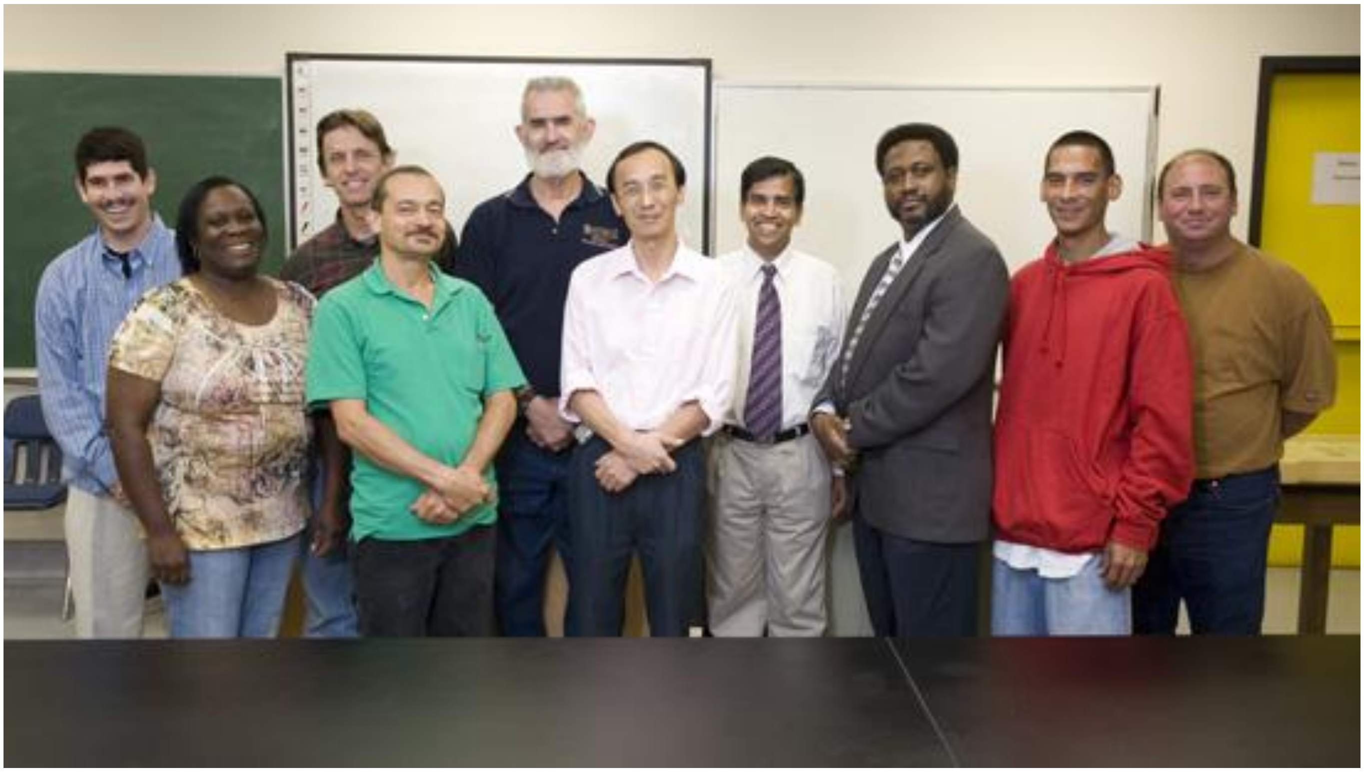


CANE FARMING

AOM 1261

SUGAR TECHNOLOGY PROGRAM

PALM BEACH COMMUNITY COLLEGE

GLADES CAMPUS

BELLE GLADE, FL 33430

S. CHANDRAMOHAN

FALL 2008

CHAPTERS

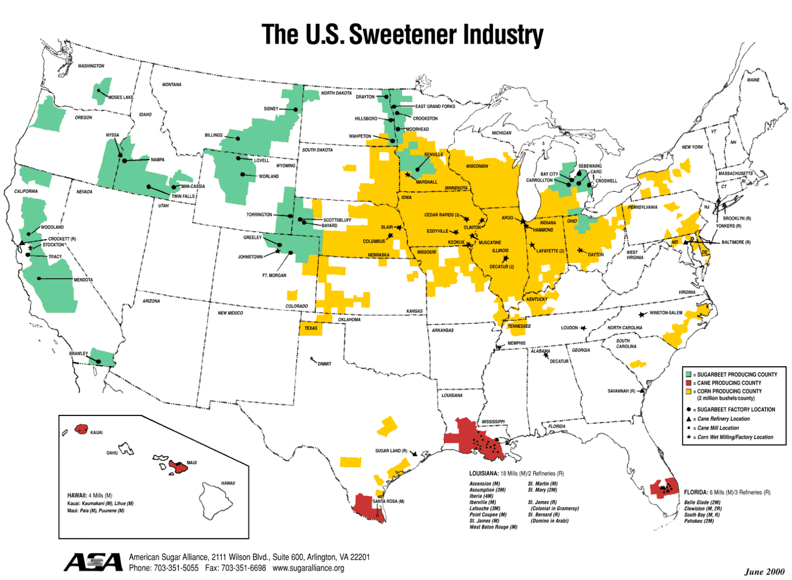
The Origin of Sugarcane

- Sugarcane is a <u>giant tropical C_4 grass</u>.
  - ➢ Originated in <u>southeast Asia</u> during the Cretaceous epoch (> 65 million years ago).
    - o Primitive man selected the sweetest, softest, and thickest canes for chewing.
      - ▪ Preferred "varieties" became dependent on human cultivation.
        - • From these activities, the species *Saccharum officinarum* was ultimately developed (likely in New Guinea).

- Sugarcane was distributed to other continents through trading activities.
  - ➢ Sugarcane arrived to the New World during a Columbus voyage to Hispaniola (1493).
    - o The first artificial cane hybrid was produced in <u>1708</u>.
      - ▪ The ability to produce consistent hybrids was discovered in the <u>1880s</u>.
        - • Modern cultivars are interspecific hybrids mostly originating from *Saccharum officinarum* and *Saccharum spontaneum* (wild type).

- 100 lbs of fresh sugarcane yields:
  - ▶ <u>75 lbs</u> of water (about 9 gallons)
  - ▶ <u>11 lbs</u> of fiber (used for fuel in the mill)
  - ▶ <u>11 lbs</u> of raw sugar
  - ▶ <u>3 lbs</u> of molasses (about 1 quart)

- Sugarcane is a ratoon crop:
  - ▶ After a harvest, the plant re-grows from the stubble and makes a new crop
  - ▶ This process can produce a number of annual crops before re-planting is required
  - ▶ The average for Florida: 4 annual crops



Sugarcane is grown in over 380,000 acres. As of 2000-2001 harvest season, the area harvested was 465,000 acres in the Everglades Agricultural Area (EAA) in South Florida. The average yield at nearly 38 tonnes/acre (total of 17,534,270 tonnes) valued at \$555,836,359 or \$1,195 per acre. (Total Ag production in EAA \$759,874,239 or \$1,441 per acre).

Sugar Cane Breeding

- Primary means for controlling diseases
- Developing varieties adapted to a wide variety of environmental conditions (cold, low nutrient and low OM sand soils)
- <u>Focus on increasing sugar production (lbs sugar per acre)</u>
- Improved cultivars require lower inputs to grow the crop
- USDA-ARS Sugarcane Field Station (Canal Point) was set up in 1920s to produce seed cane for the Louisiana industry

<u>Procedure:</u>

Male and female flowers present on the plant. Males protected in a greenhouse at night. Crosses are arranged with male pollen-producing tassels raised above females. Cross is maintained for 7 days. Seed mature in about 1 month. SeedS are collected, tested for germination, weighed and stored

Year 1: 400-600 crosses produce ≈ 500,000 seeds
Year 2: 80,000 to 100,000 seedlings are transplanted
Year 3-10: Agronomic/disease evaluations, rapid “thinning out”
Year 11: Six or fewer clones remain..average of 1 cultivar release/year

Seed Cane Cutting

Seed can be cut by hand or machine
Each man cuts about 600 feet of sugarcane on two rows (1,200 linear feet) per day

Furrowing for Planting

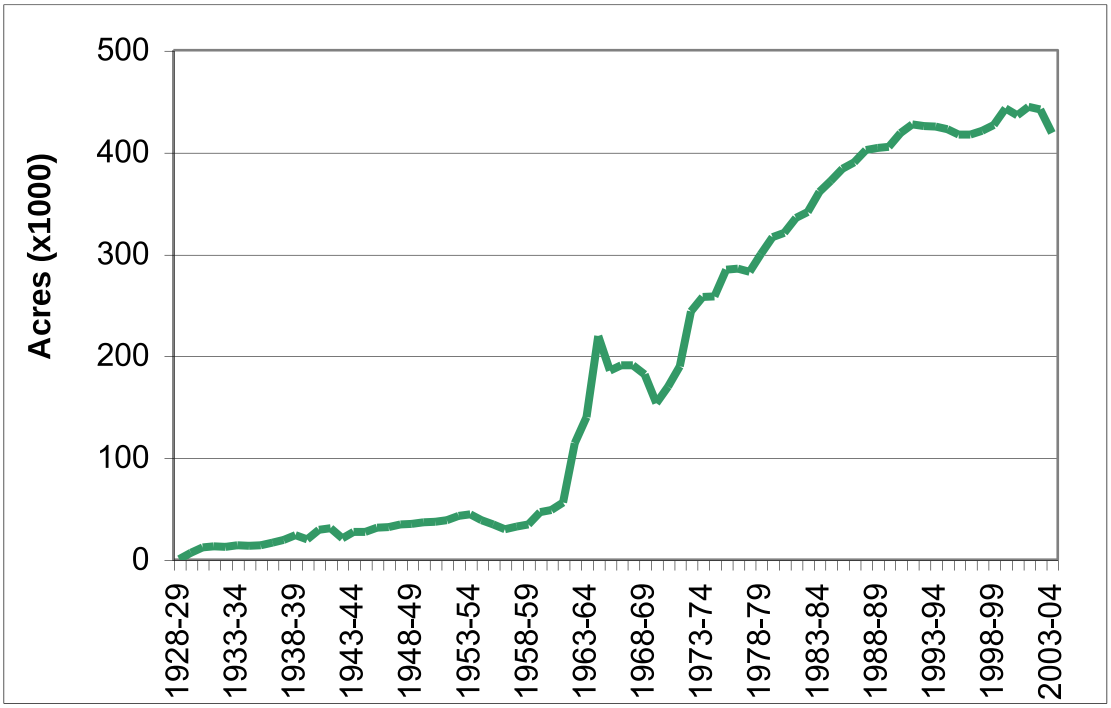
3 or 5 furrows made in one pass; Furrows are 4 to 6 inches deep
Fertilizer is applied, banding reduces fertilizer use.
Whole stalk seed cane is loaded on wagons using a “Grab Loader”
An 8-man crew plants about 40 acres per day
With hand planting, it takes about 4 tons of seed cane to plant 1 acre
Whole sugarcane stalks are dropped in furrows in double-row density
Hand-cut with machetes into smaller (≈ 5-eyes) pieces

Machine Planting Sugarcane

Seed cane billets are loaded on a mechanical planter, laid in the furrows and covered with soil.
Machine planting requires more seed cane, up to 8-10 tons of seed cane to plant 1 acre
After planting, the cane pieces (setts) in the furrows are covered with the soil.

After planting, the sugarcane crop grows steadily for 12 to 15 months before harvesting
Planting season:Sep thru Dec
Harvest season:Oct thru mid-Apr

Percent of Florida sugarcane acreage by plant age:
88% of sugarcane is 3 years old or less (Plant cane (Year 1), 1st ratoon (Year 2), 2nd ratoon (Year 3). Less than 10% is 4-5 years old (3rd and 4th ratoons).



Florida Sugarcane Production History

Variety	2000	2007
CP 89-2143	1.2	29.8
CP 88-1762	4.1	20.4
CP 80-1743	22.1	19.9
CP 78-1628	9.3	12.4
CP 84-1198	3.8	3.9
CP 72-2086	14.2	3.5
Other	45.4	10.1

Glaz, 2008. Sugarcane Variety Census Florida 2007. Sugar Journal, July 2008 www.sugarjournal.com

Total planted area (organic + sand soils) approx. 380,000 acres

Variety	Organic Soils		Sand soils	
	acres	%	acres	%
CP 89-2143	104,067	34.1	9,804	12.9
CP 88-1762	72,178	23.7	5,750	7.6
CP 80-1743	68,001	22.3	8,042	10.6
CP 78-1628	18,203	6.0	28,848	38.0
CP 84-1198	7,638	2.5	7,275	9.6
CP 72-2086	12,843	4.2	328	0.4
All others	21,972	7.2	15,876	20.9
Totals	304,902	100.0	75,923	100.0

Glaz, 2008. Sugarcane Variety Census Florida 2007. Sugar Journal, July 2008 www.sugarjournal.com

Nutrient	lbs/acre	Soil
N	110 – 180	Sand only
P_2O_5	40 – 75	Sand & organic
K_20	150 – 250	Sand & organic
Mg	6	Sand only
Cu	2	Sand & organic
Zn	2	Sand & organic
B	1	Sand & organic
Mn	2.5 – 5	If soil pH > 6.0
Silica slag	1 to 3 tons	Sand & organic

- Florida: With no weed control, sugarcane losses to Fall Panicum would be 50%
- In 2000, over $51 million was spent for weed control in US sugarcane
- Mechanical cultivation is a common practice:
- Weed control
- Increased tillering
- Florida has good herbicides
- <u>Time of application</u> is most important

- Herbicides used:
    - Atrazine
    - 2,4-D
    - Ametryne (Evik)
    - Sulfanilylcarbamate (Asulam)
    - Glyphosate (Roundup)
    - Metribuzin (Sencor)
    - Pendamethalin (Prowl)
    - Trifloxysulfuron (Envoke)
    - Hexazinon +diuron (Dupont K4)

Sugarcane Pathogens

- Sugarcane Rust
- Sugarcane Brown Rust
- <u>Discovered: March 1979</u>
- Early Spring (Feb - May) problem
- Cooler temperatures
- Drier, low rainfall conditions

Sugarcane Orange Rust

- <u>Discovered: July 2007</u>
- Mid-to late (Jun – Sep) summer
- Hot to very hot temperatures
- Hot, rainy, humid conditions

Major Insects

- Wireworm (click beetle) (*Melanotus communis*)
- Soil insecticides control larval stage (the worm)
- Thimet: apply 14 - 19 lb/acre
- Mocap: apply 10 – 19 lb/acre
- Damages newly planted sugarcane, buds and young shoots die, stalk population declines
- Injury to young shoots allows fungus (sugarcane red rot disease)
- Flooding fields provides control

Yellow Sugarcane Aphid (*Sipha flava*)

- Adult can produce > 100 eggs in 3 weeks
- Hatched nymphs feed for several weeks
- Leaves turn yellow, die
- Reduced tillers, young shoots damaged, stalk diameter declines, yield loss
- Sooty molds develop
- Transmits sugarcane mosaic virus

Lesser Cornstalk Borer

- Early-season damage to young shoots
- More problems in dry weather
- Once the borer gets inside the shoot, control options very difficult
- Must control the adult
- Adults deposit eggs on young shoots near the soil
- Larvae hatch in 3 to 18 days
- Eat hole into the soft young sugarcane tissue about 1 inch below soil surface
- Make feeding tunnels inside shoot, which kills the shoot.

Sugarcane White Grub (*Ligyrus subtropicus*)

- Adult = hard-shelled, black beetle, most active in late May/June
- Final instar (large grub) lives 8 to 9 months, feeds on sugarcane roots
- Mature grubs are 1 to 2 inches long
- Leaf yellowing (chlorosis)
- Stunted growth, lodging, plant uprooting and death
- Damage more severe in ratoon crops
- Re-planting may be necessary
- No insecticides are labeled for grub
- Flooding (2-inch deep) fields (in August) for 1-week will kill the grub

Sugarcane Burning/Harvest

Farmer must get permission from Forestry Department to burn a sugarcane field
Burn permits issued daily by zone
If wind is wrong (or road is nearby) … no burn permit

Green Cane Harvest

Objective: Compare different sugarcane harvest management strategies
- Burning sugarcane (traditional)
- Green harvest
- Rake trash mulch
- Disk (cut) trash mulch
- Time of harvest
- Early - warm wet November
- Late - cool dry February
- Compare soil temperatures, insect/weeds, sugarcane shoot growth and yields on both organic and sand soils

- Each harvester cuts about 50 tons per hour
- 1 to 1.5 acres per hour
- Cane is loaded into field wagons
- Field wagons transfer cane into over-the-road trucks or rail cars
- Each harvest unit (4 to 5 harvesters) cuts about 2,200 tons per day

Loading Cane

- Cane is loaded into trucks or rail cars via conveyor or dump wagons

Cane Delivery

- Cane is delivered to the mill in trucks or by rail
- Truck trailers carry ≈ 20 tons per load
- Railcars carry ≈ 40 tons per load

- At the mill, each truck trailers or railroad car dumps cane ≈ every 2 minutes for a milling tandem
- Each truck trailer delivers about 10 loads per day (≈ 200 tons/day) to the mill

Cane Milling

- Cane is carried by conveyor through sets of knives
- Chopped cane is passed through sets of mills in a tandem (crushed)
- There are 6-7 mills in a milling tandem
- Each mill presses cane with a force of about 5 tons of pressure
- About 98% of the sugar in the cane is extracted

Making Sugar

- Juice is heated
- Impurities removed (limed to take soil out)
- "Clarified" juice is boiled to remove water
- Concentrated syrup is "seeded" (powdered sugar) to begin crystal formation
- Crystals are grown
- Molasses is separated centrifugally (like washing machine rinse cycle)
- Molasses is re-processed to extract more sugar

Florida Sugar Statistics

<u>Daily</u> Milling Capacity (metric tons sugarcane/24 hours)

Glades Sugar House	25,000
Okeelanta Corporation	26,000
Osceola Mill	16,800
U.S. Sugar	<u>42,000</u>

Florida 24-hour total ---à 109,800 tons/day

<u>2007 – 2008 Season Florida Sugar Production</u>

14.55 million tons sugarcane milled from 380,000 acres
1.61 million tons of 96-pol sugar
Average sugarcane yield = 35 to 37 tons / acre

Florida produces 49% of USA sugar from sugarcane
25% of USA sugar supply

Websites

University of Florida Sugar Handbook (electronic)
http://edis.ifas.ufl.edu/TOPIC_BOOK_Sugarcane_Handbook

USDA Sugarcane Breeding Station
http://www.ars.usda.gov/Main/site_main.htm?modecode=66-25-00-00
United States Sugar Corporation http://www.ussugar.com/
Florida Crystals Corporation http://www.floridacrystals.com/
Sugar Cane Growers Cooperative http://www.scgc.org/
American Society of Sugar Cane Technologists http://www.assct.org/

BREEDING - Dr. Comstock

The objectives of breeding program are to:

- Develop cultivars adapted to local conditions
- Increase yield
  - More cane tonnage, High sucrose content
- Eliminate reliance on importing foreign cultivars
- Increase cultivar diversity
- Better cold tolerance
- Better disease resistance

Screening for disease resistance:

Screen clones in program

- As early as possible
  - Influenced by % susceptibility
  - Ease of screening
- Concentrate on major diseases
  - Leaf scald, smut, mosaic, ratoon stunt, rusts
- Develop better methodology
  - More precise, More efficient

Major Diseases that affect Cane in Florida:

- Challenges In Disease Control
  - Introduction of new pathogens
    - Brown rust 1970s; Smut 1970s; Orange rust 2007
  - Pathogenic changes
  - Brown rust different races; No screening methods for Yellow leaf virus

Needs of a successful breeding program:

- Quality Germplasm
  - Quarantine
- Knowledgeable staff
  - Breeders, pathologists, agronomists
  - Support staff
- Cooperation between research and growers
- Scientific quality
- Economic efficiency of program
  - Optimum balance between resources and outcome
- Program success

Breeding at Canal Point, FL:

Program Mission: To develop high-yielding, disease and stress-tolerant sugarcane cultivars, and also development new breeding, pathology, soil, crop, and water management technologies that result in improved production efficiency and soil conservation.

- Produces “fuzz” for FL, LA and TX programs
- Provides “hands on training” for visiting scientists
- CP-cultivars % acreage in Florida
  - 1970 14%
  - 2000 83%
  - 2005 91%
  - 2007 over 98%
- CP-cultivars grown in other countries
  - Guatemala over 80 % of acreage; Nicaragua over 90% of acreage; Costa Rica approx. 40% of acreage

- Cooperating Agencies:
  - USDA-ARS Sugarcane Field Station, University of Florida, EREC and Florida Sugar Cane League

Importance of CP Cultivars:

- 2 Billion dollar economic impact in Florida
- Thousands of jobs in Florida
- Used in many breeding programs
- Florida produces 20% of sugar consumed in US
- Florida cane production 38.3 tons/acre 2003/4
- Florida sugar production 4.38 tons/acre 2003/4

Resources available at Canal Point, FL:

- Six Scientists
- 28 Support Staff and other Employees
- $ 2,850,590 Federal Appropriation
- $ 400,000 Florida Industry Support (7 employees); $ 20,000 American Sugar Cane League
- Research Cooperators
  - University
  - Industry
  - Buildings
  - Laboratory, Admin, Shop, Crossing house, Photoperiod house, Mill house, and Green houses
  - Equipment: Farm implements, Laboratory equipment
  - Land: 10.5 acres federally owned; 113 acres leased

Steps in Cultivar Development:

- Parental selection
  - Flowering characteristics
  - Parental traits
  - Success of progeny
- Crossing
  - For introgression of traits
  - For potential commercial cultivars
  - Recurrent selection: Introduction of superior clones back into program

Desirable Traits for Selection of Clones:

- Based on either individual or family
- Yield (cane tonnage and sucrose content)
- Growth type; Harvesting and milling ability

- Disease resistance

Seedcane increase:

- Each stage of program increases seedcane
- During Stage IV promising clones increased
  - Initial increase as clones are tested in first ratoon
  - Secondary increase as clones are tested in second ratoon
- After released increased by grower

Stage	**No. of clones**	**Disease testing**
Seedling	75-100,000 Single stools	Natural infection Discard infected
Stage I	10-15,000 Single stools	Natural infection Discard infected
Stage II	1,500-17,500 Single plots	Eye spot and ratoon stunt – inoc. Natural infection Discard infected

Sugarcane Yield estimates:

- **Stage II Plant crop:**
  - Total stalks per plot
  - Harvest 10 stalk bundles

- Bundle weight
- Juice samples-sugar content

– Stage II-1700 plots; 1000 samples harvested and milled

- **Stage III**

– Plant crop: 135 plots X 2 reps X 4 locations, equals 1080 harvested and milled samples

– Ratoon crop: 40 plots X 2 reps X 4 locations, equals 320 harvested and milled samples

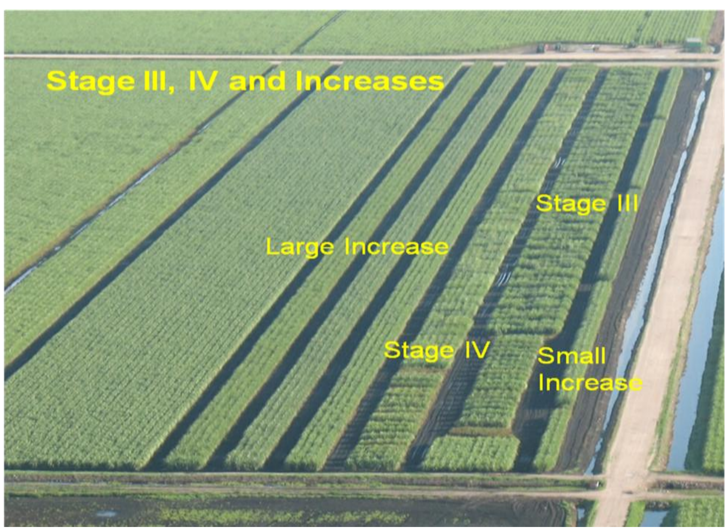
- **Stage IV**

– Plant crop: 16 plots X 6 reps X 9 locations,

equals 864 harvested and milled samples

– First ratoon crop: 16 plots X 6 reps X 9 locations, equals 864 harvested and milled samples

– Second ratoon crop: 16 plots X 6 reps X 9 locations, equals 864 harvested and milled samples



– **Disease Screening**

– Eye spot: Stage II inoc.

- Ratoon stunt: Stages II, III, III incease and IV, inoc.
- Mosaic: Stage III increase and Stage IV inoc.
- Leaf scald: Stage III increase and Stage IV inoc.
- Smut: Stage III increase and Stage IV inoc.
- Rusts
  - Brown
    - Stage II, III and IV
      - Natural infection
      - Inoculated
  - Orange
    - Stage II, III and IV
      - Natural infection
      - Inoculated

- **Naming of Sugarcane Cultivars**
- Examples: CP 80-1743, LCP 85-384, ISACP 00-1000
- Letters abbreviations for place of selection and crossing; in this order
- Abbreviation of year named

Program Summary:

- Number of selection
- 11 plus years of testing
- Usually 1 clones per year
- 1 of 4-to 6 released clones become commercial
- Adapted to Florida and other countries

Impact of CP Breeding Program in Florida:

- Continual increase in sugar production
- About 1 cultivar per year
- Increased diversity
- 2 Billion dollar economic impact in Florida
- Florida produces about 20 % of the sugar consumed in Florida

International Impact:

- Around 1970 CP 72-2086 introduced
- Production more than doubled
  - Increased yields per area
  - Increased area of production
- Revitalized Guatemalan Sugar Industry; More jobs created; High economic impact; Cengicaña (Guatemalan Sugarcane Research Institute) created

PHYSIOLOGY - Glaz

Objectives:

- Learn about the need for restoration of the Everglades ecosystem.
- Learn about Best Management Practices that contribute to Everglades restoration plans.
- Learn about research to improve sugarcane yields exposed to Best Management Practices.

Research Areas:

Agronomy, Plant Genetics, Plant Physiology, Plant Morphology, Plant Nutrition

- **Photosynthesis**
- $6CO_2 + 6H_2O$ + Energy + (in the presence of chlorophyll) >>>> $C_6H_{12}O_6 + 6O_2$
- Photosynthesis is how plants use light and water to make sugar. Sugar is created in the green parts of a plant and every animal on earth depends on it. Without plants we would have no food to eat or oxygen to breath.
- Photosynthesis is the process in which carbon dioxide (CO_2) and water (H_2O) are used to produce carbohydrates ($C_6H_{12}O_6$) and evolve oxygen (O_2) in the presence of light and chlorophyll.
- The net result of photosynthesis is that light energy (radiant energy) is converted into chemical energy in the form of fixed carbon compounds (carbohydrates such as $C_6H_{12}O_6$).

- **Respiration**
- $C_6H_{12}O_6 + 6O_2$ >>>> $6CO_2 + 6H_2O$ + Energy
- What occurs during respiration?
- Respiration (in plants or animals) releases the stored energy that was produced by photosynthesis, and it also releases CO_2 and H_2O.

- **Indicators of Ecosystem Problems**
  - 90-95% reduction in wading bird populations.
  - 60 threatened or endangered plant and animal species.
  - 1.7 billion gallons of water per day lost by discharge to ocean; water shortages/salt water intrusion.
  - 1 million acres have health advisory for mercury contamination.
  - Over 1.5 million acres infested with invasive species
  - Declining populations of fish species in St. Lucie and Caloosahatchee estuaries and Biscayne and Florida Bays.
  - Defoliation of sea grasses, fish kills, and deformed fish in St. Lucie estuary.

        - Reduction in number of birds initiating breeding;

The Original Everglades Ecosystem – A River of Grass

- Water connected the system, from top to bottom
- 9 million acres of wetlands providing a variety of habitat
- Diverse mosaic of landscapes and seascapes
- Natural hydrology was flood 9-11 months per year
- Diversion of water flow for agricultural purposes has affected the ecosystem that existed
- Hydrologic restoration is a necessary starting point for ecological restoration

Impacts on Sugarcane

- Best management practices (BMPs) to improve water quality
    - Primary issue is **phosphorus**
- Key BMP Principles
    - After heavy rains, allow water levels to drop more by evapotranspiration and seepage and less by pumping water to public canals.
    - If you must pump, reduce pumping rate.
    - A third principle of BMPs is to control soil subsidence as much as possible.
- Fortunate Consequence of BMPs
    - Less pumping and reduced pumping rates also contribute to better ability to reproduce timings, distributions, and quantities of water flow through EAA.
- Unfortunate Consequence of BMPs
    - Sugarcane is subjected to more periodic flooding and higher water tables than farmers prefer.
    - Another key farming and ecological issue is **soil subsidence**
- How do EAA Soils Differ from most other Soils?
    - They are highly organic, originally more than 85%.
    - Most of world’s soils are mineral.
    - Sawgrass
        - Over 5,000 years, primarily sawgrass roots decomposed into the EAA soils.

- How did soils form during 5000 years?
    - Under these anaerobic conditions, (Remember O_2? and that respiration needs it?), photosynthesis was greater than respiration just enough so that an average of 0.03 inches of soil formed per year.
- What happened when humans began farming in the EAA about 100 years ago?
    - We drained the soils so that O_2 was now usually available in the soil.
    - Instead of forming 0.03 inches of soil per year, about 1 inch was lost per year.
- What happened to this soil?

    $6CO_2 + 6H_2O$ + Energy ® $C_6H_{12}O_6 + 6O_2$

    $C_6H_{12}O_6 + 6O_2$ ® $6CO_2 + 6H_2O$ + Energy

    Soils formed during 5000 years of photosynthesis were losing depth due to increased rates of respiration

    Soils were becoming air (CO_2) and water (H_2O)

    Note also that there is substantial carbon evolution due to this change in balance between photosynthesis and respiration.
- Getting back to BMPs
    - Another fortunate consequence of BMPs to reduce phosphorus discharge to the Everglades was that they resulted in less soil loss.
    - Now rate of loss is 0.56 inches per year instead of 1 inch per year.

- Sugarcane Helps Conserve Soil
    - Jake Stephens 1951first reported it as data in a table but did not elaborate on it.
    - Tony Shih showed that one reason was reduced soil temperature under sugarcane compared with other crops.
    - Dolen Morris showed that compared to other crops, the root biomass of sugarcane was much greater.

- **Review**
  - What are some reasons that Federal, State, and local governments wanted to restore the Everglades ?
    - Increased numbers of threatened and endangered plant and animal species.
    - Loss of water resulting in water shortages.
    - Mercury contamination.
    - Invasive species.

Regarding hydrologic restoration of the Everglades, getting the water right refers to what four characteristics of water flow?

Quality, Quantity, Timing, Distribution

What is a negative consequence on sugarcane growers of efforts to restore the Everglades ?

- BMPs to reduce P discharge from the EAA to the natural Everglades have resulted in higher water tables and more periodic flooding than is optimal for sugarcane.

Agricultural Research to Support Sugarcane as Ecosystem Restoration Continues:

Agronomic Research to Improve Yields of Sugarcane Subjected to High Water Tables and Floods that Result from Best Management Practices

- Identify effects of BMP-related water management on yields.
- Improve yields and profits under BMP-related water management.

DISEASES – Dr. Comstock

- **Types of Pathogens and Diseases caused**
  - Fungal: Smut, Rusts
  - Bacterial: Leaf Scald
  - Viral: Mosaic
  - Phytoplasma: White leaf

- **Disease Control Principles**
  - Quarantine, Disease Resistance, Heat Therapy, Phyto-sansitation, Cultural Practices
  - Chemical Control

- **Disease Diagnosis**
  - Symptoms
  - Pathogen Observation
  - Diagnostic Assays
    - Serology
    - PCR
    - RT-PCR

- **Major Diseases**
  - Smut
    - Brown Rust
      - Orange Rust
        - Leaf Scald
          - Mosaic
            - Yellow leaf
              - Ratoon Stunt

- **Sugarcane Smut**
  - Ustilago scitaminea
  - “Whip-like” sorus
  - Grassy stalks
  - Found in most countries
  - Causes economic losses
  - Favored by hot-dry weather
  - Less problem in wet areas

- **Smut Control**
  - Primarily resistant cultivars
  - Resistant varieties
    - % stools infected
    - % “whips
    - Severity of sympoms
    - Resistance Evaluation
    - Dip inoculation
    - Natural infection
- Cultural practices
- Limit ratoons
- Plant in wet areas
- Clean seedcane
- Rouging infected plants
- Heat Therapy at 52 C for 30-45 minutes

- **Sugarcane Rusts**

General Facts

- Leaf symptom only, not systemic
- Spores wind blown
- Short life cycle
- Needs leaf dew during infection
- Causes yield losses on susceptible clones
- Control with resistant varieties
- Brown Rust, Pathogen: ***Puccinia melanocephala***
  - 1978 in western hemisphere
  - World-wide distribution
  - Major pathogen
  - Brown spores
  - Favored by cooler temperatures
- Orange Rust, Pathogen: ***Puccinia kuehnii***
  - 2007 in western hemisphere
  - Previously minor pathogen
  - Q 124 major losses
  - Orange spores
  - Favored by warmer temperatures
- **Cultivars with Orange Rust**
  - CP 80-1743, 20 % acreage in Florida
  - CP72-2086, Major variety in many countries; infected in Guatemala
  - SP 79-2233 Costa Rica; orange rust

- **Cultivars with Orange Rust**

- CP 80-1743, 20 % acreage in Florida
- CP72-2086, Major variety in many countries; infected in Guatemala
- SP 79-2233 Costa Rica; orange rust
- Rust control
    - Resistant varieties
    - Screening program in development program
    - Response to outbreaks
    - Fungicidal control

- **Leaf Scald**
    - *Xanthomonas albilineans*
    - Wide distribution
    - Seedcane transmitted
    - Wind blown
    - Mechanical transmitted with knives
    - Causes yield losses
    - **Leaf Scald Control**
        - Resistant varieties
        - Clean seedcane program
        - Heat therapy (2h 50 C)
        - Disinfesting Knives
- **Ratoon Stunt (10.4-11.8% Yield Loss)**
    - Economically important
    - Wide distribution
    - Resistance available
    - *Leifsonia xyli* subsp. *Xyli*
    - No good symptoms
    - Spread mechanically

- **Ratoon Stunt Control**
    - Thermal treatment of seedcane
    - Heat Therapy and Sanitation
      (Traditional Control Method)
        - Advantages
            - Eliminates pathogen from seedcane
            - Part of a broader IPM system
        - Disadvantages
            - Sanitation difficult to maintain
            - Locked into a control system
            - Usually no emphasis on resistance
    - Phytosansitation
    - Seed fields
    - Resistance will help

- **Yellow leaf, SCYLV (30-33% Yield Loss)**
    - Brazil 1994
    - Large losses
    - SCYLV
    - Yield losses
    - Aphid vector, *Melanaphis sacchari*
    - Tissue blots, RT-PCR

- SCYLV causes yield losses
    - All cultivars 11 % significant at P = 0.05. Individual cultivars SCYLV-free yields usually higher but not always statistically significant.
- Based on unpublished data, the incidence of SCYLV at the end of the crop cycle would be 30 to 40 %, except for CP72-1210. The use of tissue-culture derived seedcane should be a benefit to growers in Florida.

- **Sugarcane Mosaic**
  - SCMV
  - Wide distribution
  - Causes yield losses
  - Aphid transmitted
  - Seedpiece transmitted
  - Mechanical transmitted
  - Sugarcane Mosaic Assays
    - Bio-assays, ELISA, Tissue Blots, PCR
    - Smith et al. Plant Dis. 78:557-561

- **Sugarcane Mosaic Control**
  - Disease-free seedcane
  - Resistant varieties
  - Screen varieties using mechanical inoculation
    - Presently, CP 72-2086 is susceptible, but is a minor variety
    - CP 72-2086, no significant yield differences
      - Plant biomass –plant and first ratoon crop
      - % sucrose – plant and first ratoon crop
      - Sugar per ton – plant and first ratoon crop
- **Minor Diseases:** Eye Spot, Dry Top Rot, Brown Spot, Chlorotic Streak, Red Stripe, Pokkah Boeng

INSECT PESTS – Nuessly & Cherry

Factors affecting insect management decisions:

Crop, insect identification, insect biology, sampling, control options, resistance development.

Crop selection Considerations:

Germination and Growth

Shoot production: Increased production of shoots in response to insect damage increases chance of yield compensation.

Horticultural characteristics: Stem cracks increase attack by diseases and insects that enter through stalk (West Indian Sugarcane Weevil).

Faster germination and establishment leads to reduced chance of soil insect damage to eyes and shoots. Faster growth gets the growing point above the soil out of damage zone for wireworms and lesser cornstalk borers.

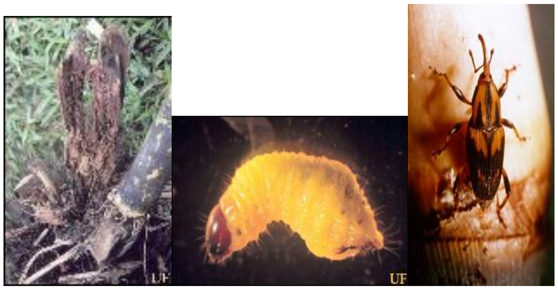
Lesser cornstalk borer feeding damage may kill plant stools in early shoot growth stage. Shoot production increases in response to insect damage to primary shoot.

Leaf characteristics: Shape and growth character effect micro-habitat for insect development. Flat verus V-shaped leaves are better for aphids, mites, delphacids and fulgorids. Upright versus gentile sloping leaves changes micro-habitat for leaf feeding insects. Leaf shedding removes matter from stems, but this reduces available habitat for small predators and parasitoids.

Leaf hairs: hirsute versus glaborous leaves. Leaves with more hairs protect better than smooth leaves against thrips, aphids, and mites.

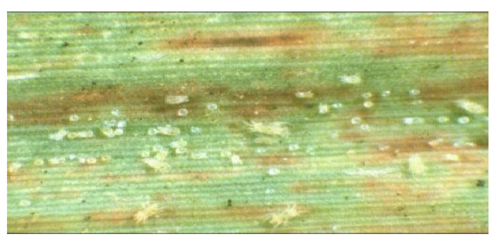
Diaprepes abreviatus, Diaprepes root weevil

Metamasius hemipterus sericeus, West Indian or Silky Cane Weevil or sugarcane borer



Perkinsiella saccharicida, Sugarcane delphacid, Vector of Fijivirus - Fiji disease

West Indian Sugarcane Fulgorid 

Oligonychus stickneyi, Sugarcane spider mite 

Sugarcane grubs= Scarabaeidae = June beetles

Control: No insecticides, Flooding, Discing, and reduced ratoon

Sugarcane wireworms = Elateridae = Click beetles

Control: Soil insecticide at planting, Flooding

Wireworm sampling in field (figure below):

Crop Selection:

- Varieties
  - Insect resistance
  - GMO – Bt-enhanced

Field Selection

- Placement
  - Location relative to surrounding agricultural and
  - non-agricultural areas can affect which insects and
  - insect vectors are problems
- Field History
  - Previous and nearby problems should be considered
  - Sequential planting or rotation from other crop may
  - help or worsen problems for sugarcane
  - Fallow fields may have allowed soil insect colonization
  - Surrounding vegetation (weeds and natural canopy)
  - provide alternate hosts for pests and natural enemies

    and virus reservoirs - Island vs. ocean

  What are your neighbors planting?

  What are you planting in neighboring blocks?

  Weeds in and around fields provide reservoir for natural enemies and their prey, as well as viruses

- Soil type

  Affects insect colonization and effectiveness of treatments

  Soil type can effect how long insecticide remains active in soil (e.g., wireworms)

Insect Identification

- Key to pest management decisions

Insect may or may not need to be controlled

May be new or emerging pest previously not known from the area/region/ country

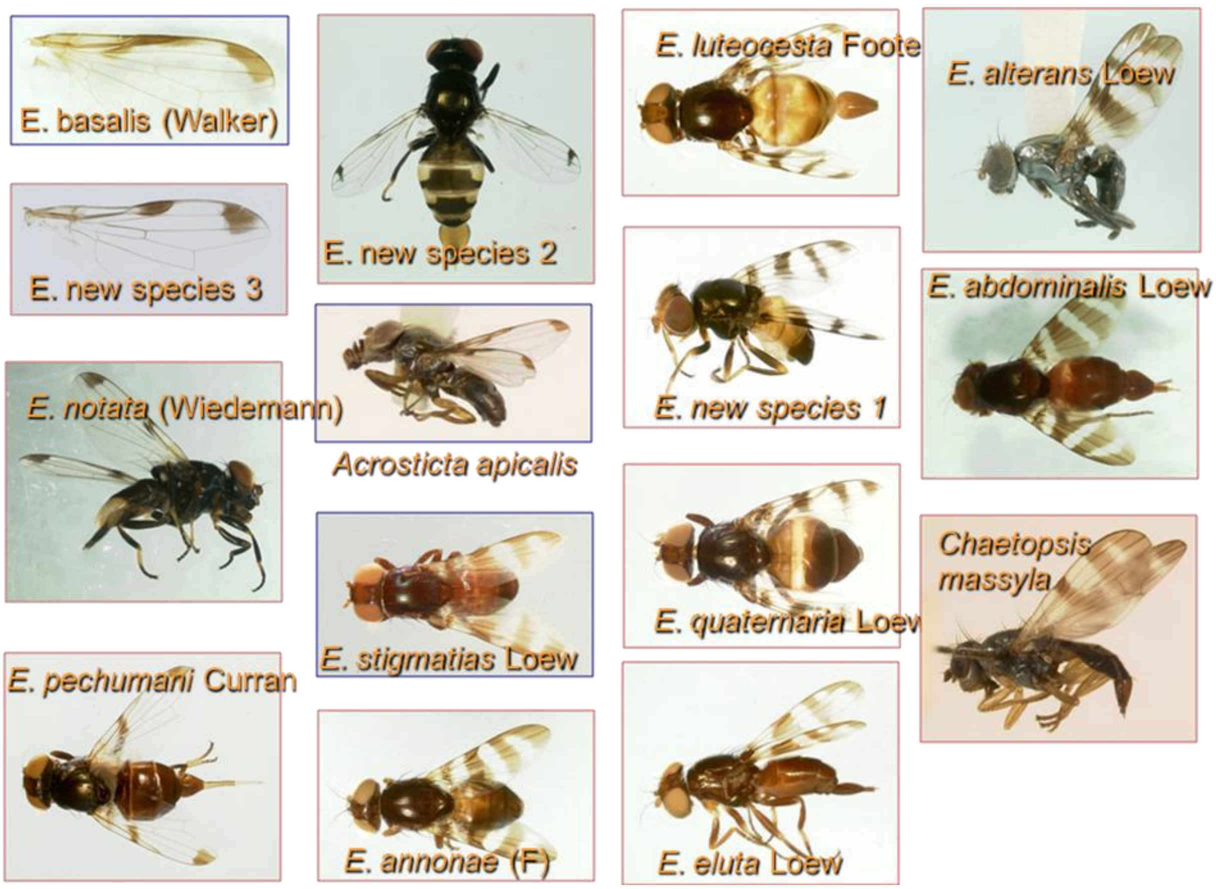
- Identification leads to biology, damage potential, host range

- Incorrect identification may lead to poor control, crop loss, lost business, or unnecessary treatments

- Important to recognize adults and immatures of same species

Adult may not damage crop, but is an indication of development in or migration into a field

- Proper identification indicates where to look for damaging insect stages



ID Sources: State agencies; Local experts – DIECA; Books; Internet; Training, internships and summer classes

Insect Biology: Important at the order, family and species level

- Length of development
    - How long will it be munching on your crops?
    - How much time do you have to kill it before it completes development?
    - Single or multiple generations per season / crop
- Damaging stages of insect
    - Larva or nymph, adult, or both
- Local or long distance movement
    - Should you expect insect reinforcements?

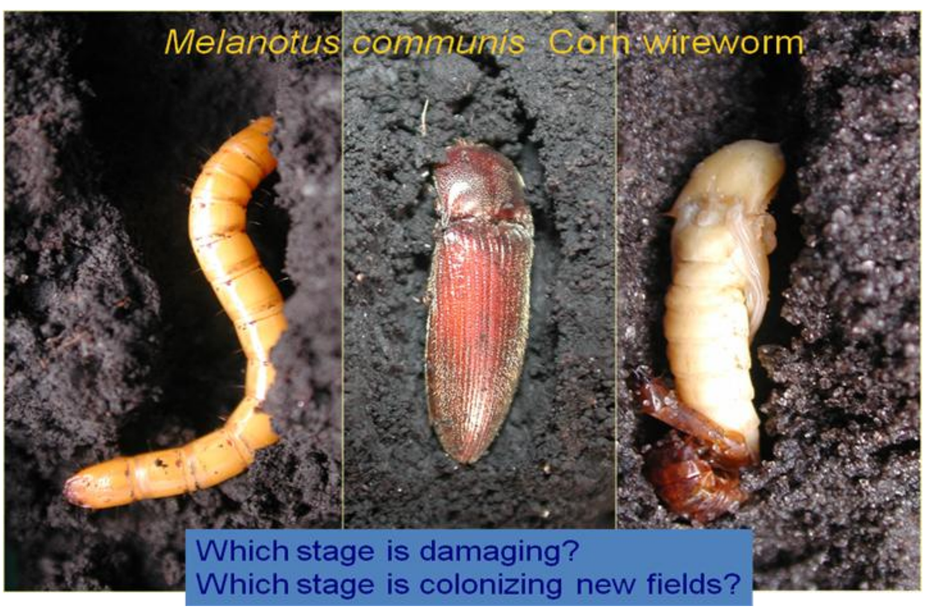
Plant parts attacked: Above, at or below soil surface

- Supportive or marketable plant parts
- Surface feeder or borer or both

Reproductive output: Individual eggs / masses of eggs / live nymphs

Host preference & alternate hosts

- Are they only in the field for a snack or are they setting up shop?



Insect behavior:

Are they nocturnal or diurnal - this may affect your ability to find and identify them

Are they active year round or only during certain parts of growing season

Environmental factor interaction: dry soil often associated with lesser cornstalk borer

<u>Learn to associate specific insect species with specific plant parts or seasons</u>

Sampling: Requires knowledge of potential pests and their biology

- Development of personal search image
- Where to look on the plant
- Damage symptoms
  - Physical damage, discoloration, wilting, frass
  - Pinholes or rows of holes in old or young leaves
  - Sooty mold fungus growth indicates phloem feeders
  - Leaf notching, leaf tying indicates chewing feeders; Spittle formation

- Sampling plans
  - Sampling method – destructive or non-destructive
  - Crop circles or zig zags or transects
    - Number of samples in a given area of a field
    - Transects across a field
    - Splitting open stalks
    - Cutting open larvae to look for parasitoids
  - Infestation or damage level

- Decision time
  - Action or damage thresholds
    - Expected crop value; Treatment efficacy ; Level of unacceptable damage
    - Treatment costs; Crop age

Control Strategies:

- **Mechanical**
  - Cultivation
    - Disruption, indirect and direct mortality
- **Cultural**
  - Crop Residues
    - Conservation tillage
    - Green harvesting versus pre-harvest burning
  - Water management
    - Moist soil surface
    - Flooding
  - Crop rotation

Sanitation

- Weed control 
- Weeds within and outside of a field can serve as alternate hosts for insects and viruses
- Weeds also provide nectar and prey source for natural enemies
- Wild mustards and lettuces, pancake weed, ragweed, Spanish needle, elderberry
- Surrounding fields
- Fields with poor pest management can allow insects populations to grow and move
- Infested seed cane
- Avoid using seed cane infested previously or
- currently infested with borers
- This will seed new field with insects and lead to
- greater problems with pineapple disease and red rot

- Post harvest crop destruction
- Disk down and incorporate remaining plant matter after harvest to destroy remaining insects and their food

- **Natural / Biological Control**
  - Not a quick fix
  - Season long decision
    - Must conserve natural enemies to have them when needed.
  - Knowledge of habitat and environment
    - Predator and parasitoid presence: is anybody out there?
  - Sugarcane is perennial, multiyear crop that provides reservoir for many arthropods, including predators and parasitoids

- **Insecticides**
  - Hundreds available, so important to become familiar with classes and the following points:
    - Mode of entry to insect
      - Contact or ingestion
    - Speed of control
      - Quick or slow death
      - Starvation, dehydration
    - Place of action
      - Surface, trans-laminar, systemic
      - Above or below ground
      -

Considerations using insecticides:

- Harvest (PHI) and field entry restrictions (REI)
- Plant back restrictions
  - What do you mean I can't plant that now?!
- Crop grouping and proximity to others
- Surfactants
  - Distribution and penetration vs.

  phytotoxicity and surface bacteria penetration
- Water rates
  - coverage & penetration vs. number of tank refills to treat a field vs. labor costs

Ground versus aerial application

Number of applications

- Total ai per crop per acre per year
- Most new products have max 3 to 4 apps / crop

Soil type

- Pore size, water holding capacity, organic matter, silt and sand

Canopy penetration

- Pressure and water rates

Chemical versus bacterial or fungal pesticide**,** *Beauveria bassiana* or *Metarhizium* spp.

Resistance Management:

- Goals
  - Maintain control of insects
  - Slow or prevent loss of potency
- Insecticides
  - Label rates
    - Stay within upper ***AND*** lower rate range

    - Rotation between modes of action

- GMO crops – Bt enhanced
    - Currently not available in the USA
        - High potential for control of stalk boring pests
    - Management considerations
        - Vegetatively propaged crop:
            - How do you keep track of what is GMO?
            - Will rules require destruction and crop free period following several stubble crops?

INTEGRATED PEST (WEED) MANAGEMENT

Dr. Chandramohan

Pest (Weed) Management Strategies

Prevention (Monitor/Quarantine/Act)

Physical/Mechanical (Burning/Foam etc.)

Cultural (Cane Trash/Mulch/Cover crop)

Chemical (Herbicides as needed; READ LABEL)

Biological

- Inoculative strategy – CLASSICAL Strategy
- Augmentative strategy
- Inundative strategy – BIOHERBICIDE Strategy

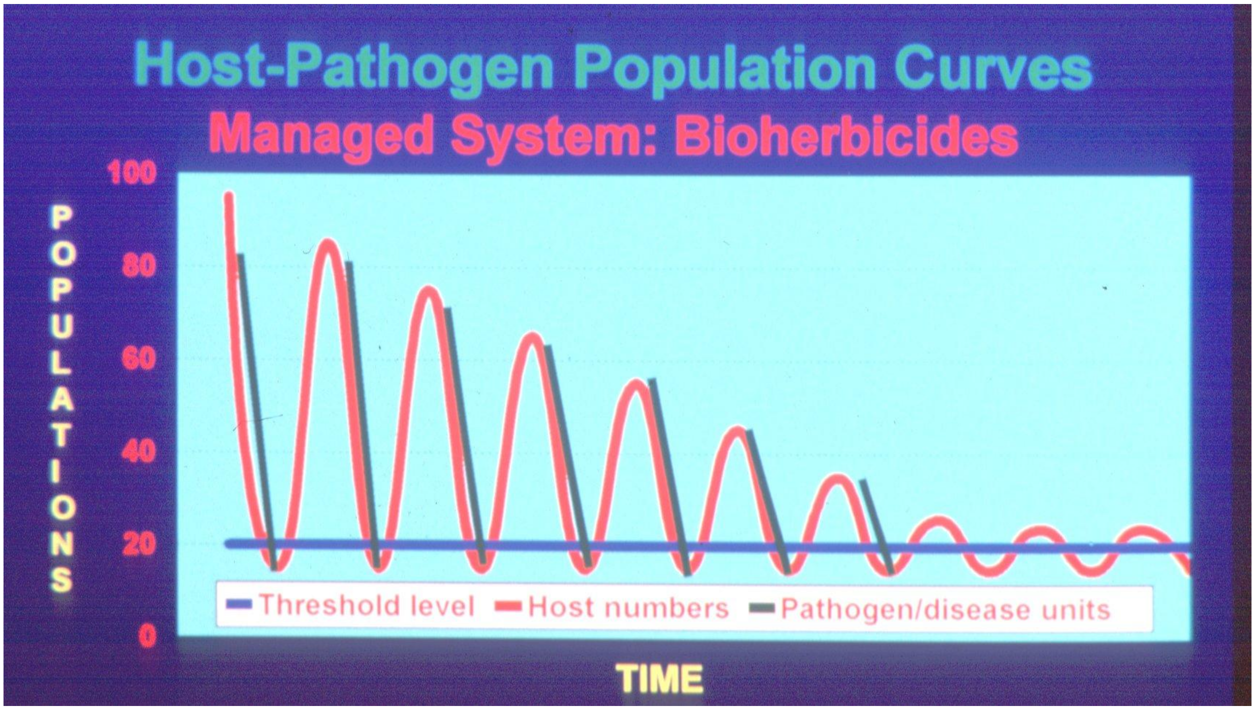
Bioherbicide Strategy

There are numerous pathogens (BACTERIA, FUNGI, VIRUSES) on ALL plants (including weeds) that rarely cause major epidemics. Pathogens usually occur in an "endemic" disease state (as opposed to "epidemic" state). Also, host / pathogen/environment create constraints to disease development in nature.

By applying a large dose of inoculum when the plant is most susceptible and when the environmental conditions are conducive for disease development, a rapid disease development leading to epidemic buildup can be artificially produced.

Pathogens that can be grown on artificial media can be used to produce large quantities of standardized inoculum, and the inoculum can be applied at levels that inundate the infection sites on the plants, overcoming inoculum limitation and possible environmental and host-defense limitations.

This approach, based on human manipulation of the pathosystem, is called the bioherbicide strategy.



Courtesy of Prof. R. Charudattan

How do we find and develop a bioherbicide?

- Look for diseased plants (Pathogens are indigenous)
- Identification of pathogen
- Efficacy tests in Greenhouse
- Host-range Evaluation
    - Crop species where the fungal pathogens will be used as bioherbicides.
    - Selected crop species with which species of fungal agent are normally associated.
    - Other selected crop species that are economically important.

    HOST REACTIONS:

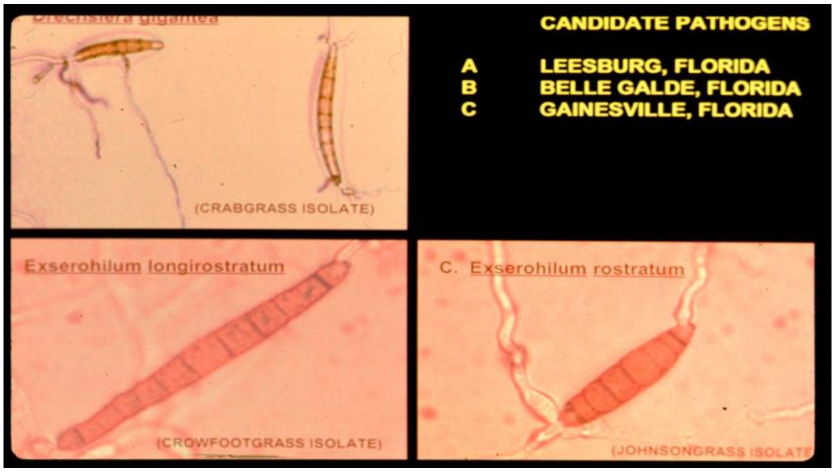
    I = IMMUNE (0 % disease severity, no visual symptoms of disease)

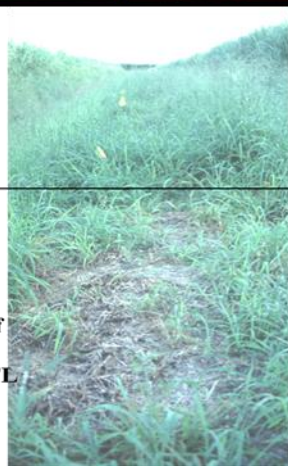
    R = RESISTANT (slightly diseased, but plants recovered)

    S = SUSCEPTIBLE (completely diseased)

- Mass production of inoculum

- Formulation of biocontrol agent (e.g., in oil/emulsifier)
- Application of biocontrol agent (sprinkler, pivot, etc.)
- Field-evaluation, data collection for EPA approval and registration
- Patent & Register following EPA guidelines.





Uninoculated (30% Oil Emulsion alone)

Inoculated (Pathogen Mixture in 30% Oil Emulsion)

Bioherbicidal Efficacy of Pathogen Mixture on Guineagrass, Pahokee, FL (Sep 2001)

SUMMARY

- Presently, there are no bioherbicides commercially available to control weeds in the Everglades Agricultural Area (EAA).
- US Patent issued to University of Florida. Technologies are available for licensing for the use of bioherbicide agents for pigweeds, nutsedges and grasses that are problem weeds in sugarcane in the EAA region.
- Need to be developed as registered, commercial bioherbicide products.

PESTICIDE SAFETY – Kiley Harper-Larsen

Objectives:

- Understand pesticide regulations affecting agricultural production
- Identify proper personal protective equipment
- Follow correct pesticide handling decisions
- Observe and evaluate special environmental considerations

Worker Protection Standard (WPS):

- Created by the EPA in 1993
- Regulated by FDACS
- Two-fold purpose:
    - Decrease pesticide exposures among agricultural employees
    - Provide employers with a minimum standard for training, recordkeeping and compliance
- Only 4 application areas are regulated by WPS
    - Farms, Forests, Nurseries, Greenhouses
- WPS does not regulate
    - Ranches, Rose production
- Employee Definitions
    - Handler
        - Someone who can come in direct contact with pesticides or pesticide residue
    - Worker
        - Someone who will NEVER come in direct contact with pesticides or pesticide residues

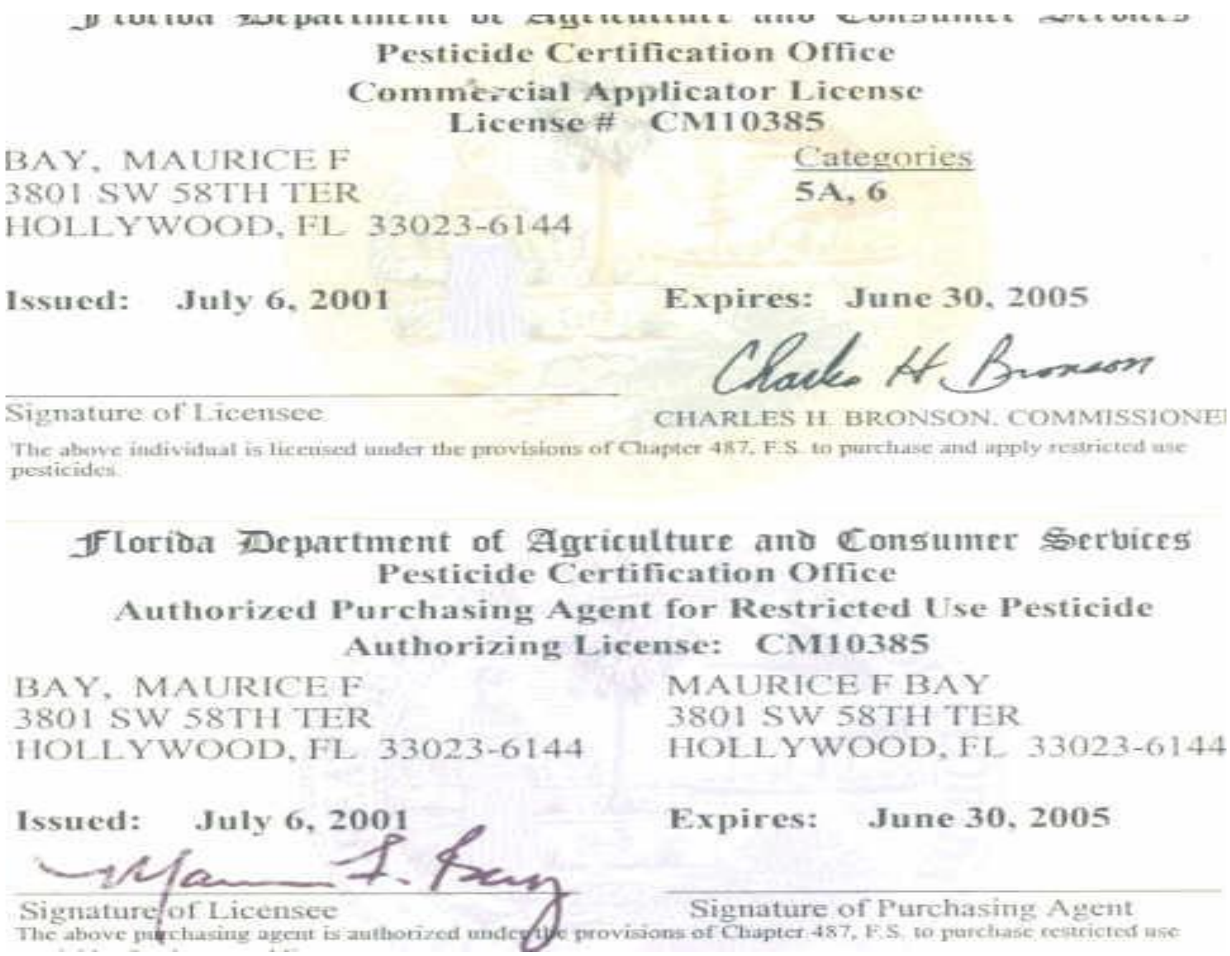
- Employee Training*
    - Handler
        - Before performing any handling task
        - Re-trained at least every five years
    - Worker
        - Before end of fifth day
        - Re-trained annually

*Can only be conducted by WPS Trainer, License Holder or Handler

- **Application Recordkeeping**
    - Employees must be notified
    - Others must be notified
    - Records must be maintained at central posting for 30 days
    - Records must be kept on file for at least 2 years
    - http://www.doacs.state.fl.us/onestop/forms/13340.pdf
- **Restricted Entry Intervals (REI)**
    - Amount of time following application before any individual can safely enter without personal protective equipment
    - Minimum is four hours
    - Manufacturer can stipulate more time
    - Labels specifies different REIs for different crops

Restricted Use Pesticide (RUP) Licensing:

- State law requires application of RUPs to be directed by a license holder in an appropriate category
- Most common licenses
  - Private Applicator
  - Agricultural Row Crop
- Exams available at local Extension Office , call 996-1655
- Continuing Education Units (CEUs)
  - Private Applicator = 8
  - Agricultural Row Crop = 12


Florida Department of Agriculture and Consumer Services
Pesticide Certification Office
Commercial Applicator License
License # CM10385

BAY, MAURICE F
3801 SW 58TH TER
HOLLYWOOD, FL 33023-6144

Categories
5A, 6

Issued: July 6, 2001

Expires: June 30, 2005

Signature of Licensee

CHARLES H. BRONSON, COMMISSIONER

The above individual is licensed under the provisions of Chapter 487, F.S. to purchase and apply restricted use pesticides.

Florida Department of Agriculture and Consumer Services
Pesticide Certification Office
Authorized Purchasing Agent for Restricted Use Pesticide
Authorizing License: CM10385

BAY, MAURICE F
3801 SW 58TH TER
HOLLYWOOD, FL 33023-6144

MAURICE F BAY
3801 SW 58TH TER
HOLLYWOOD, FL 33023-6144

Issued: July 6, 2001

Expires: June 30, 2005

Signature of Licensee

Signature of Purchasing Agent

The above purchasing agent is authorized under the provisions of Chapter 487, F.S. to purchase restricted use

Personal Protective Equipment (PPE): 

- PPE are devices worn to prevent or protect individuals from pesticide exposure
- It includes:
  - Rubber Boots, Hats, Gloves, Long-sleeved shirts, Long pants, Goggles, Respirators
- Early-entry PPE ALWAYS requires more equipment

- USUALLY requires the use of:
  - Coveralls, Respirator, Rubber Boots, Heavy gloves
- Wash PPE after every use
- Separate hampers
- For clothing, wash:
  - In hot water, Large load selection, Wash Two times, Allow washer to run a third time on same selections to sanitize, Hang out to dry, if possible

Correct Pesticide Handling Decisions:

- Profit, Safer workplace, Cleaner environment
- Reading is Fundamental
  - Research; Label; MSDS

Formulations:

- Liquid
- Emusifiable Concentrate
- Wettable Powder
- Microencapsulated

When choosing a formulation consider:

- Site
- Target Pest
- Equipment
- Pesticide Movement
- Personal/Personnel Safety
- Cost

Mix and Load:

- Activity where most accidents occur
- Avoid pouring above your neck
- Before mixing…
  - Suit up in PPE
  - Have a second person watch
  - Clear the area

Helpful Tips:

- Observe spraying from inside a closed cab
- Use the least amount possible to achieve desired control
- Speed determines application rate/amount
- Add ingredients by **WALE**:
  - Wettable Powder
  - Agitate
  - Liquids
  - Emusifiable concentrate

Environmental Considerations:

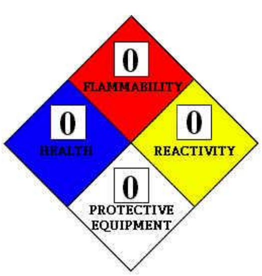
- Soil: Texture, Organic matter content, Permeability
- Ground water contamination : Pesticide solubility, Pesticide adsorption, Let IPM guide you
- Helpful hints for Environmental Stewardship:
    - Apply at right time, Measure carefully, Calibrate equipment, Clean up spills quickly, Be aware of Pesticide persistence
    - Use an anti-siphoning device, Triple rinse containers, Store safely, Dispose properly
- Protection of Wildlife and Fish:
    - Non-point source contamination
    - Keep application far away from aquatic areas
    - Keep mix and load sites to a minimum
    - Pesticide movement

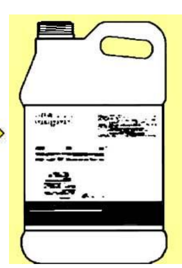
Pesticide Label:

- Info printed on container
- Info attached to container, and
- MSDS sheets

The Label and The Law:

The label is the law and the law is the label. Most labels are available in English and Spanish.

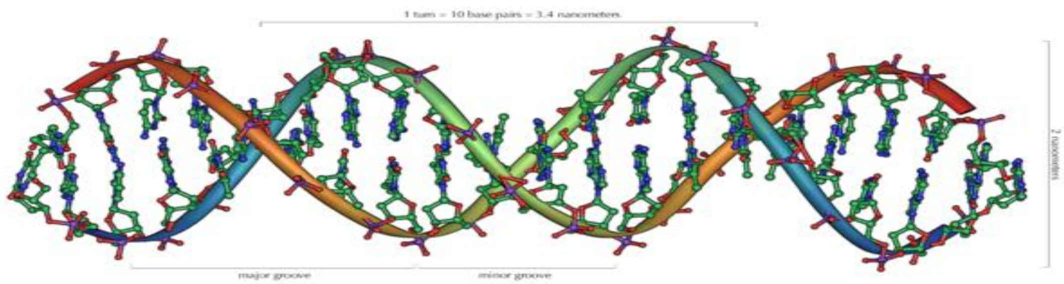


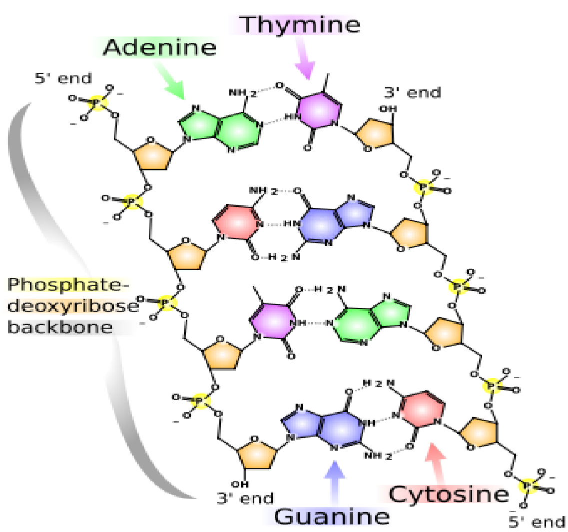



MOLECULAR BIOLOGY

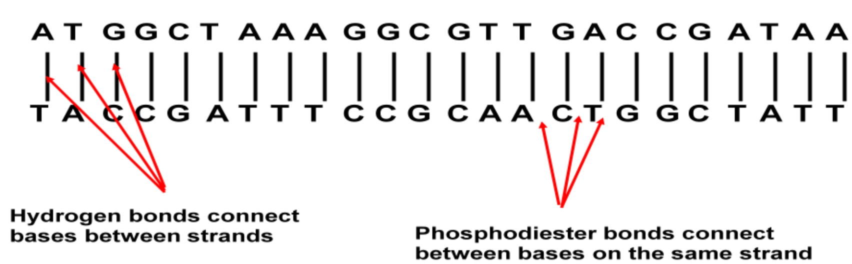
Introduction:

Deoxyribonucleicacid (DNA) sequence is a double-helix (2 strands) made from nucleotides made of purines (Adenine and Guanine) and pyrimidines (Cytosine, Thymine). The nucleotides pair based on the rule of complementary-base pairing, i.e, A can pair with only T (DNA) or U (Ribonucleicacid, RNA) and G can pair only with C. The bases in the two strands of DNA are connected by hydrogen bonds and the bases within the same strand are connected by phosphodiester bonds.

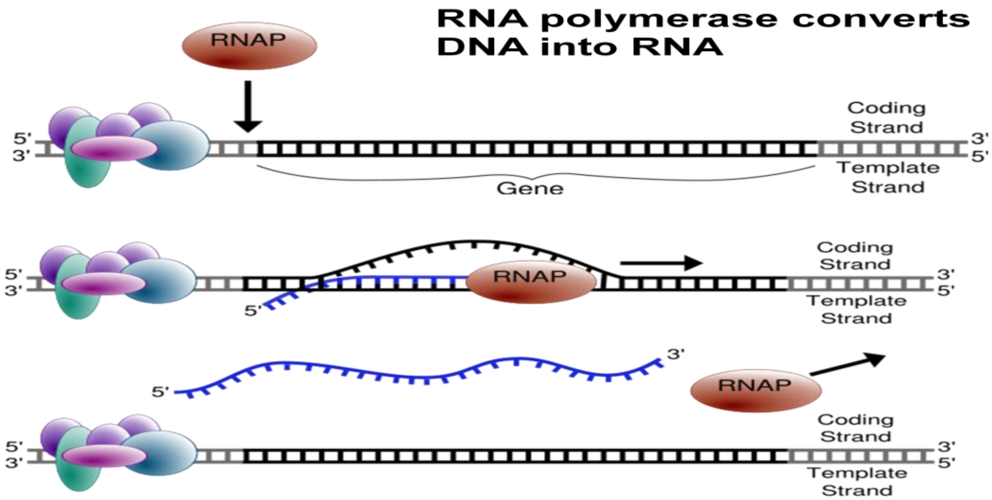




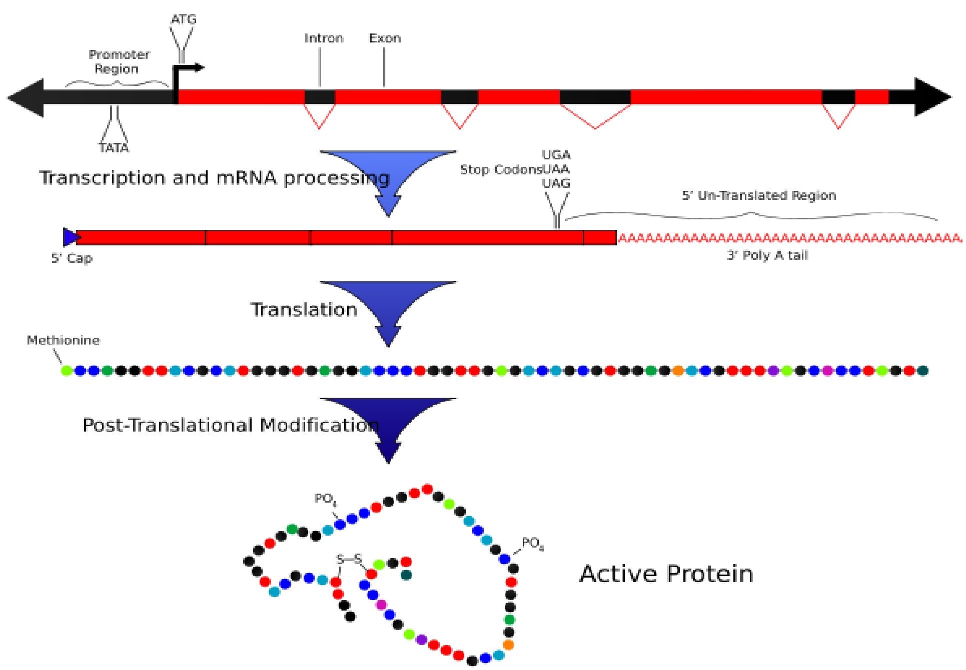
Representation of double stranded DNA



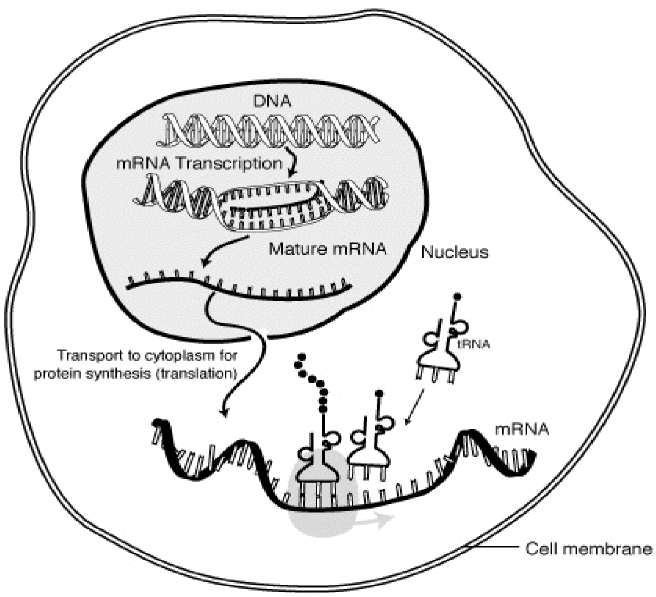
DNA is converted by an enzyme, RNA polymerase to RNA by a process called transcription (transcribing the message contained in the DNA sequence).



Transcription is followed by translation (RNA is converted to protein (sequence of aminoacids)). In eukaryotic cells, both RNA and protein go through some post-transciptional/post-translational modifications before the formation of active protein, the end product.



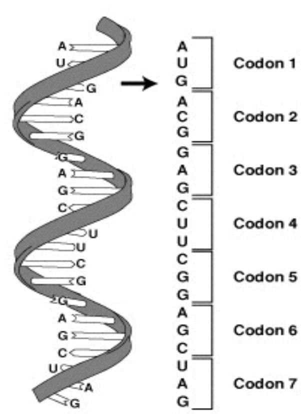
The following diagram illustrates where all the DNA processing to protein occur:



Genes are expressed constitutively or in response to a stimulus

<u>Examples</u>
Cold temperature
Disease/ pest attack
Growth stage (flowering)

Every three nucleotides (codon) in a sequence specifies a single amino acid



RNA

Ribonucleic acid

A G G G A U G A A G G C G U U G A C C G A U A A

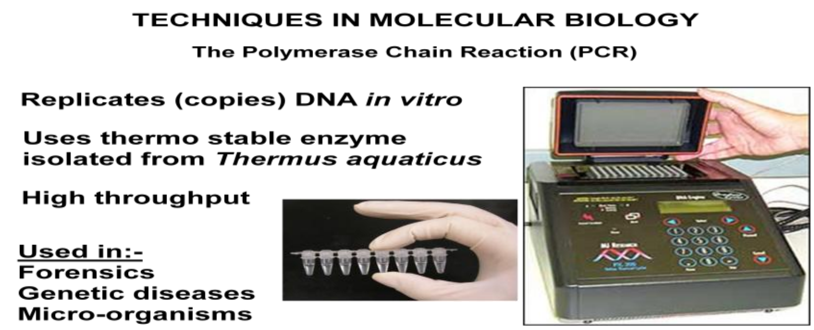
START (met) lys ala leu thr asp

Seconed Position

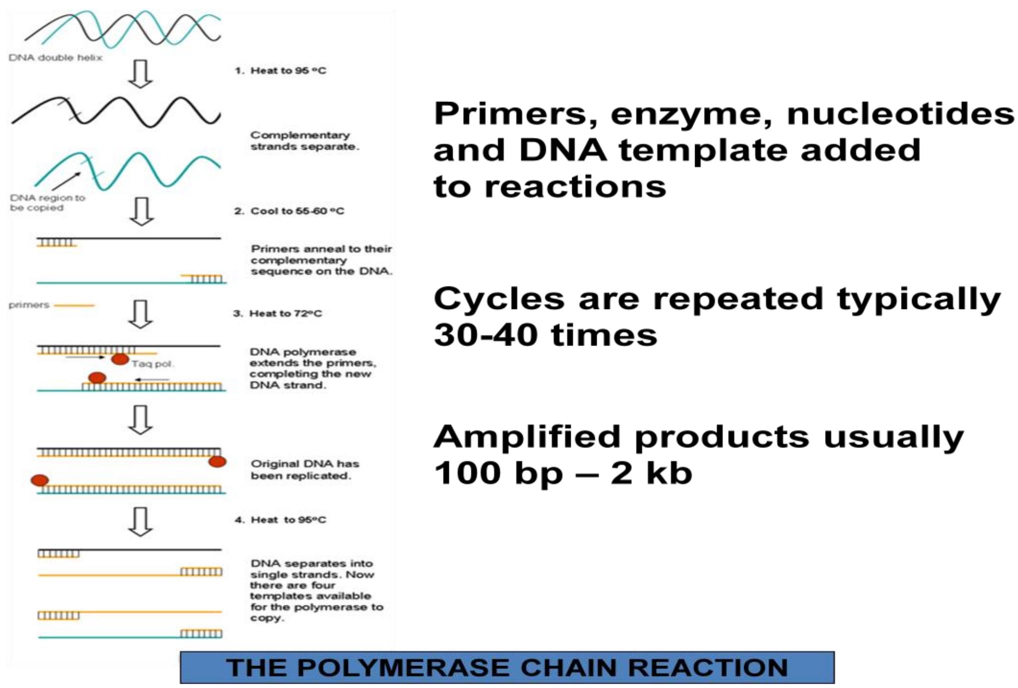
First Position	U code	U Amino Acid	C code	C Amino Acid	A code	A Amino Acid	G code	G Amino Acid	Third Position
U	UUU	phe	UCU	ser	UAU	tyr	UGU	cys	U
U	UUC	phe	UCC	ser	UAC	tyr	UGC	cys	C
U	UUA	leu	UCA	ser	UAA	STOP	UGA	STOP	A
U	UUG	leu	UCG	ser	UAG	STOP	UGG	trp	G
C	CUU	leu	CCU	pro	CAU	his	CGU	arg	U
C	CUC	leu	CCC	pro	CAC	his	CGC	arg	C
C	CUA	leu	CCA	pro	CAA	gln	CGA	arg	A
C	CUG	leu	CCG	pro	CAG	gln	CGG	arg	G
A	AUU	ile	ACU	thr	AAU	asn	AGU	ser	U
A	AUC	ile	ACC	thr	AAC	asn	AGC	ser	C
A	AUA	ile	ACA	thr	AAA	lys	AGA	arg	A
A	AUG	met	ACG	thr	AAG	lys	AGG	arg	G
G	GUU	val	GCU	ala	GAU	asp	GGU	gly	U
G	GUC	val	GCC	ala	GAC	asp	GGC	gly	C
G	GUA	val	GCA	ala	GAA	glu	GGA	gly	A
G	GUG	val	GCG	ala	GAG	glu	GGG	gly	G

The above table gives all the possible combinations of nucleotide codons that generate 20 different aminaoacids (note: there are more than one codon for some aminoacids, and there are start and stop codons).

Polymerase Chain Reaction (PCR) technique allows DNA sequences to be amplified for further use (diagnostic, sequencing to determine nucleotides present). The amplified products are subjected a method, gel electrophoresis and separated based on size. Once a nucleotide sequence is obtained, it can be compared with known sequences in a nucleotide sequence database using Basic Local Alignment Search Tool (BLAST). Databases can be 'mined' to identify candidate genes for specific traits. High level of sequence conservation and variation exist between divergent species.



The following is the sequence of steps involved in a PCR reaction:



SUGARCANE BIOTECHNLOLOGY

First genetic map of sugarcane was released in the mid 90’s JAG Da Silva of Brazil. Brazilians released 250,000 mRNA sequences in 2004. They used 27 different plant sources (libraries). They found Circa 30K genes, Circa 90% of total genes expressed. The first gene cloned from genetic map was *Bru*1 - D’hont .

Application of technology:

To isolate disease resitance genes and analogues in sugarcane. Conventional breeding for disease resistance has constraints:

- No high throughput screening method
- Natural inoculums needed
- Many years' trials
- Resource constraints

Application of biotechnology has potential to improve sugarcane selection through

Marker Assisted Selection (MAS). Many other *R* (disease resistance) genes have been isolated in other crops to date.

Gene	**Species**	**Pathogen**	**M.O.**
Pto	Tomato	*Pseudomonas syringae* p.v. tomato	Bacteria – Leaf
RPM1	*A. thaliana*	*P. syringae* p.v. *maculicola*	Bacteria – Leaf
I2	Tomato	*Fusarium oxysporum* f.sp. *lycopersicon*	Fungus – Root
N	Tobacco	Mosaic virus	Virus – leaf + phloem
L6	Flax	*Melampsora lini*	Fungus – leaf
RPP5	*A. thaliana*	*Peronospora parasitica*	Fungus – leaf
Xa21	Rice	*Xanthomonas oryzae*	Bacteria – leaf

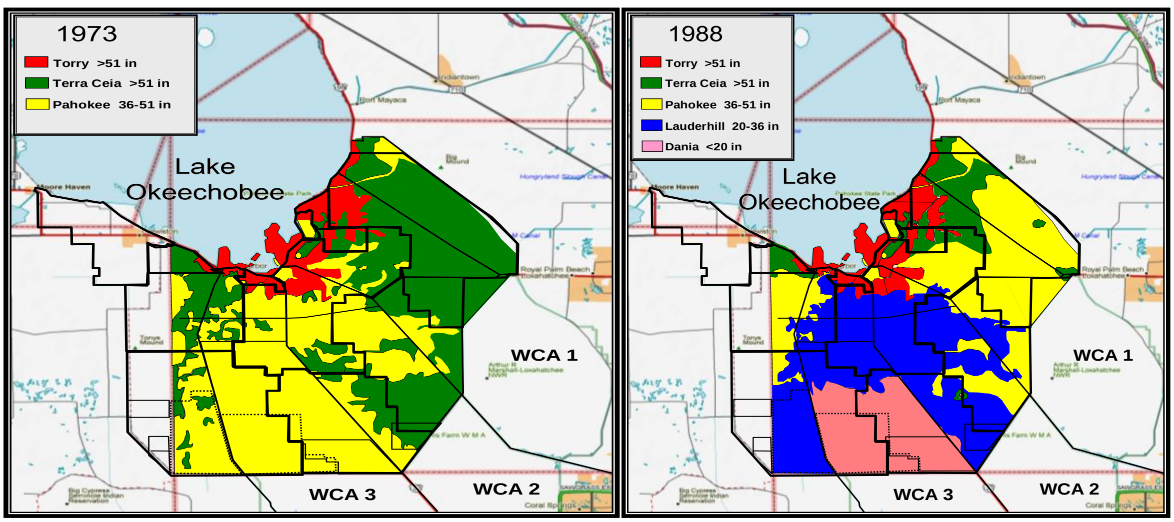
GENETIC TRANSFORMATION USING GENE GUN

- Gold particles coated with DNA fired at plant material
- Insert DNA is integrated into plant DNA
- Plant cells regenerated on growth media

In sugarcane, research is being done at the USDA-ARS research center in Canal Point, FL to understanding resistance to brown rust, yellow leaf. Once the resistance genes are identified, they are used to transform sugarcane varieties and the resulting transgenic plants are further evaluated for specific disease resistance traits in greenhouse and field.

BEST MANAGEMENT PRACTICES (BMPs) – McCray

- 80% of the sugarcane in south Florida is grown on organic soils, 20% on mineral soils
- Sugarcane in south Florida is grown on 4 of the 12 soil orders
- There are a wide range of soil conditions across the area: pH can vary from <5 to 8 and organic matter varies from <1 to >90%
- Field variability can be large, particularly on mineral soils
- **Mineral Soil Horizons**
    - **Spodic**: Subsoil layer with an accumulation of organic matter. This horizon can limit water movement.
    - **Argillic**: Subsoil layer with an accumulation of silicate clays. In our mineral soils this may be a clay loam, sandy clay loam, or sandy loam.



Best Management Practices (BMPs) for Water Quality Improvement in the EAA

- These BMPs specifically target the reduction of phosphorus (P) moving from the farms to the Everglades
- These BMPs are designed to use nutrient management, water management, and management of particulate P to reduce the amount of P moving south in drainage water to the Everglades

- **Soil Testing**

Importance

- Part of the “Nutrient Control Practices” listed under approved BMPs for water quality improvement in the EAA.
- Soil testing is an essential tool to formulate a sound amendment and nutrient management program.
- With increased emphasis on environmental quality and rising cost of fertilizer materials, soil testing has become an important tool to identify areas where inadequate or excess fertilization has occurred.

- **Soil Testing: 3-Step Process**

- 1. Soil Sampling:

a) Collection of Soil Samples

b) Handling and Submitting

- 2. Laboratory Extraction and Analysis:

a) Sample Preparation

b) Extraction and Measurement of Nutrients.

- 3. Interpretation and Fertilizer Recommendation:

Making sense of the results to make reasonable nutrient (fertilizer) application recommendations for a specific crop.

- **Leaf sampling**

- Leaf Sample Procedures
- Collect leaf samples in a similar pattern to soil samples and stay away from ditch banks and field ends
- Collect approximately 30 top visible dewlap leaves
- As soon as possible strip the blades off the midrib and wash in deionized or distilled water
- Place washed leaf blades in a paper bag, label, and the sample is ready to be dried

Leaf Analysis Guidelines:

- Leaf samples are best taken early in the grand growth period, in June-July
- Leaf samples can be taken at other times for diagnosis of specific problems
- Leaf nutrient values can be used to adjust the next fertilizer or amendment application for a field or area
- Leaf analysis will complement soil testing

Goals of Fertilizer Application BMPs:

- ➢ Fertilize to cover all crop needs
- ➢ Reduce over- or misapplication
- ➢ Eliminate spills, cleanup spills

Apply minimum amount of P fertilizer that is needed to produce optimum yields

- ❑ Increase fertilizer use efficiency
- ❑ Timing of fertilizer application/split applications
- ❑ Placement of fertilizer close to root zone
- ❑ Fertilizer sources: soluble/slow release fertilizers

Banding of P Fertilizers:

- ➢ Places fertilizer close to the root zone; more efficient uptake by plant.
- ➢ Reduces the soil-fertilizer surface contact area, resulting in less P fixation.
- ➢ Reduces likelihood of overlapping application to same rows.
- ➢ The most important advantage of banding is the significant reduction of the overall amount of P applied especially to vegetables.

Misapplication of fertilizer P:

- ➢ Application of P fertilizer to soils with high P fertility levels.
- ➢ Application of P fertilizer to soils at higher than the recommended rates.
- ➢ Application of P fertilizer to non-target areas due to mechanical failures or lack of proper training.

Problems caused by increased P concentrations:

- Algal blooms & Excessive aquatic weed growth
- Low dissolved oxygen levels
- Increased TP and TDP in drainage water, Increased P loads off the farm
- Decreased drainage capacity of canals

Helpful Hints:

- Before planting season starts
- Monitor actual application rates vs. calculated amounts
- Never apply fertilizer beyond the field where it may easily move into canals.
- Proper Training of applicators

Recommendations to Reduce Fertilizer Spills:

- Park fertilizer hoppers/trailers and field application rigs far away from ditch/canal banks.
- Park fertilizer hoppers/trailers on level ground (avoid slopes leading to open water).
- Limit the number of loading sites … easier to “police”.
- Properly train all personnel involved in handling fertilizer material.
- Policy: Park fertilizer hopper/trailers ONLY at sugarcane loading ramp sites.

Recommendations to Reduce the Impact of Fertilizer Spills:

- Contain spills on tarps placed under/between trailer and application rigs.
- Have buckets/shovels available for immediate clean-up.
- Sweep “mini-spills” off trailer/hopper onto tarp and apply soil/dirt/fertilizer clean-up mix in target field.
- Policy: All personnel involved in handling and spreading fertilizer should have a copy of the Standard Operating Procedures (SOP) on handling fertilizer spills.

Water Management BMPs

- ➢ Amount of rainfall detained before pumping water off farm
- ➢ Re-circulating water on farm
- ➢ Flooding fields
- ➢ Optimizing drainage and irrigation schedules to decrease discharge

Detention: temporarily holding water until conditions for release are met; object is to control discharge rates to reduce impact on downstream receiving systems.

Retention: preventing water from discharging into receiving waters; water is held until it is lost to percolation, evapotranspiration or evaporation.

Rainfall Detention BMP (On-Farm Watre Management)

Effective, versatile, and completely farm-specific

Goal: reduce volume of water pumped off-farm

Benefits: less soil subsidence + lower P conc

Risks: higher WTs may harm crop, reduce yields

Processes: ET, seepage, water tolerant crops

Unknown: subsurface drainage/seepage shellrock

Water Detention Methods:

- Rainfall detention
  - Selected fields with high/low water tables
    - Booster pumps, gates, culverts
  - On-farm water storage areas
    - Retention pond, Seasonally flooded fields or blocks
  - Higher water tables across whole farm
    - Use of water tolerant crops/varieties, Regulated pumping practices

Particulate and Sediment P BMPs

- Any P-Containing Matter with Particle Size Greater than 0.45 micron
- Covers Broad Range from Protozoa to Tree Branches

Particulate Phosphorus sources:

Constitutes 40-60% of a Farm's Annual P Load

- In-Stream Biological Growth, Canal Bed Erosion, Soil Erosion from Overland Flow, Bank Erosion from Channel Flow

Sedimentation Control measures:

Drainage Velocity Control:

- Limit the maximum velocity
- Extend pumping time at a lower rate
- Long period pump cycling may be beneficial, short period pump cycling is always detrimental
- Determine critical level and control above it – Do not pump canal too low.

Land Leveling, Field Ditch Sumps, Ditch and Canal Bank Berms, Raised Culverts

Control Vegetation on Canal Banks, Removal of Floating Aquatic Weeds

Use Cover Crops, Flooded Fallow Fields, Weed Booms, Trash Rack

Regular Canal Cleaning, Canal Improvements

Slowed Drainage Near Pump Station.

Summary: EAA Farm Phosphorus Load Reduction

- LOAD = VOLUME X CONCENTRATION
- Slow soil oxidation → slow P mineralization, Amount, type, and placement of P fertilizer
- Minimize pumped drainage volume; Further farm P load reductions possible?
    - Control drainage velocity in canals, Eliminate floating aquatic weed growth

BIOMASS ENERGY (BIOFUELS) – Dr. Helsel

- **Advantages**
  - Energy Positive
  - Often Lower Inputs
  - Low Pollutants
  - Utilize Residues/Wastes
  - Carbon Sequestration
- **Challenges**
  - Competition w/ Food
  - Low Energy Density
  - Sugar Conversion
  - Water, Transportation, Handling
  - Organic Matter Loss
  - Pests

Bioenergy Crop Species and Estimated Yields

Tall Growing Perennial Grasses:

Energycane, Miscanthus, Arundo, Elephantgrass, Erianthus

Oil Crops:

Oil Palm, Jatropha

Yields

Crop	Ethanol Yields(L/ha)	Months
Sugarcane	6000-8000	~12
Sweet Sorghum	1000-6000	4-5

Crop	%Oil Content	Ethanlo Gal/A(L/Ha)	Yrs to Produce
Soybean	18-20	48(448)	.33
Sunflower	25-45	102(952)	.33
Jatropha	40-59	300(2801)	2-3
Oil Palm	40-70	760(7096)	3-8
Algae	10-85	10,000(93,370)?	< 1