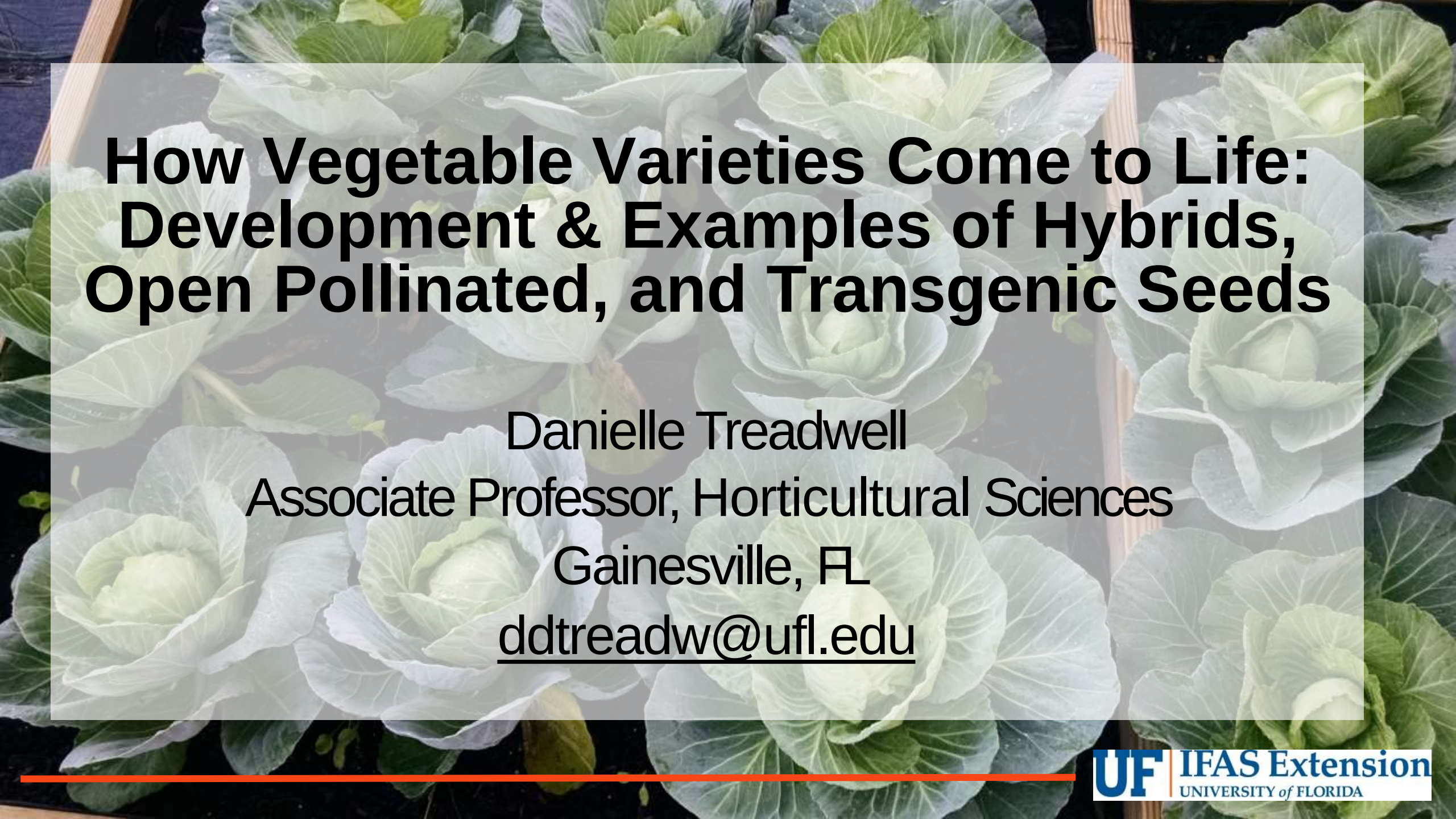


How Vegetable Varieties Come to Life: Development & Examples of Hybrids, Open Pollinated, and Transgenic Seeds

Danielle Treadwell
Associate Professor, Horticultural Sciences
Gainesville, FL
ddtreadw@ufl.edu

UF IFAS Extension
UNIVERSITY of FLORIDA

By the end of this presentation:

1. Define open pollinated, hybrid, transgenic seed, and list synonyms for each
2. Describe how hybrid seed is produced
3. Describe how transgenic seed is produced
4. Name three strategies to conserve genetics in open-pollinated lines
5. Name commercially-available examples of each: hybrid, transgenic and open pollinated

OPEN POLLINATED	HYBRID	TRANSGENIC
How do you define these seed products?		
What are the benefits or “pros” to each?		
What are the challenges or “cons” to each?		

	OPEN POLLINATED	HYBRID	TRANSGENIC
DEFINE	• Seed from crosses of different parents (self, wind, insect)	• Seed from crosses of different parents (humans)	• Seed with insertions or deletions of DNA
PROS	• Breeds true in uniform gene pool • Publically available	• Vigorous, uniform • Pest & disease resistant	• Express specific, intentional characteristics
CONS	• Lacks resistance to pests and disease	• Unstable genetics	• Not available to individuals

Seed Categories

Open Pollinated (OP)

- Breeders can improve or develop OP varieties (‘Green Zebra’)
- Heirloom – OPs that have been in production for 50+ years, has a story, not intentionally bred, and free of commercial constraints/publically available (‘Mortgage Lifter’)

Hybrid (F1)

- Developed from many parental crosses of two different species or varieties to achieve expression of desired traits (‘Silver Queen’)
- Traditional (Mendelian) breeding methods, genomic tools,

Transgenic (GMO)

- Insertion of specific trait(s) to achieve desired expression (pesticide resistance) (Round-up Ready corn)

Saving Open Pollinated Seed

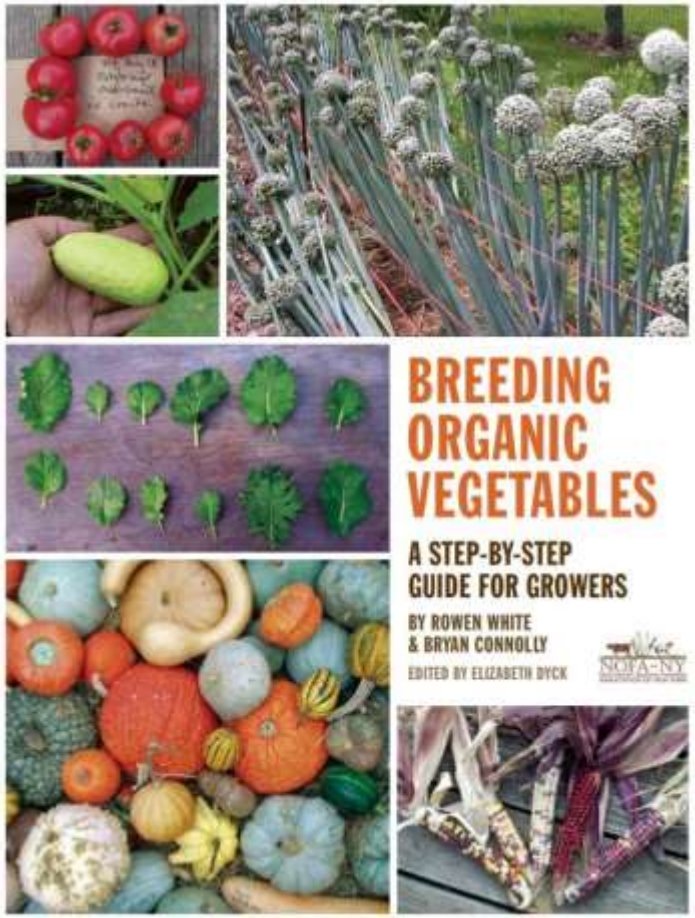
Increasing number of resources to assist with saving seed, and/or generating seed for income. The resources below have a number of references on selecting, planting, planning for isolation, saving, and storing seed.

- Saving Our Seeds
  - http://www.savingourseeds.org/publications.html
- Organic Seed Saving Guide, Organic Seed Alliance
  - https://seedalliance.org/publications/seed-saving-guide-gardeners-farmers/

Breeding Open Pollinated Seed

- Vegetable seed crops must be planted so that sufficient vegetative development occurs to support optimum fruit and seed development.
- The timing of flowering (often different between male and female flowers), soil conditions, and spacing are carefully executed
- Vegetables that are wind pollinated include beet, sweet corn and spinach; Insect pollinated vegetables include most of the cole crops, carrot, and onion.

Breeding Open Pollinated Seed



- Nationally, breeding efforts to develop varieties for organic systems is increasing.
- There are breeders from industry, the university, and from the private sector.
- However, many of the methods used in the NE and NW do not apply to the deep south, and often different characteristics entirely are needed.

Hybrid Seed

Table 1. Estimates of 2015 Global and U.S. Vegetable Seed Concentration				
	Global Sales ($M)	Market Share	Est. U.S. Sales ($M)	Est. U.S. Market Share
Monsanto	$816	22%	$204	24%
Syngenta	$616	17%	$154	18%
Vilmorin	$765	21%	$191	22%
Bayer	$443	12%	$111	13%
Rijk Zwaan	$431	12%	$108	13%
Global CR-4		71%	Est. U.S. CR-4	77%
			Current HHI	1,543
			Post-Merger HHI	2,310

- Bayer – Monsanto merger will likely reduce the choice of varieties that farmers can plant, as companies like Monsanto have shut down brands and reduced their lines after completing mergers.
- Estimates are that the two companies currently control a substantial portion of varieties for many vegetables — 43% of processed spinach, 33% of cantaloupe, 30% of lettuce, and 29% of fresh carrot varieties.

Hybrid Seed

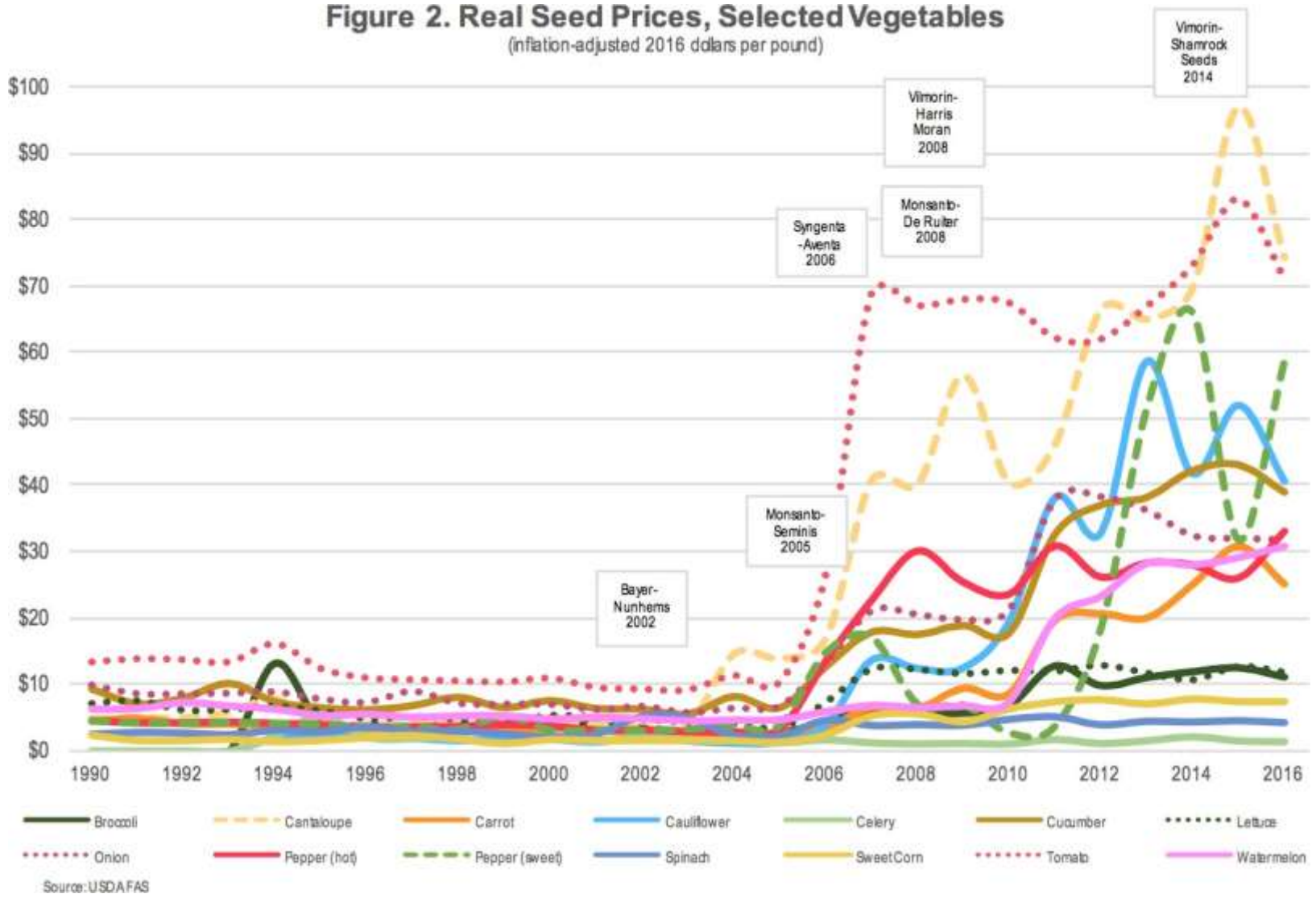


Figure 2. Real Seed Prices, Selected Vegetables
(inflation-adjusted 2016 dollars per pound)
$100
$90
$80
$70
$60
$50
$40
$30
$20
$10
$0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
Vilmorin-Shamrock Seeds 2014
Vilmorin-Harris Moran 2008
Monsanto-De Ruiter 2008
Syngenta-Aventa 2006
Monsanto-Seminis 2005
Bayer-Nunhems 2002
Broccoli
Cantaloupe
Carrot
Cauliflower
Celery
Cucumber
Lettuce
Onion
Pepper (hot)
Pepper (sweet)
Spinach
Sweet Corn
Tomato
Watermelon
Source: USDA FAS

Biotechnology Terms

GENETIC MODIFICATION (GM) – Any change in the genome during breeding and selection. Includes full range of breeding methods and technology.

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Gregor Mendel (1822-1884)

- Austrian monk viewed as the Father of Modern Genetics
- Studied heredity of traits in tens of thousands of pea plants over an 8-year period
- He cross-fertilized peas and described the Law of Segregation (how individual traits are inherited) and the Law of Independent Assortment (how traits are inherited relative to one another or "linked").

Biotechnology Terms

AGRICULTURAL BIOTECHNOLOGY – A set of tools, including traditional breeding methods, that alter organisms or parts of organisms to make or modify products (Bt), improve plants or animals (reduce apple browning) or develop microorganisms for specific agricultural purposes (fermentation).

TRANSGENIC TECHNOLOGY (TT) describes breeding methods that rely on engineered technology. *Transgenic Technology* works by turning something OFF that is normally ON or by turning something ON that is normally OFF or previously not there. Also: **GENETIC ENGINEERING (GE) or MODIFICATION (GM).**

GENETICALLY MODIFIED ORGANISM (GMO) is a commonly used term (not widely accepted by the academic/business community) that is used to describe the product of TT/GE methods.

Biotechnology Terms

TRANSFORMATION - the heritable change in a cell or organism brought about by the uptake and establishment of introduced DNA. There are two primary methods of transformation:

The **"Gene Gun" method** (microprojectile bombardment or biolistics). Literally, shooting gene fragments into DNA with a gun.

The **Agrobacterium method**. *Agrobacterium tumefaciens* is a soil-dwelling bacteria that infects plant cells with a piece of its DNA. Gardeners know this organism because it causes crown gall in ornamentals (location of insertion is everything!) More precise and therefore easier to monitor than the gene gun.

Transgenic Technology - Vegetables

Vegetable	Trait	Patent/Cultivar	Status
Sweet corn*	Earworm/ glyphosate resistant; Bt resistant (plant produce toxic protein)	Attribute ®II and Performance Series ™. Seminis, Monsanto, Syngenta	Sold now in US
Potato	Low acrylamide, resists bruising	J.R. Simplot Co. patent	USDA approved, not on mrkt yet
Rice	Bt resistance, Golden Rice (high beta carotene)	Many patents; Syngenta; Farmers can save seed in developing countries	Bt rice in development; Golden Rice in development
Squash zucchini, yellow crook & straight	Virus resistance (mosaic)	Not named. Syngenta, Monsanto patent	Sold in US and Canada. 25,000 acres
Tomato	Ripen without softening	'FLVR SAVR'	Released 1995. Not produced now. Consumers did not accept.

*Underlines denotes current commercial production in the US

Transgenic Technology - Fruits

Fruit	Trait	Patent	Status
Apple	Non-browning (absence of polyphenol oxidase)	Artic® Apple by Okanagan Specialty Fruits, bought by Intrexon.	Approved in Canada and US.
Papaya	Resists Papaya Ring Spot Virus	'Rainbow' and 'Sunup' by Univ. Hawaii & Cornell	82% GM papaya grown in HI. UF/IFAS will release new cultivar 2015-17

*Underlines denotes current commercial production in the US

Transgenic Technology - Fruits

Fruit	Trait	Patent	Status
Citrus	Greening Resistance	N/A	University of Florida: Germplasm has been developed and successfully (no symptoms of HLB) for 5-6 years. The germplasm has not gone through approvals yet. Will likely take 8+ years before anything is approved and on the market.
Citrus	Greening Resistance	N/A	Southern Gardens Corp. developed germplasm (w/spinach defense gene). EPA, FDA, USDA approved. On market ~2019-2021

Transgenic Technology – Row Crops

Row Crop	Trait	Patent	Status
Alfalfa	Glyphosate resistant (modified amino acid biosynthesis) (Roundup-Ready (RR)	Monsanto	Released 2011
Canola	RR	Monsanto	90% of US crop (2011)
Cotton	RR and Bt	Monsanto	90% of US crop (2011)
Corn	RR and Bt	Monsanto	88% of US crop (2011)
Soybean	RR	Monsanto	94% of US crop (2011) off-patent in 2014
Sugar Beet	RR	Monsanto	95% of US crop (2011)

*Underlines denotes current commercial production in the US

Variety Selection Considerations

Seasons

Spring & Fall – Traditional

Winter – Surprisingly Good

Summer – Tough

Type of Garden

Field-grown

Hoop house, high tunnel or greenhouse

Containers

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Are You Using Strategies to Extend Seasons?

- Diversity of Adapted Crops & Varieties
- Mulches
- Transplants
- Frost Protection
  - Covers
  - Tunnels
- Shade Areas
- Greenhouses

Establishment Methods

Transplanted typically

- Tomato
- Pepper
- Eggplant
- Broccoli
- Cabbage
- Collard
- Watermelon (3X)
- Cantaloupe
- Sweet potato (slips, cutting)

Seeded typically

- Bean
- Southern pea
- English pea
- Sweet corn
- Pumpkin
- Okra
- Turnip
- Radish
- Beet
- Lettuce mixes
- Microgreens

Variety Selection

- Disease Tolerance
- Adapted to Region
- Market Acceptance
- Flavor
- Earliness
- Yield
- Quality
- Familiarity




So Many Seed Sources!

- Seed companies such as Southern Exposure Seed Exchange, Victory Seeds, High Mowing Seeds, and many more…
- Community Gardening Clubs like *Grow Gainesville*
- National non-profits that support diversity such as Seed Savers Exchange
- Local non-profits such as Forage Farms and Working Food, who have missions to support plant diversity and promote seed saving/sharing
- UF/IFAS FNP's Farm to School, Farm to Community Team

WORKING FOOD

FORAGE

https://workingfood.org/

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Cool Season Options

Beets

- Early Wonder
- **Red Ace**
- **Detroit Dark**
- Chiogga
- Tall Top

Broccoli & Cauliflower

- **Broccoli**
  - Emerald Crown
  - Pacman
  - Arcadia
  - **Waltham**
  - Raab
  - Early Green
  - DeCicco
- **Cauliflower**
  - Snowball
  - Brocoverde
  - **Romanesco**
  - **Graffitti (purple)**
  - Cheddar (Yellow)

Carrot

Mostly Nantes and Nantes x Imperator types

- Choctaw
- Apache
- Navajo
- **Scarlett Nantes**
- Danvers 126
- **Purple Haze**

Collards

- Bulldog
- **Flash**
- Top Bunch
- Tiger
- Hi Crop
- Champion
- Vates
- Georgia
- Morris Heading

Over years of experimentation we have found that the hybrid cultivars tend to produce greater yield and more uniform plants than the open pollinated varieties. Hybrid seed also costs more. ~$75 / 4 oz VS. ~$5 / 4 oz

Lettuce

- Buttercrunch
- Sandy - Oak leaf
- Prizehead – loose-leaf
- Red Iceburg
- **Salanova**

Spinach

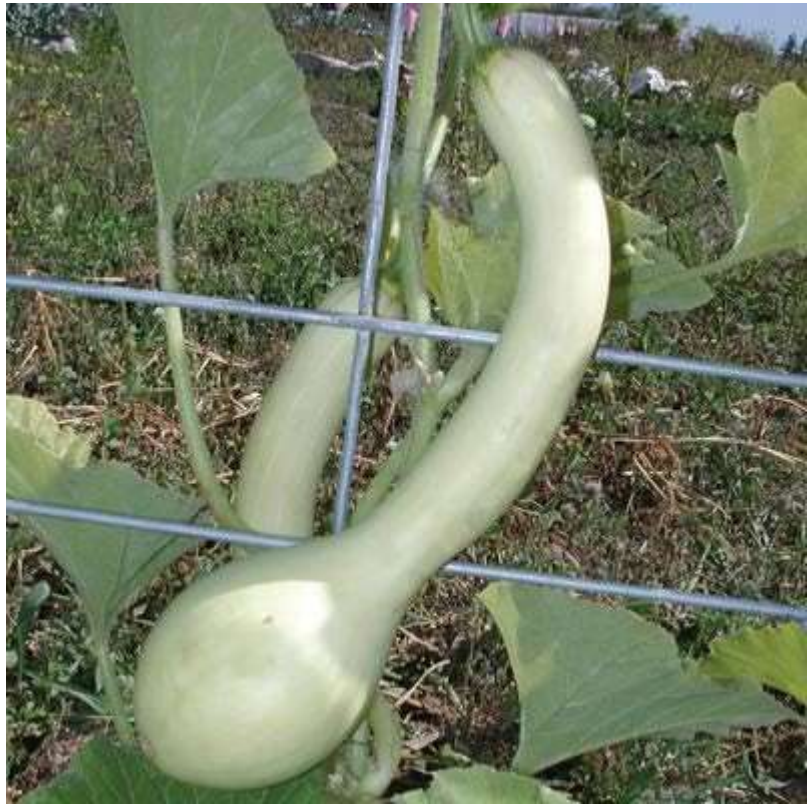
- Okinawa
- Longevity

Turnips

- **Hakurei**
- Purple top
- White Globe

Winter Squash

- Early butternut
- Spaghetti
- **Cushaw**
- **Seminole**
- **Tromboncino**



Warm Season Options

Pole and Bush Beans

- **Kentucky Wonder**
- Rattlesnake

- Contender
- Provider Pole
- Striped Greasy
- Yard Long Noodle
- **Turkey Craw**

Lima Beans

- Jackson Wonder
- Pigeon Pea
- Whippoorwill
- Little Leaf
- Dixie Butterpea
- **Henderson**

Cucumbers

- Slicers
  - Ashley
  - Poinsett
  - Marketmore
  - Straight Eight
  - Lemon
  - Sweet Success
- Pickle
  - A&C Pickling
- **Mexican Sour Gherkin**
  (Baker Seed Company)

Eggplant

- Rosa Bianca
- Ichiban
- Long
- **Black Beauty**
- Diamond
- Dancer – super!

Peppers

- Seasoning Peppers
  - Aji Dulce
  - Banana
  - Carolina Wonder
  - Charleston Belle
  - Marconi
- Colored Bell Peppers
  - California Wonder
  - Revolution
  - Red Night

Sweet Potatoes

- Beauregard
- Covington
- Jewel
- Vardaman
- O’Henry
- Puerto Rico
- Japanese

Sweet Corn

- Silver Queen
- How Sweet it is
- Sweet Riser
- Early Sunglow

Pumpkin

- Ghost
- Baby Bear
- Touch of Autumn
- Peek-A-Boo

Calabaza ‘LaEstrella’

Available from Rupp Seed Co

Tomato

- Sungold
- Arkansas Traveler
- **Everglades (Currant)**
- Black Krim
- Juanne Flamme
- Green Zebra
- Sun Gold
- Juliet
- Homestead

Watermelon

- Ali Baba
- Moon and Stars
- Sugar Baby
- Crimson Sweet
- Jubilee

Cover Crops

How to plant cover crops?

1. Seedbed preparation important.
2. Seed cover crops by:
    1. Broadcast on a rough surface, lightly incorporate with a rake, shallow tiller, or roller. Increase seeding rate by 20%
    2. Drill
3. Garden rate: or every POUND/ACRE of seed recommended, use 0.35 ounces (10g) of seed for 1,000 ft.
    1. Ex.) recommended rate = 50 lb/acre. Recall there are 16 ounces in 1 pound
    2. 50 x 0.35 = 17.5 ounces per 1,000 ft; or 17.5oz/16oz = 1.1 pounds, or = 1 pound + ~2 oz.

Tried and True Summer Cover Crops

COMMON NAME	LATIN NAME	CULTIVARS
Sunn hemp	*Crotalaria juncea* L.	'Tropic Sun'
Cowpea	*Vigna unguiculata* (L.) Walp	'Iron Clay'
Velvet bean	*Mucuna puriens* var. *utilis* (Bort) Merr.	
Sesame	*Sesamum indicum* L.	
Pearl millet	*Pennisetum glaucum* (L.) R. Br.	
Lablab	*Lablab pupureus* (L.)	
Sunflower	*Helianthus annuus*	'Mammoth'

Tried and True Winter Cover Crops

COMMON NAME	LATIN NAME	CULTIVARS
Crimson clover	*Trifolium incarnatum* L.	'Dixie'
Alyce clover	*Alysicarpus ovalifolius*	
Austrian Winter pea	*Pisum sativum spp. Arvense* (L.) Poir.	'Frost'
Daikon radish	*Raphanus sativus* L.	
Triticale	*Triticum aestivum X triticosacale*	
Cereal rye	*Secale cereale*	'FL 401'

Moringa oleifera (L.) Moringa

- Known as: moringa, drumstick tree, horseradish tree, ben oil tree, or benzoil tree
- Tropical nitrogen fixing legume from NW India
- Easily coppiced
- Many health benefits for humans and livestock