USDA United States Department of Agriculture

Risk Assessment Research for Biotechnology

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GMO sorghum is a reality

Ian Godwin, Univ. Queensland

The purpose of this presentation is to generate discussion about research needs for testing and deployment.

GMO approaches have solved problems in other crops

- Insect pests (Corn Root Worm, European Corn Borer)
- Weed control (herbicide resistance)
- Diseases (Papaya Ring Spot Virus, Plum Pox Virus, numerous squash viruses)
- Chemical composition (improved oil composition in canola and high lysine maize)

Future potential:

- Abiotic stress tolerance – Drought, salt, metals
- Stacking traits
- Biofuels Etc.

Example: Bt Maize

Example: RR Soybean

GMO Sorghum could solve problems

- Insect resistance
- Disease resistance
- Bioenergy content & conversion
- Drought resistance
- Chemical composition
- Aluminum tolerance
- Striga resistance
- Weed control

Sorghum Insect Pests

Stalk borer

Clemson University - USDA Cooperative Extension
Slide Series, Bugwood.org

Midge

A. Sparks, TAMU

Sorghum Diseases

Maize dwarf mosaic virus infection on sorghum showing characteristic mottling of leaf
Courtesy Joseph Krausz, Texas Agricultural Extension Service - 1995.

Inadequate herbicide control of weeds

Roundup resistant Johnsongrass (Vila-Aiub et al, 2007; Monsanto Company 2008)

ALS resistant sorghum (Heap, 2008)

GMO Sorghum could create problems

- Gene flow
- Weedy relatives
  - Johnsongrass (*Sorghum halepense*)
  - Shattercane (Sorghum bicolor ssp)
- Non GMO sorghum production
  - Effect on markets
- Genetic erosion in center of diversity
  - How to differentiate from non-GMO

Outcrossing occurs

3% average outcrossing with a range from 0% to 10%

within
Sorghum bicolor

42% average outcrossing with a range from 11% to 68%

within
Sorghum bicolor ssp. *drummundii*

…. and is likely associated with panicle architecture.

(Pedersen et al. 1998)

Johnsongrass

S. halepense

Tetraploid

Invasive

Noxious

Pest reservoir

Can cross with sorghum and produce viable seed.
(Arriola & Ellstrand 1996)

In Great Plains, some Johnsongrass may actually be stable Johnsongrass x sorghum introgrades. (Wunderlin 1998)

Uncontrolled shattercane in soybean

S. bicolor

Diploid

Aggressive weed in sorghum

Crosses easily with cultivated sorghum

Caused as much as 85% yield reduction in maize & soybean prior to effective herbicides

(Fellows & Roeth, 1992; Has & Johnson, 2002)

Sorghum marketed as GMO-free

Sorghum for feed and food

- Functional/Health Food
- Gluten Free
- Antioxidant Dense

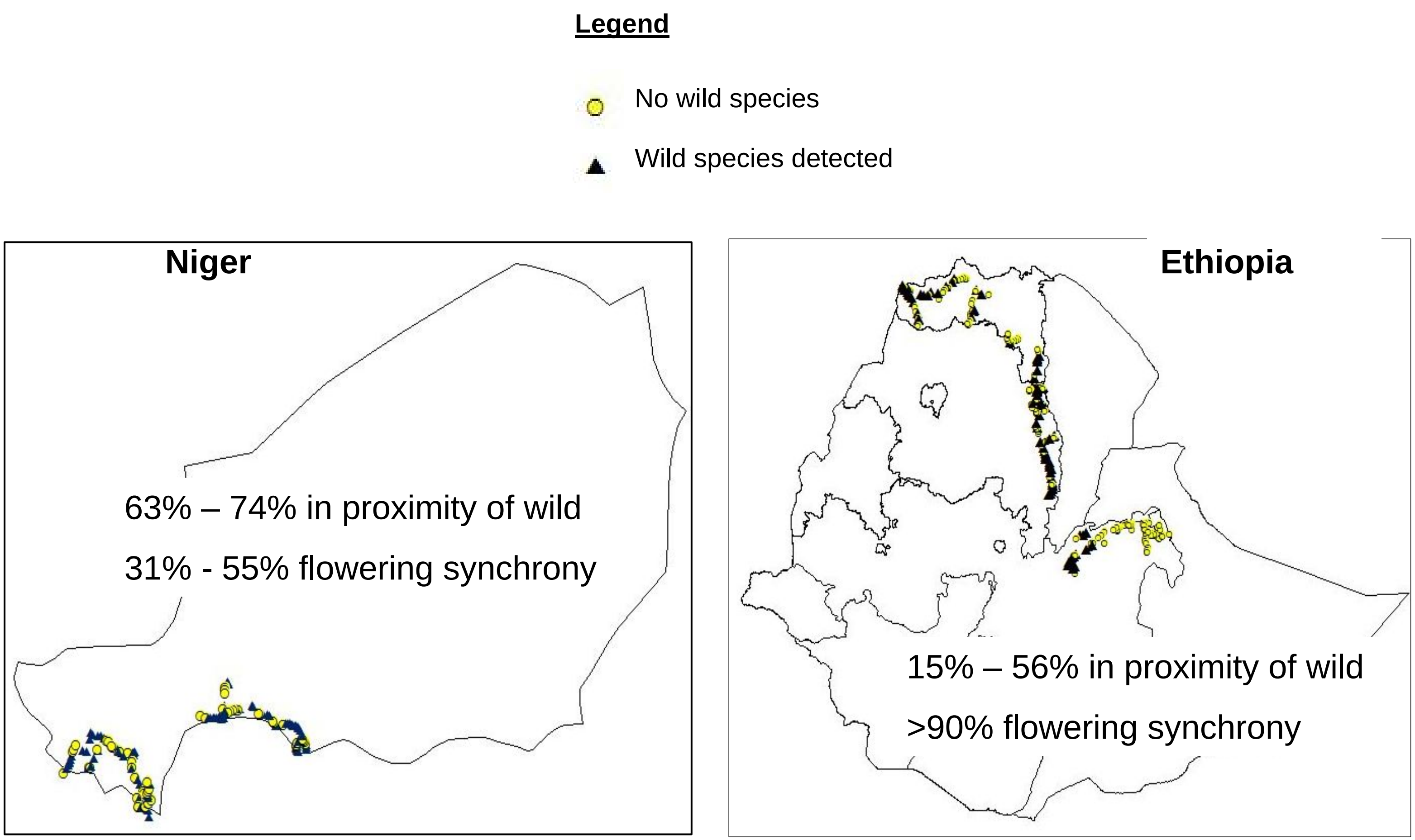
- Other Attributes
  - **GMO Free**
  - Absorbs/Enhances Flavors
  - Environmentally Friendly Production

Center of Diversity & Genetic Erosion

Genetic erosion has been occurring wherever diverse landraces, etc., are displaced by improved varieties and hybrids.

Transgenes or other genes that affect fitness or fecundity depending on the selection pressures acting in the environment could have a larger impact on genetic erosion.

400 site survey in Niger and Ethiopia sorghum-growing region published



(Tesso et al. 2008)

Bio-Containment:

CMS system to prevent gene flow through sorghum pollen

(Pedersen et al. 2003.)

Subsequent discovery of new restoration mechanisms in *Sorghum bicolor* (L.) Moench ssp. *Drummondii*

(Hoang et al. 2007)

APHIS Confinement Recommendations

Susan Koehler, Subray Hegde, Virgil Meier, Neil Hoffman – USDA APHIS BRS

Size (acres)	**Trait of Concern**	**Tillering of GE Variety**	**Bagging**	**Minimum Isolation To Weedy *Sorghum*** during the flowering and seed fill period.	**Minimum Isolation from Cultivated Sorghum** grain, Sorghum grass or broomcorn production or seed production fields
1 or less	Yes	Low or High	Yes	660 ft.	1,320 ft.
>1	Yes	Low or High	Prepare a pest risk assessment and EA and if we can't reach a FONSI, then an EIS. Bagging would be required and isolation distances of at least 1,320 to 2,640 ft. to weedy and cultivated sorghum types, respectively.		
1 or less	No	Low or High	Yes	330 ft.	1,320 ft.
>1	No	Low only	Yes	330 ft.	1,320 ft.
Any size	No	Not applicable	No	2,640 ft.	2,640 ft.

Sorghum has some advantages over other potential biofuel candidates (e.g. switch grass and Miscanthus):

- Mostly selfing, annual, no rhizomes or stolons
- Low seed dormancy
- Less invasive
- Improved varieties and abundant seed supplies
- Biology and agronomic practices well established
- Herbicides and pesticides are already registered
- Both grain and stalk have biofuel applications

Less familiarity with the biology, ecology, and management of other candidate biofuel plant species may warrant a relatively more cautious approach for confinement.

APHIS/BRS

Research Needs for Regulatory Decisions

- Distance and rate of seed dispersal and outcrossing to Sorghum spp. +/- bagging when combined with isolation distance.

- Impact of slitting pollination bags post-anthesis on seed dispersal and seed quality.

- Dormancy or emergence over time (from seed or rhizomes) in different environments, particularly frost-free environments, of sorghum hybrids with johnsongrass or shattercane, and effects of tillage.

- Fertility of transgenic sorghum x weed hybrids

Research Needs for Regulatory Decisions

- Impact of the escaped biofuel and selectable marker transgenes or transgenes that confer higher fitness on the weediness and management of the volunteer or feral transgenic plants, or their weedy hybrids.

- Impact of high biomass producing biofuel crops on soil, water use, water tables, nutrient requirements and nutrient runoff.

- Impact of transgenes on pest susceptibility and wildlife.

- Effectiveness and reliability of biocontainment strategies for transgenes that might have adverse or unknown effects.

Data will be critical for sound deployment decisions

When people learn no tools of judgment and merely follow their hopes, the seeds of political manipulation are sown.

Stephen J. Gould, *An urchin in the storm: Essays about books and ideas,* 1987.