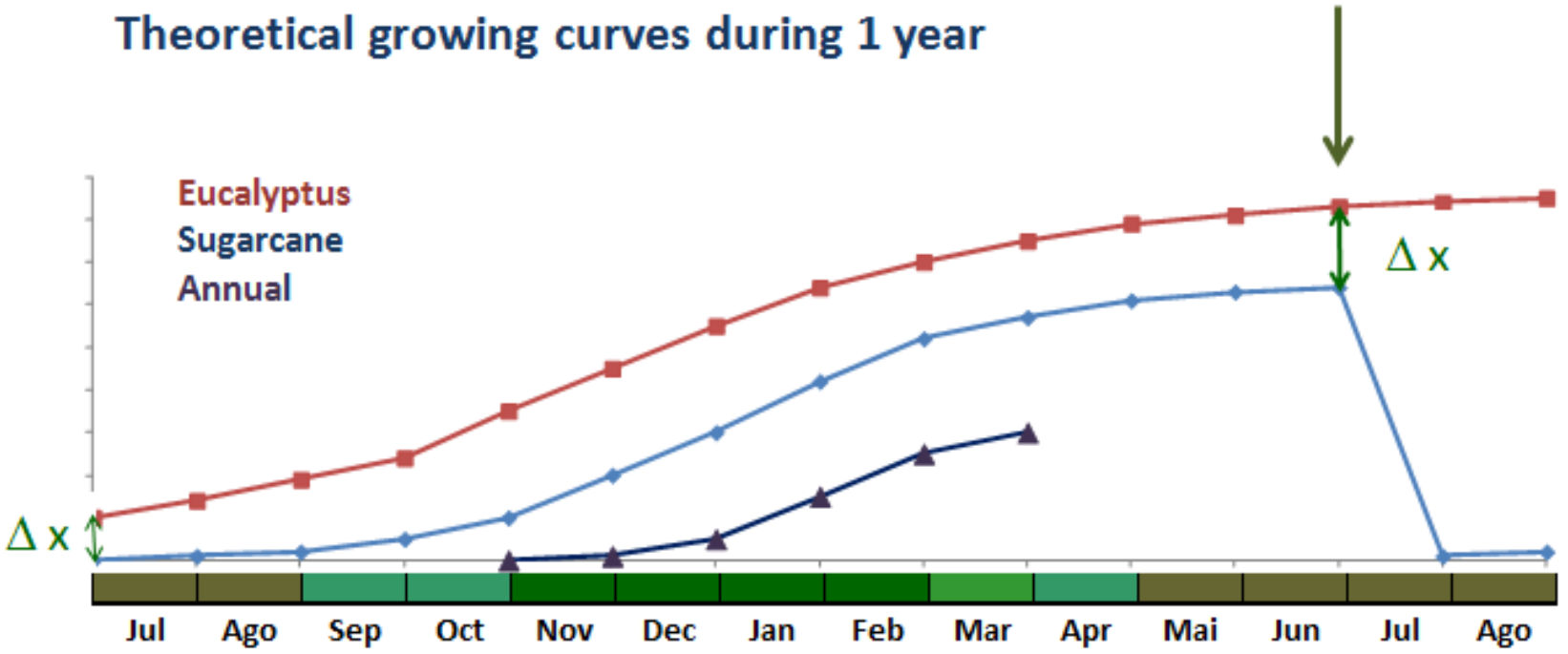
Fertilizer consumption	World	Brazil (Cane)	USA (Corn)
N	2,1	0,32	1,57
P_2O_5	0,8	0,16	0,58
K_2O	1,2	0,43	0,65
Total	**4,1**	**0,91**	**2,80**
Ethanol Production (billion L)		22,5	24,7

Biofuel in the world: 2.4 % of NPK

Sugarcane in Brazil: 13 to 17% of NPK consumption

Source: Heffer & Prud'homme. IFA 2008

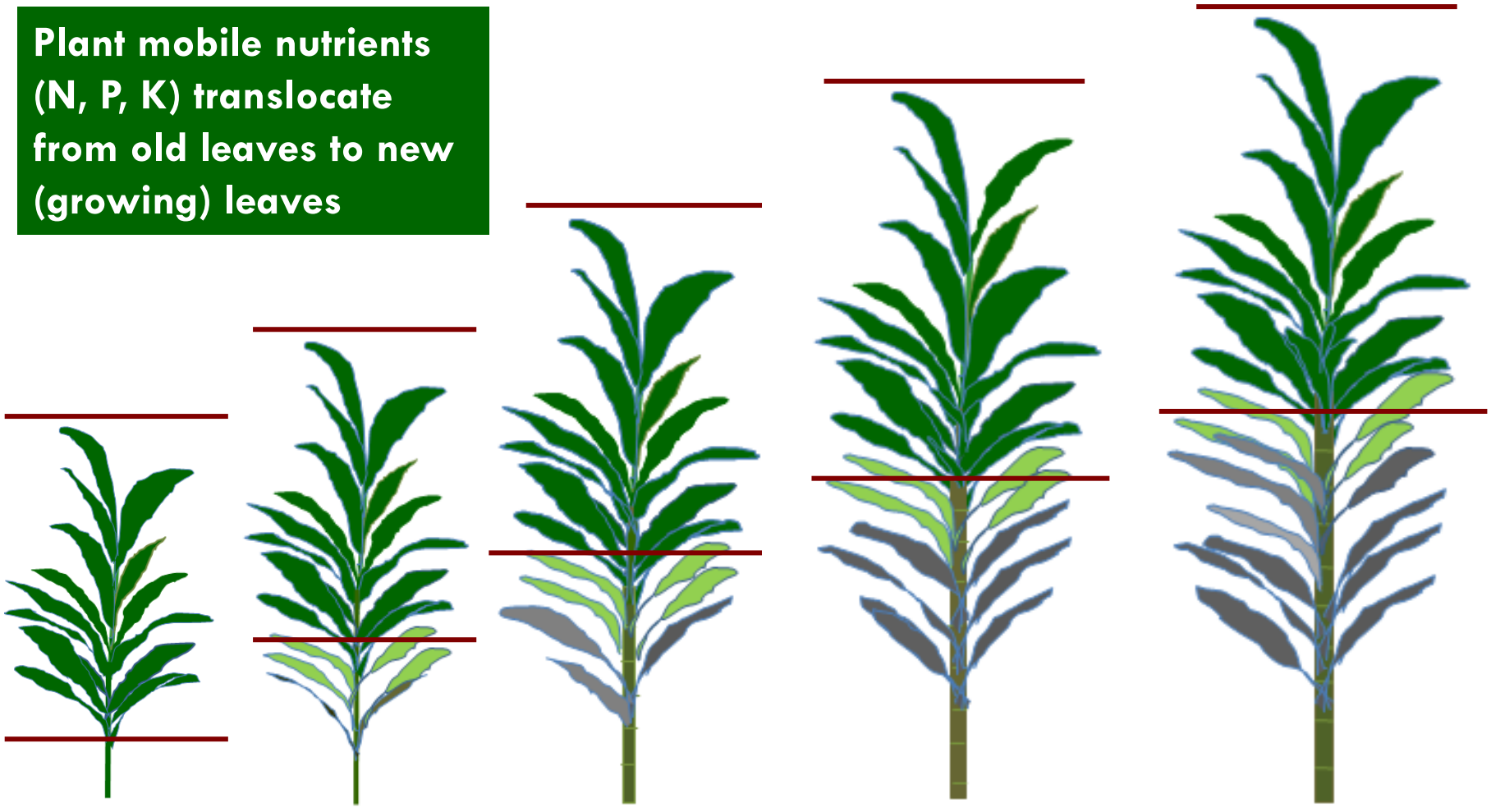
Biomass production:
plants with different growing cycles



Nutrient requirements are not proportional to biomass production

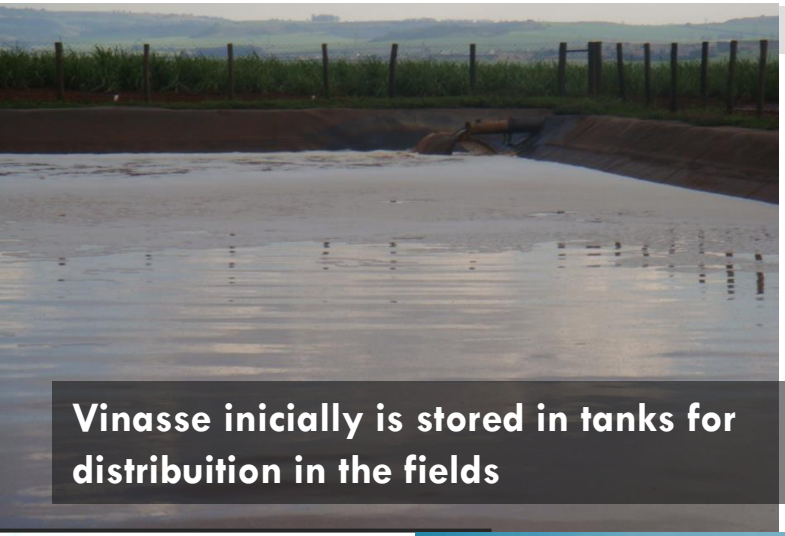
Photosynthetically active plant parts remain approximately constant

Plant mobile nutrients (N, P, K) translocate from old leaves to new (growing) leaves



Long-cycle crops: green area increases up to a point

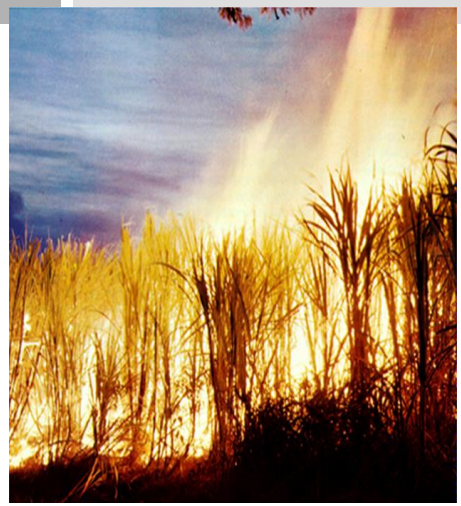
Recycling of By-Products & Nutrients



Vinasse inicially is stored in tanks for distribuition in the fields

Impermeable channels or pipelines are used in flat areas.
Pumping stations help distribute vinasse to far away fields

Traditional burn-and-cut is being replaced by green cane (mechanical harvest)



Preserve Soil Quality

Necessary to maintain yield
Environmental services/biodiversity

- **Soil quality (chemical, physical, biological):**
  - **Replenish nutrients (fertilizer application, recycling)**
  - **Maintain or return (some) organic C**
    - **But C is a source of energy: how much plant residues should be left behind?**
      - **This is an open question in Brazil (and elsewhere where energy crops are grown)**

Trash removal for energy production vs nutrient cycling and soil preservation

- Farmers in several regions are already removing sugarcane trash to produce bioelectricity
  - R$ 70.00 – 90.00/t = (US$35 to 45/t)
  - Extra income

Issues to be addressed

- Investigate nutrient use efficiency (nutrient/biomass or nutrient/energy) of important biofuel feedstock
  - Compare important biofuel feedstock
  - Derive indicators for helping to choose more sustainable crops/management options
- Investigate nutrient recycling opportunities of various feedstocks
- Get the numbers right


Thank you
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