

Maize: New Uses for an Old Crop



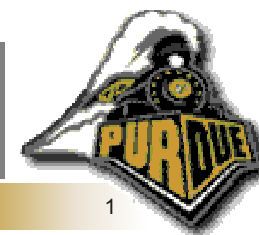
Image source: www.goodyear.com

R.L. (Bob) Nielsen
Agronomy Department
Purdue University, Indiana, U.S.

Email: rnielsen@purdue.edu
Web: www.kingcorn.org/rln-bio.htm



Links to this presentation can be
found under "Presentations & Papers"



Maize is an old crop!

- Genetic modification of maize has been occurring for thousands of years.
 - Center of origin = Mexico, central America
 - Earliest plant breeders = women
 - Important source of human and animal sustenance
- The miracle of maize is manifested in the thousands of ways that the grain has been used for years.

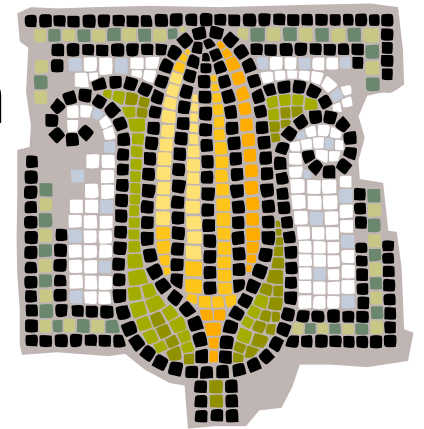


Image source: USDA-ARS, <http://www.ars.usda.gov/is/graphics/photos/k7743-13.jpg>



Many uses of maize...

- Alcoholic beverages
- Animal feed
- Baking, snack foods
- Other beverages
- Building materials
- Cannery/packers
- Cereals
- Chemicals
- Condiments
- Confectionary
- Fats & oils
- Formulated dairy products
- Fuel alcohol

Source: Corn Refiners Association



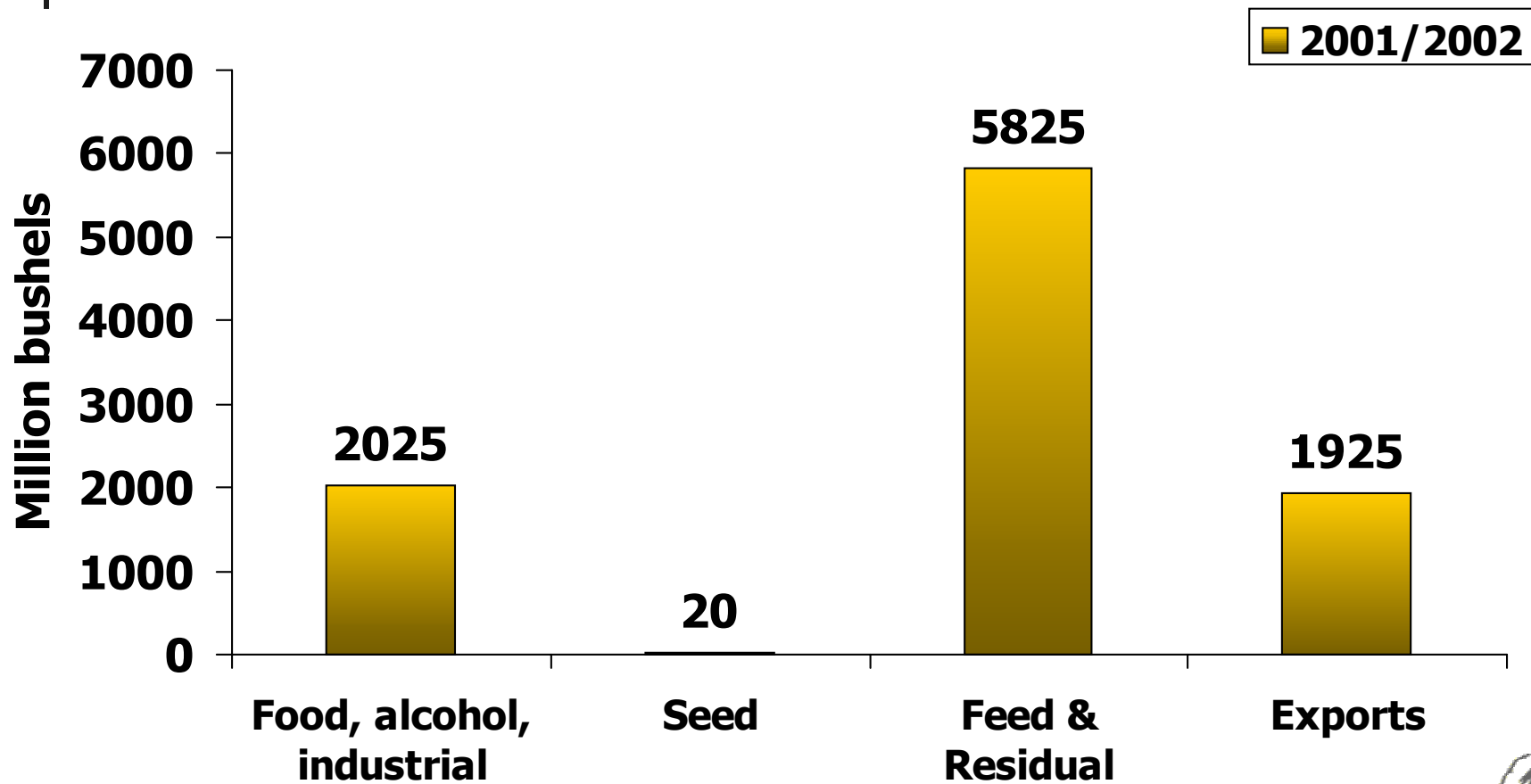
Many uses of maize ...

- Household needs
- Ice cream/frozen desserts
- Jams, jellies, preserves
- Meat products
- Mining/metallurgy
- Misc. foods
- Misc. industrial
- Prepared mixes
- Paper & related products
- Paste, adhesives
- Syrups, sweeteners
- Textile
- Tobacco

Source: Corn Refiners Association



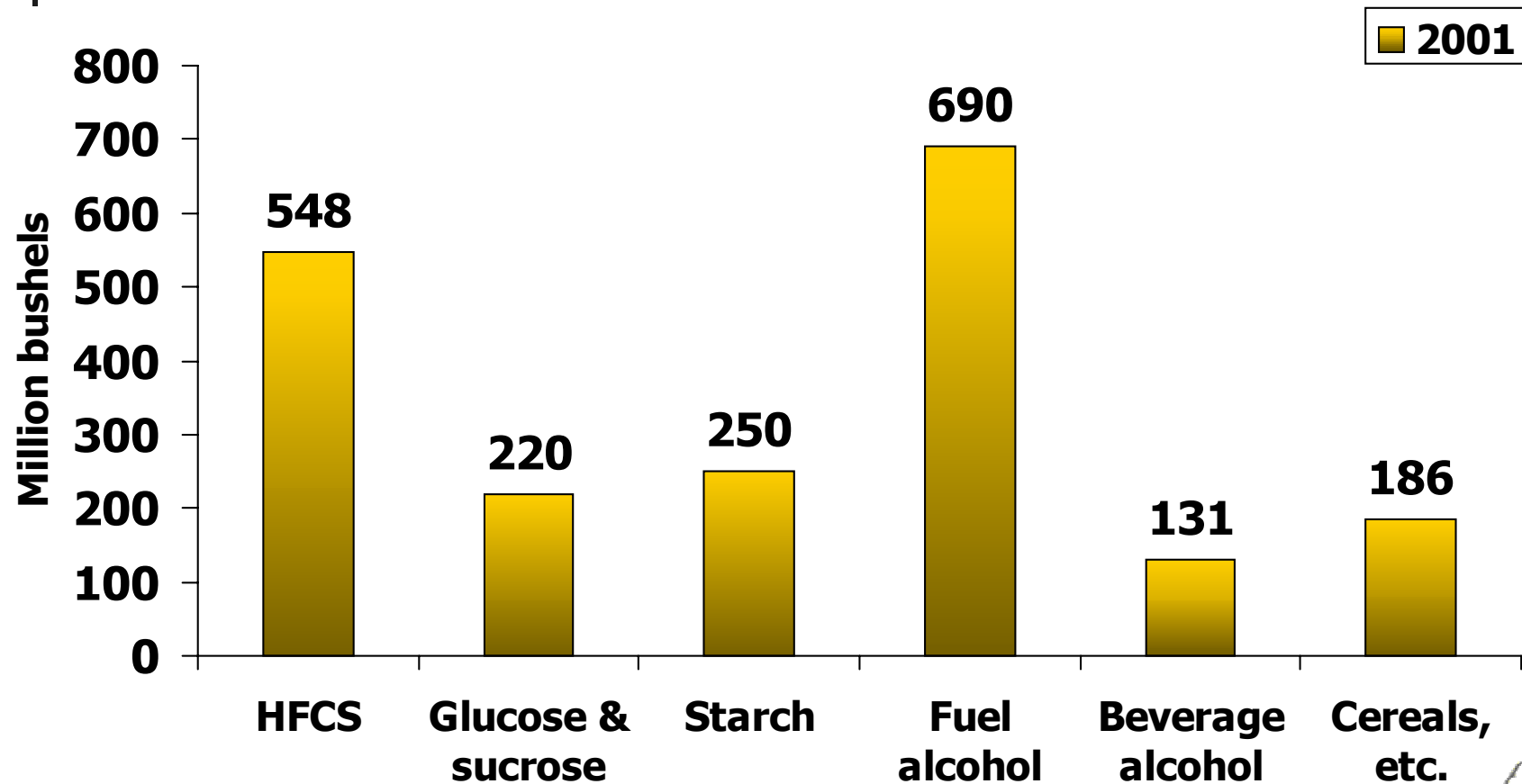
U.S. maize use...



Data source: Corn Refiners Assoc., <http://www.corn.org/web/ca2002.htm>



U.S. food & industrial use...



Data source: Corn Refiners Assoc., <http://www.corn.org/web/ca2002.htm>



Specialty grain traits...

- Characteristics that add value to end-user...
 - Blue
 - Hard Endosperm/Food Grade
 - High Amylose
 - High Lysine/Opaque
 - High Oil
 - High Oil/High Oleic
 - High Starch
 - Low Phytate
- Low Stress Cracks
- Low-Temperature Dried
- Non-GMO Corn
- Nutritionally Dense
- Nutritionally Enhanced (sometimes called High Protein)
- Organic
- Post-Harvest Pesticide Free
- Waxy
- White

<http://www.vegrains.org>



New uses in their infancy...

- Tires (BioTred™)
 - "...micro-droplets of corn starch as a tire ingredient to reduce tire weight and rolling resistance."
 - "...less energy to produce and their lower rolling resistance is expected to reduce fuel consumption and noise."



Image source: www.goodyear.com

<http://www.iowacorn.org/newuses.htm>

<http://www.goodyear.com/media/pr/22251ti.html>



New uses in their infancy ...

- HarvestForm™, a polymer composite manufactured from maize and soybean polymers.
 - Deere® claims that all combines manufactured in 2002 would include panels made from this new composite.



http://www.deere.com/en_US/ag/feature/newpolymers.html

New uses in their infancy ...

- Compostable plastics...
 - Compostable plastics, packaging films, fast food serving utensils manufactured with maize-based polylactic acid (PLA).
 - "...takes less fuel to produce and breaks down into natural components – water and carbon dioxide – when composted."

<http://www.iowacorn.org/newuses.htm>

New uses in their infancy ...

- Plastic foam...
 - Loosefill packaging material also manufactured from maize PLA.
 - Non-static (great for electronics)

<http://agproducts.unl.edu/plastic.htm>



New uses in their infancy ...

- Clothing, carpeting, textiles, bedding...
 - “Corn-based PLA can be blended with cotton, wool and silk to make exercise clothing, suits, even a 100% corn-fiber wedding dress.”

NatureWorks™ at <http://cargilldow.com>

<http://agproducts.unl.edu/plastic.htm>



Image source: <http://www.kanebotx.com/english/new/corn-f.htm>



Cargill Dow partnership...

- NatureWorks™ production facility in eastern Nebraska.
 - Targeted production of 140,000 metric tons of PLA per year.
 - Targeted maize usage of 1,000 metric ton of maize processed per day.

NatureWorks™ at <http://cargilldow.com>

New uses in their infancy ...

- Antifreeze from maize...
 - “Levulinic acid....has proven to be an effective ingredient in antifreeze. This chemical could replace the toxic, petroleum-based ingredients now in use.”

<http://agproducts.unl.edu/antifrez.htm>

New uses on the horizon...

- Plant-based manufacture of pharmaceuticals & therapeutics
- Crops as an oral delivery system for vaccines and other health-related products

- Examples:
 - Prodigene
 - Epicyte
 - Monsanto
 - Meristem Therapeutic



<http://www.epicyte.com>



Epicyte

- Plant-based manufacture of human monoclonal antibodies (Plantibody™)
 - Partners w/ Dow Chemical & Dow AgroScience
 - Rice and maize = targeted crops
 - Oral, topical, inhaled modes of delivery
 - Herpes simplex virus (clinical trials 2002)
 - Respiratory Syncytial Virus
 - *Clostridium difficile*-associated diarrhea



<http://www.prodigene.com>

Prodigene...

- Maize-based manufacture of...
 - Oral vaccines
 - Hepatitis B
 - Lt-B (*E. coli* toxin assoc. w/ traveler's diarrhea)
 - Transmissible gastroenteritis virus (swine)
 - Therapeutics (e.g., aprotinin)
 - A human therapeutic protein that is commonly used to control blood loss during surgery.
 - Industrial enzymes (e.g., laccase, trypsin)
 - Proteins used in applications such as laundry detergents, paper bleaching and food processing.

Long term goal:

Oral delivery system
for an AIDS vaccine



<http://www.mpt.monsanto.com>

Monsanto Protein Technologies

- Maize-based manufacture of therapeutic proteins.
 - “Monsanto’s experience and technology in corn (maize) has enabled the development of a manufacturing process compatible with the stringency of pharmaceutical and regulatory standards.”
 - “Additionally, pharmaceutical proteins are stable in corn (maize) and can be expressed in large quantities of protein, while potentially lowering the costs of goods.”





<http://www.meristem-therapeutics.com>

Meristem Therapeutics...

- Plant-based manufacture of therapeutic recombinant proteins.
 - Mammalian gastric lipase (maize) for treatment of exocrine pancreatic insufficiency common to cystic fibrosis and pancreatitis patients.
 - Clinical trials at the moment.
 - Human lactoferrin (maize), a natural defense protein against infections.
 - Collagen (tobacco), for skin and tissue repairs.
 - Human serum-albumin (tobacco), to expand blood volume in critical situations (surgery).



New uses via transgenics...

- The use of transgenic technology to develop crops with desirable, but heretofore unachievable, output trait characteristics is accompanied by several challenges.
 - Public acceptance of transgenics to date.
 - Uncertainty about the agronomic acceptability of the resulting varieties.
 - Increased need for I-P segregation at both the farm and grain handler levels.



GE Crop Production Challenges

Public acceptance...



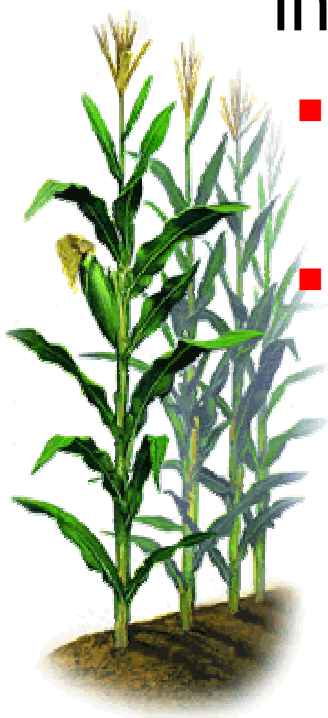
- Most, if not all, of the transgenic agronomic crops commercialized to date have no clear benefit to the consumer.
 - Insect resistant and herbicide tolerant crops benefit primarily the producer.
 - Indirect benefits to the environment.
- The next generation of human health transgenics may lessen public concern.

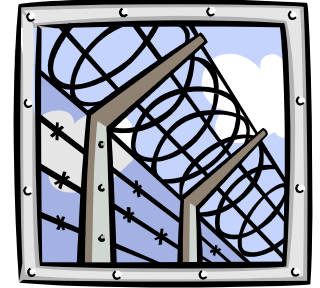


GE Crop Production Challenges

Agronomic adaptability...

- Can be an issue with any specialty grain if the genetic background is “old” or simply deficient in agronomically important traits.
- May not be an issue if value of grain is great enough to compensate for lower yield per acre.
- May not be an issue if grain production is simply a component of a larger vertically integrated manufacturing system (from seed to pill) owned by a single biotechnology firm.

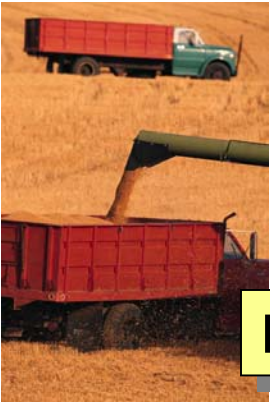
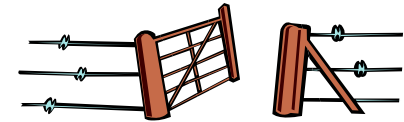




GE Crop Production Challenges

Containment & I-P needs...

- Containment of maize pollen is challenging to say the least.
 - Production in isolation among best options.
 - Genetic pollen incompatibility may be an option.
- Segregation of grain after harvest is achievable, but requires...
 - Additional expense (labor & equipment)
 - Diligence to detail



May not be an issue with vertically integrated systems





Philosophicating on new uses

- Profits associated with new uses will accrue to those who play the “game”.
 - The seed developer
 - The producer
 - The grain buyer
 - The manufacturer
 - The wholesaler or retailer
- Unfortunately, the profits are not often distributed equally to all of the players.



The challenge for producers...

- Figuring out how to participate meaningfully in the profit stream generated from the introduction of a new product or process that uses an enhanced maize trait as an input.
- Producers can...
 - Produce & sell the enhanced maize trait for a significant premium, and/or
 - Participate as an investor or partner in the new venture itself.



Producing for a premium...

- The track record to date for significant price premiums paid to producers for specialty grain production is not particularly encouraging.
 - Buyers and/or end users will always pay the least they possibly can for raw input.
 - Especially if the grain production is part of an overall larger vertically integrated system.



Typical niche markets...

- By definition, fill up quickly.
 - When the demand for the raw input is reasonably low, requiring reasonably few acres to produce, the market can become saturated quickly.
 - Requires producers to wisely identify opportunity early, be the first to participate in contract production, and know when to move to new opportunity before market drops.
 - High oil corn, white corn, waxy starch corn in the U.S.

Participate in profit stream...

- Opportunities exist for producers to cooperatively form new ventures.
 - Corn masa production facility in SW Indiana
 - Targeted at tortilla mfg thousands of miles away in Georgia.
 - Ethanol production facility in NW Indiana
 - Proximity of nearby “mega” dairies offer sales outlet for distillers’ grain by-product high protein or energy grain feed.

<http://www.ces.purdue.edu/extmedia/ID/ID-315.pdf>



A final disclaimer...

“An expert is one who knows more and more about less and less until he knows absolutely everything about nothing.”

-- Nicholas Murray Butler

