UF/IFAS Extension

The Journey to Sustainability Begins with Education

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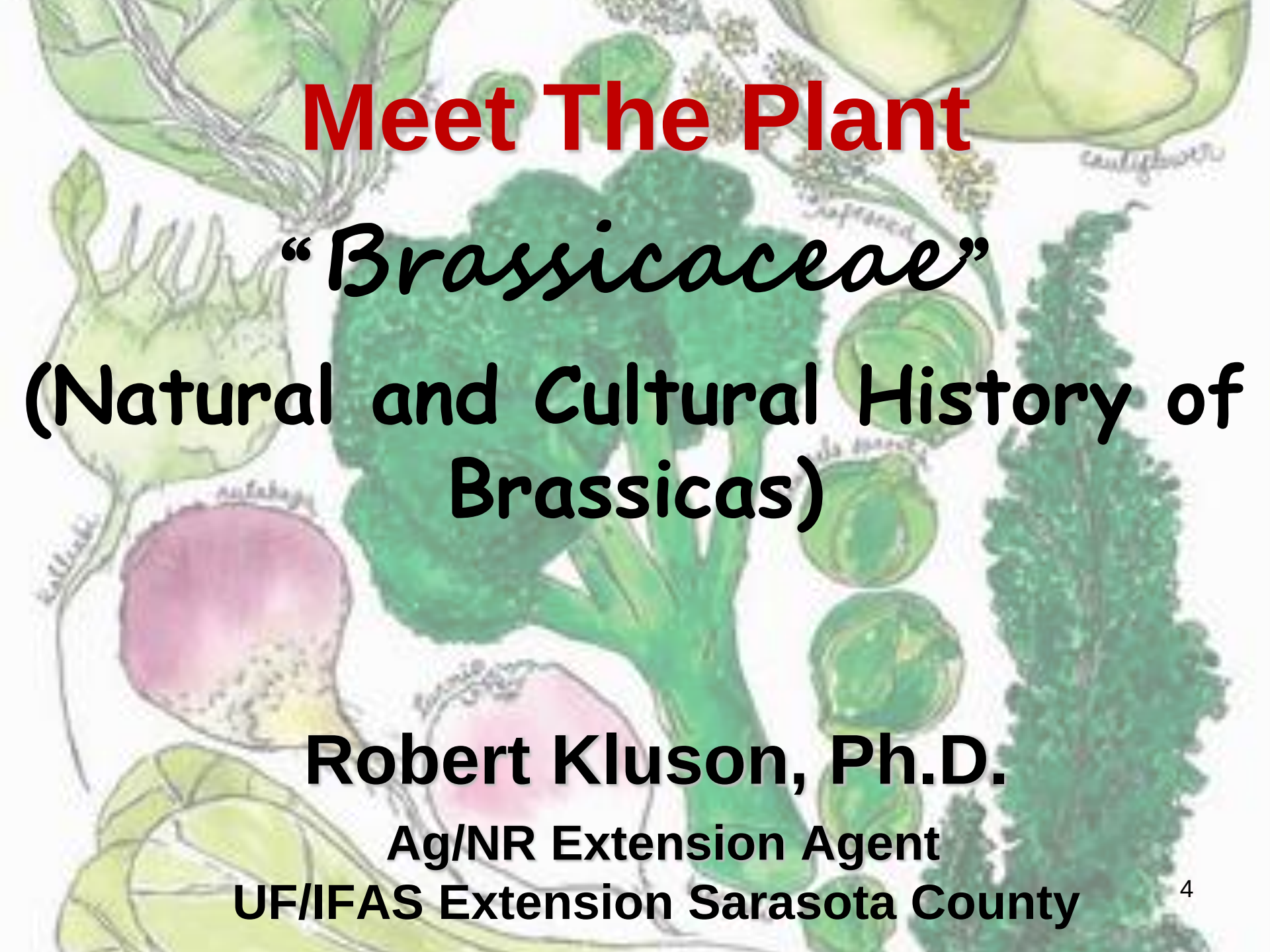
UF UNIVERSITY of FLORIDA
IFAS Extension

UF/IFAS EXTENSION SARASOTA COUNTY

- A partnership between **Sarasota County**, the **University of Florida**, and the **USDA**.
- **Our Mission** is to translate research into community initiatives, classes, and volunteer opportunities related to five core areas:
    - Agriculture;
    - Lawn and Garden;
    - Natural Resources and Sustainability;
    - Nutrition and Healthy Living; and
    - Youth Development -- 4-H

What is Sarasota Extension?



Meet The Plant

"Brassicaceae"

(Natural and Cultural History of Brassicas)

Robert Kluson, Ph.D.

Ag/NR Extension Agent

UF/IFAS Extension Sarasota County

OUTLINE

- Overview of “Meet The Plant” Series
- Introduction to Brassicaceae Family
  - What’s In A Name?
- Natural History
  - Center of origin
  - Phytochemistry
- Agricultural History
  - Worldwide production
  - FL production
  - Nutritional Benefits

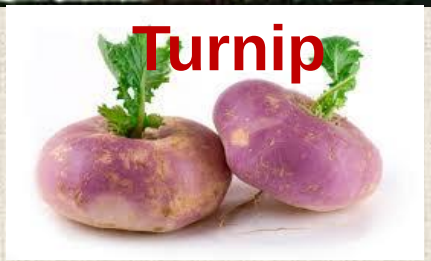
Approach of Talks on "Meet The Plant"

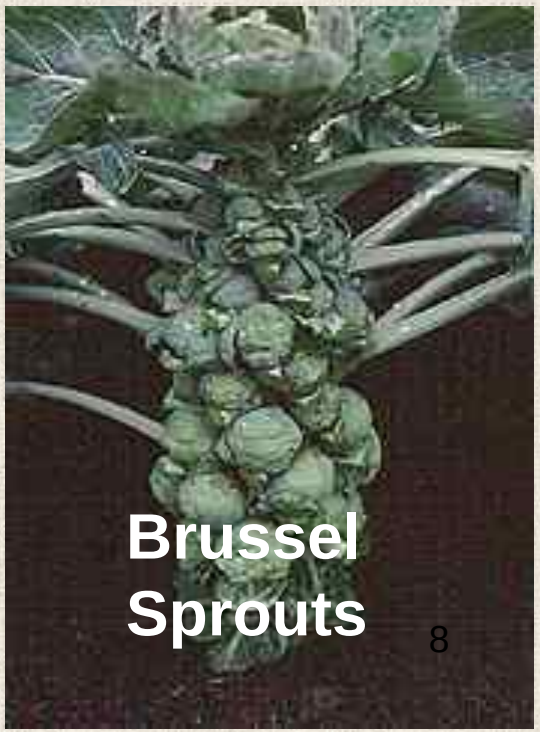
- This series of talks is intended to expand the awareness and familiarity of the general public with different Florida edible crops.
- It's not focused on crop production and management, both at the backyard and farm level.
- Provide background information from the sciences of the natural and agricultural history of FL crops from different plant families.

“Meet The Plant” Series Titles

- Brassicaceae ← Today’s Topic
- Cannabaceae ← Jan 23rd
- Leguminaceae ← Feb 26th
- Solanaceae ← March TBD
- Cucurbitaceae ← April TBD

Brassica Crops – Familiar & Less Familiar



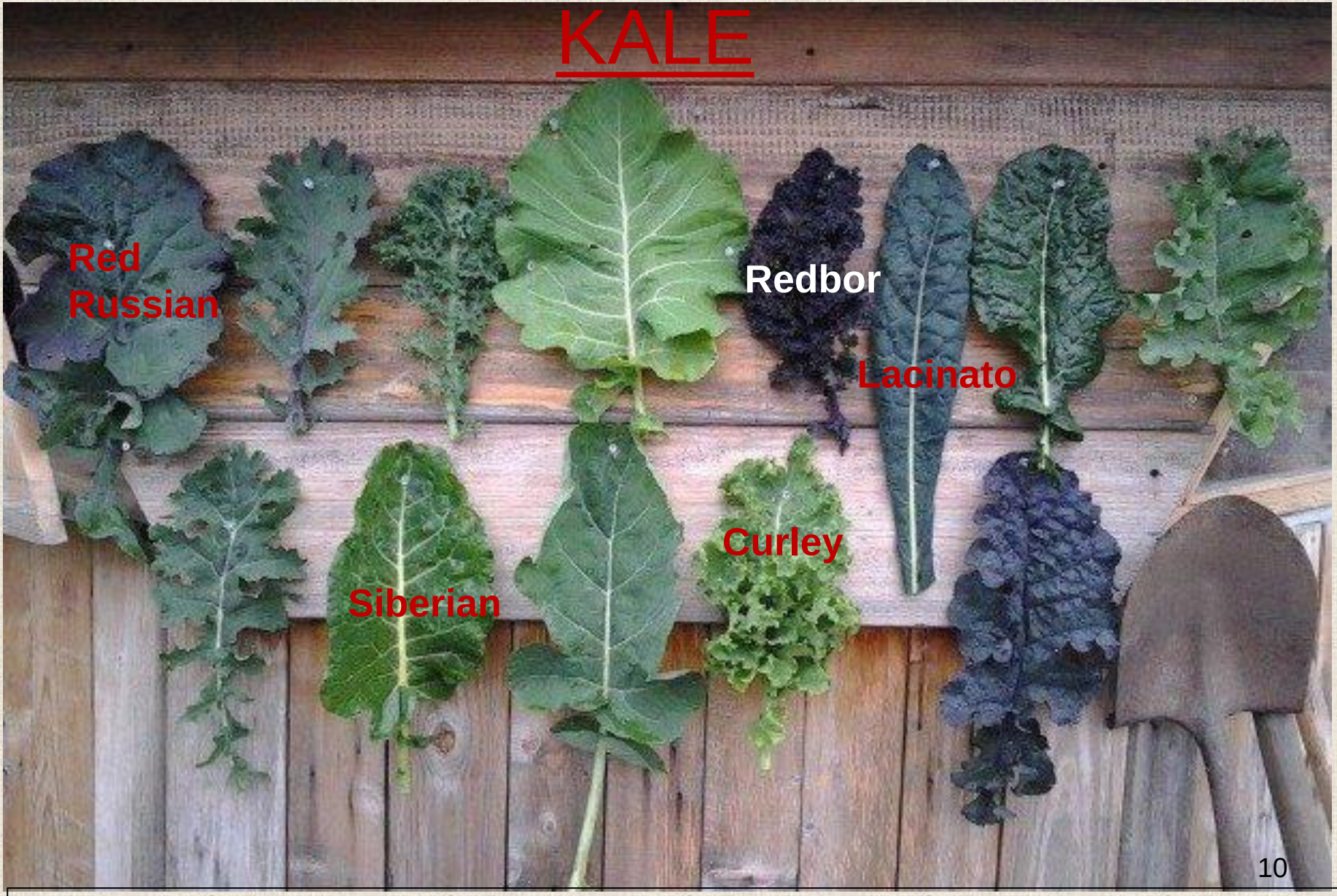


Brassica Crops –Variation Examples

CABBAGE

http://www.hungrymonster.com/food-facts/cabbage_guide.php

Brassica Crops –Variation Examples



https://www.chowhound.com/food-news/177634/ultimate-guide-to-using-different-types-of-kale/

Brassica Crops – Familiar & Less Familiar

What's In A Name?

- Brassicaceae = scientific family name in modern taxonomy
  - Derived from *Brassica*, the type genus, which comes from the Classical Latin word *brassica*, referring to cabbage and other related vegetables
  - The family contains 372 genera and 4,060 accepted species.
  - Crops from this genus are also sometimes called "cole crops"—from the Latin "caulis", meaning stem or cabbage and the German word "Kohl" for cabbage
- Brassicaceae is commonly known as the mustards, the crucifers, or the cabbage family.

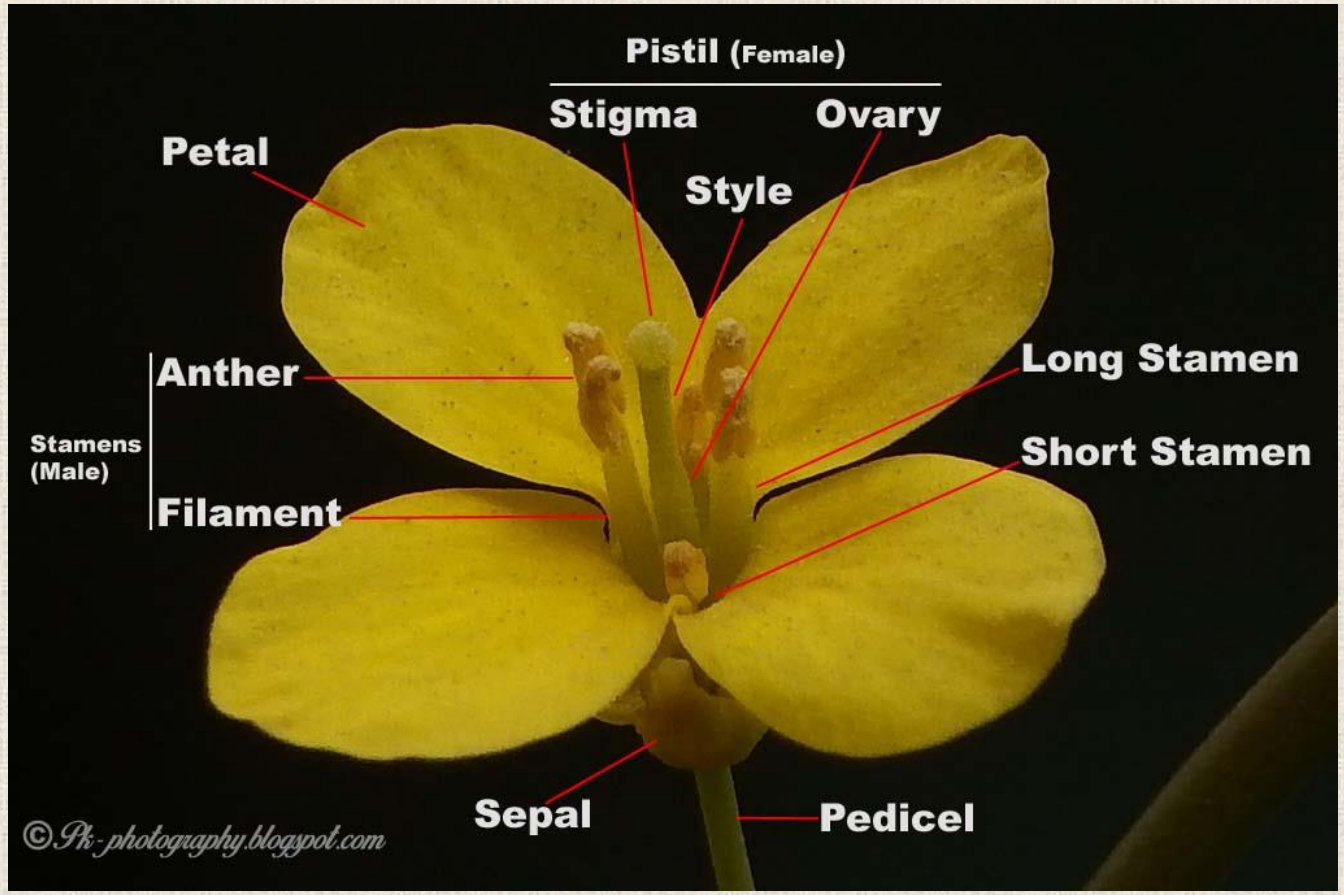
https://en.wikipedia.org/wiki/Brassicaceae

What's In A Name?

- The former name of Brassicaceae is the Cruciferae family and contains the cruciferous vegetables, including species such as
  - *Brassica oleracea* (e.g., broccoli, cabbage, cauliflower, kale, collards),
  - *Brassica rapa* (turnip, Chinese cabbage, etc.)
  - *Brassica napus* (rapeseed, etc.)
  - *Raphanus sativus* (common radish)
  - *Armoracia rusticana* (horseradish)
- The name Cruciferae is derived from Latin for "cross-bearing" based on the four (4) petals of the flowers which is said to resemble a cross.

https://en.wikipedia.org/wiki/Cruciferous_vegetables

Brassica Flower Parts

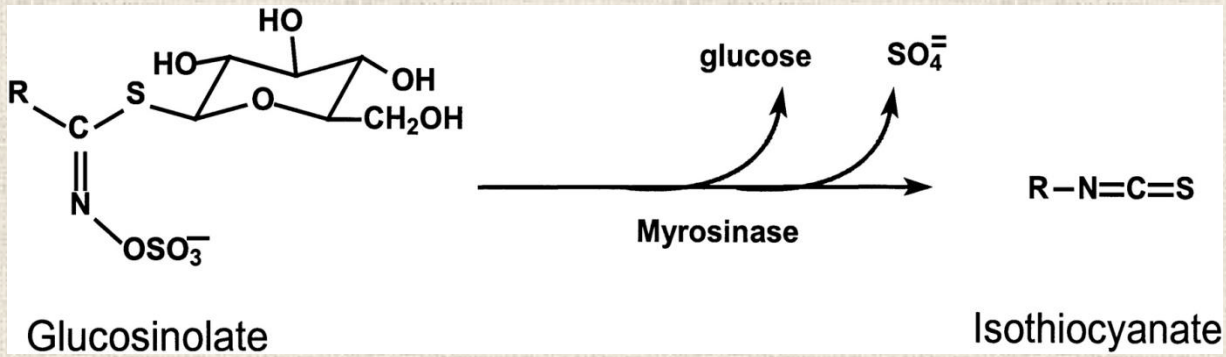


https://pk-photography.blogspot.com/2015/01/brassica-flower-parts.html

NATURAL HISTORY OF BRASSICACEAE

Natural History: Phytochemistry

- A striking and characteristic chemical property of cruciferous plants is their high content of plant secondary compounds called glucosinolates.
- Glucosinolates are the precursors of isothiocyanates (mustard oils). At least 120 chemically distinct glucosinolates have been identified.



https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Natural History: Phytochemistry

- Glucosinolates play important protective and evolutionarily important roles in brassica plants including:
  - **Allelopathy**
    - Suppression of growth of neighboring plants
  - **Specific positive and negative feeding cues**
    - For some insects
  - **Broad antibiotic properties**
    - Including nematocidal, antimicrobial, antifungal, antiprotozoal, and insecticidal activities

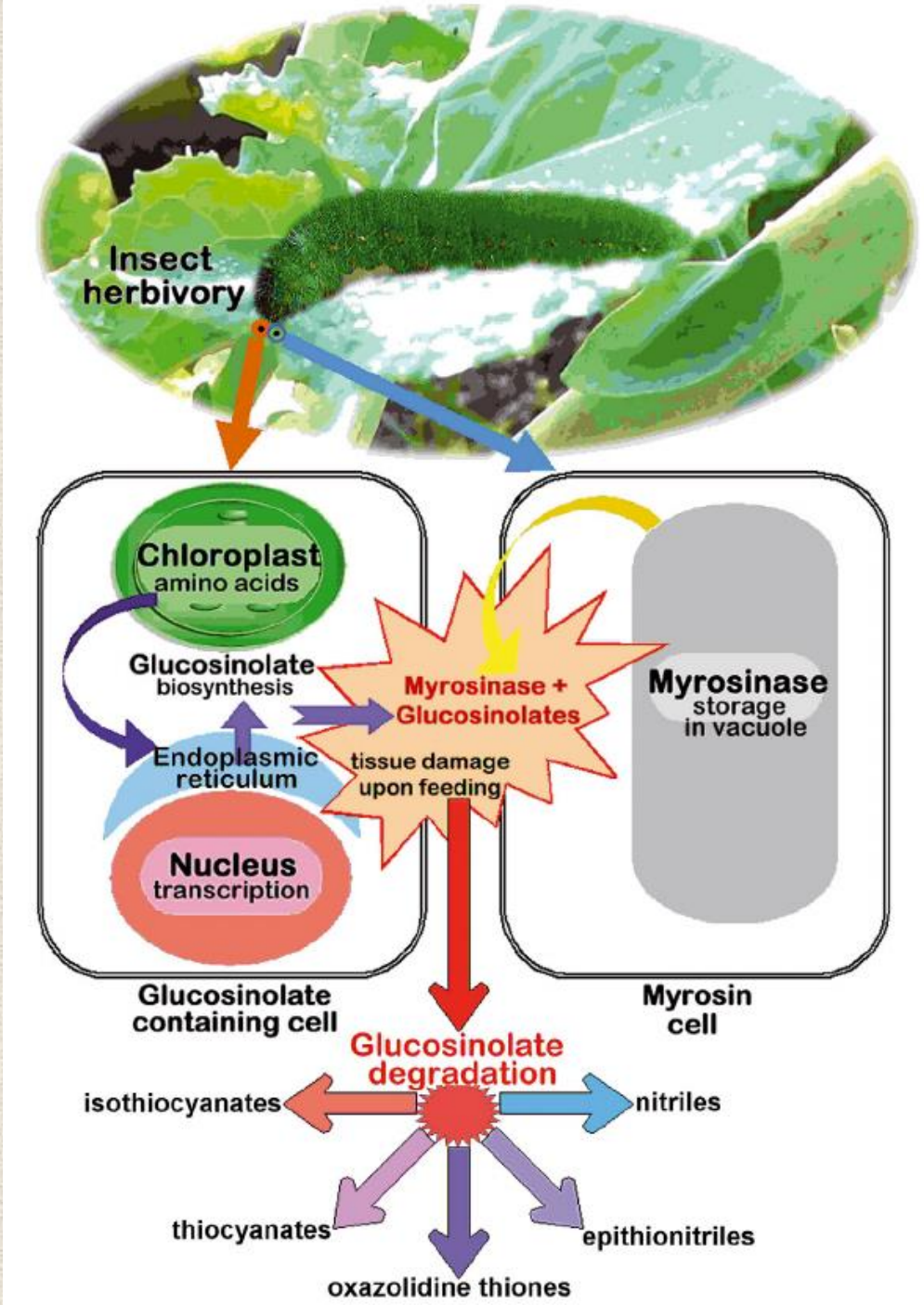
https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Natural History: Phytochemistry

- The major chemical defense of brassicas is based on a two-component activated system composed of non-toxic precursors (the glucosinolates or mustard oils) and plant enzymes (myrosinases).
- These are spatially separated in healthy tissue, but when the tissue is damaged by chewing insects both components are mixed and the so-called ‘mustard oil bomb’ is ignited, producing a series of toxic breakdown products.

https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Natural History: Phytochemistry



Natural History: Phytochemistry

- However, some insects have specialized on cabbage plants and have found various ways to cope with their host plant defenses.
- Among these are pierids (the White butterflies) & relatives, which specialized on these new host plants shortly after the evolutionary appearance of the Brassicaceae and their 'invention' of the glucosinolate-based chemical defense.

Imported Cabbage Worm (*Pieris rapae*)

http://www.e-butterfly.org/the-secret-weapons-of-cabbages-overcome-by-butterfly-co-evolution/

http://entnemdept.ufl.edu/creatures/veg/leaf/imported_cabbageworm.htm

Natural History: Phytochemistry

- Research comparing the evolutionary histories of these plants and butterflies side-by-side, discovered a co-evolution process where the major advances in the chemical defenses of the plants were followed by butterflies evolving counter-tactics that allowed them to keep eating these plants.
- This back-and-forth dynamic was repeated over nearly 80 million years, resulting in the formation of more new species, compared to other groups of plants without glucosinolates and their herbivores.

http://www.e-butterfly.org/the-secret-weapons-of-cabbages-overcome-by-butterfly-co-evolution/

Natural History: Phytochemistry

- Thus, the successful adaptation to glucosinolates enabled this butterfly family to rapidly diversify; and pierids are nowadays widespread with some species being very abundant worldwide, such as the Small White and the Large White.
- Researchers discovered the genetic basis for this arms race. Advances on both sides were driven by the appearance of new copies of genes, rather than by simple point mutations in the plants' and butterflies' DNA.

http://www.e-butterfly.org/the-secret-weapons-of-cabbages-overcome-by-butterfly-co-evolution/

Natural History: Phytochemistry

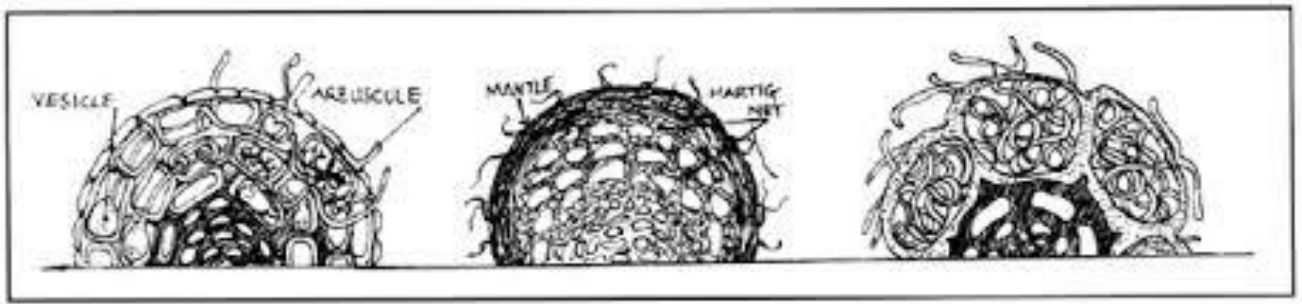
- Brassicas are non-mycorrhizal plants.

2 MAIN TYPES OF MYCORRHIZAE

- ECTOMYCORRHIZAE- the mycelium forms a sheath over the root, but does not penetrate it
- ENDOMYCORRHIZAE - do not form a sheath surrounding the root and hyphae extend into root cell walls (but do not penetrate plasma membrane)
  - More common than ectomycorrhizae, found in over 90% of plant species, including crop plants

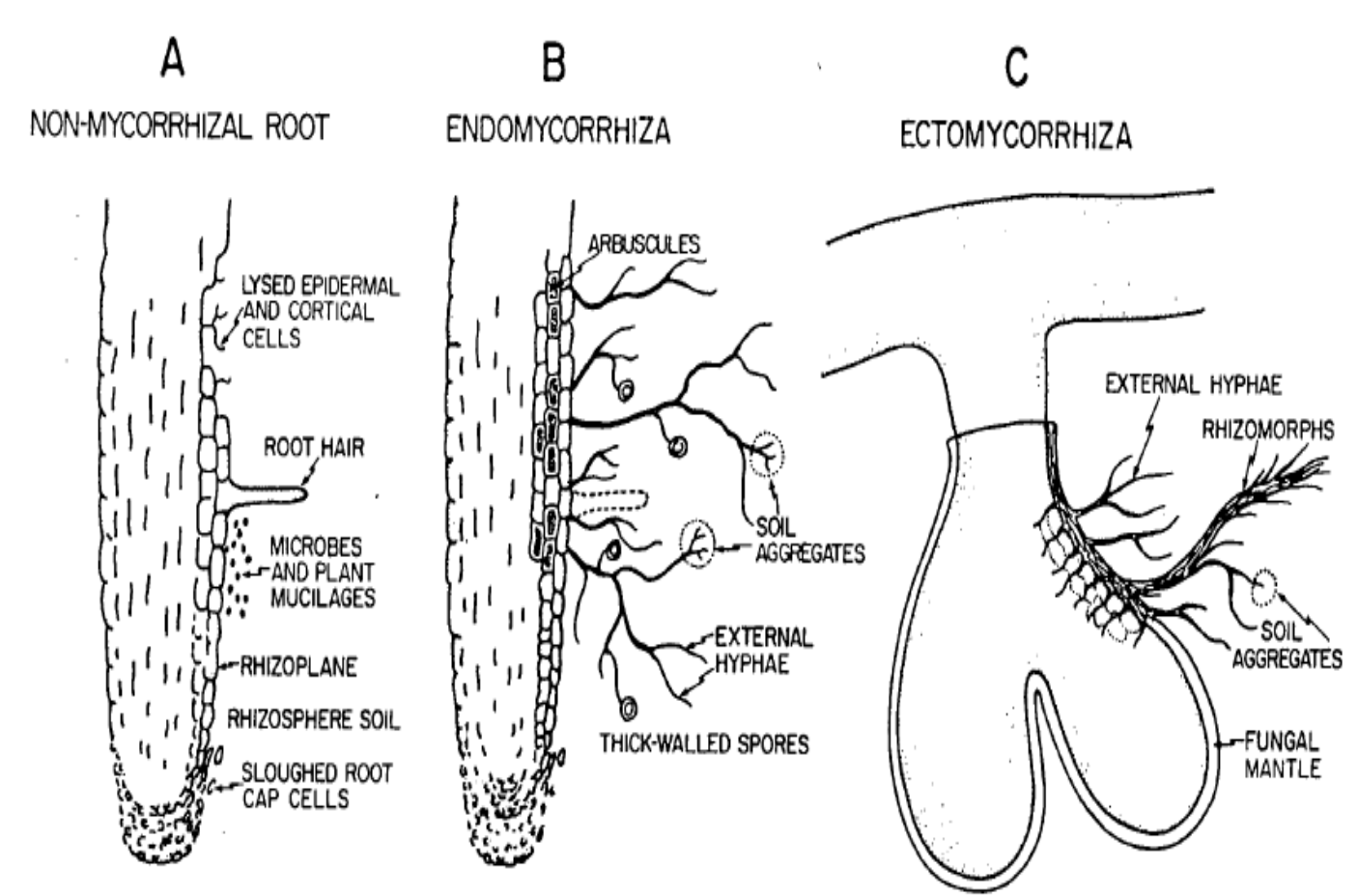
**MYCORRIHIZAE AND ROOT NODULES MAY HAVE AN EVOLUTIONARY RELATIONSHIP

-the same plant genes that are activated in the early stages of nodule formation are the same genes activated during the early development of endomycorrhizae



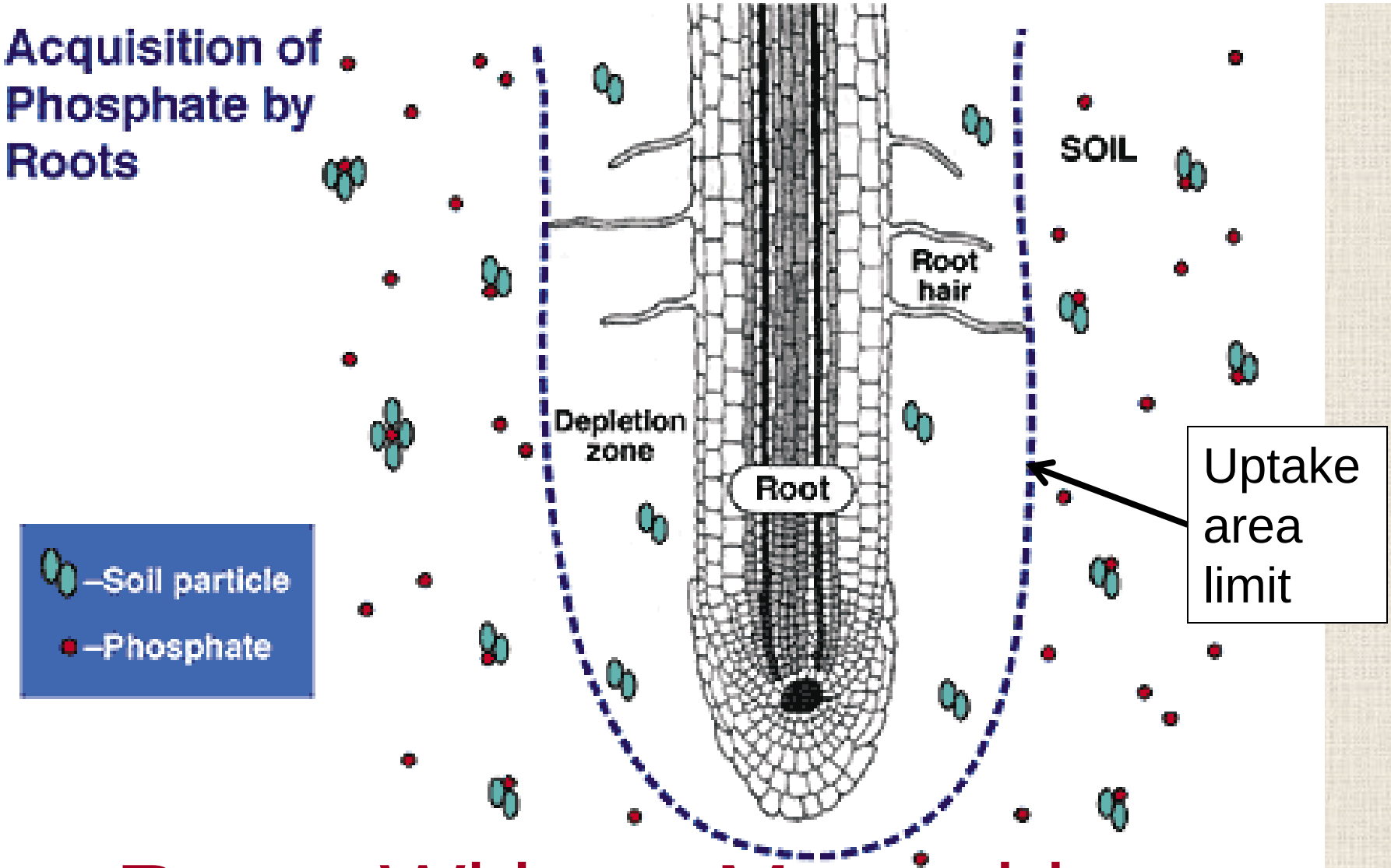
What Are Mycorhizae?

- ✓ Myco (fungi) + rhizae (root)
- ✓ Serves as an expanded root system that provides water and nutrient benefits to plant host
- ✓ More that 90 % of all plants are mycorrhizal



Pfleger and Linderman, 1994, Mycorrhizae and Plant Health.

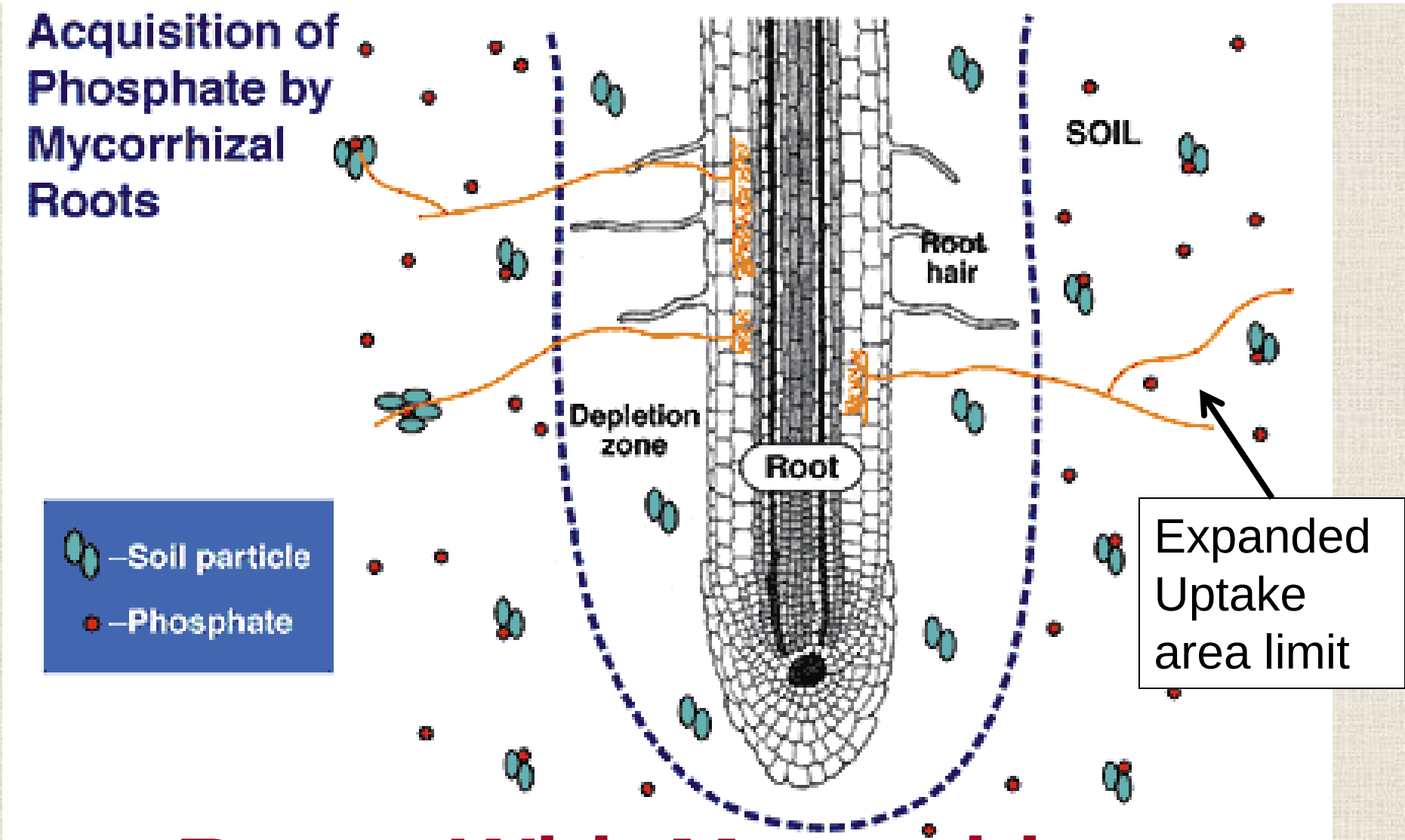
Mycorhizae Mutualism Benefit



Roots Without Mycorrhizae

Source: Harrison et al 1999

Mycorhizae Mutualism Benefit



Roots <u>With</u> Mycorrhizae

Source: Harrison et al. 1999

Management Factors With Impacts on Mycorrhizae Mutualism

- Mycorrhizae maintenance in soil require annual replenishment of soil spores via infection of living roots and/or inoculation
- Avoid excessive use of the following:
  - soluble P fertilizers (including excessive compost additions)
  - soil disturbance and/or tillage
  - fallow soils

Biotic Factors With Impacts on Mycorrhizae Mutualism

- Allelopathic plants can negatively impact mycorrhizae
- Brassicas allelopathy via release of glucosinolates and degradation products have been shown to reduce mycorrhizae infecion and growth of mycorrhizal plants
- For example, dense infestations of black mustard weeds in pastures reduces the density of mycorrhizal plants and biodiversity

Experiment of Brassica Impacts on Mycorrhizae Mutualism of Beans

- Intercropping of cabbage and beans

Brassica/Beans Intercropping Experiment

- Methodology

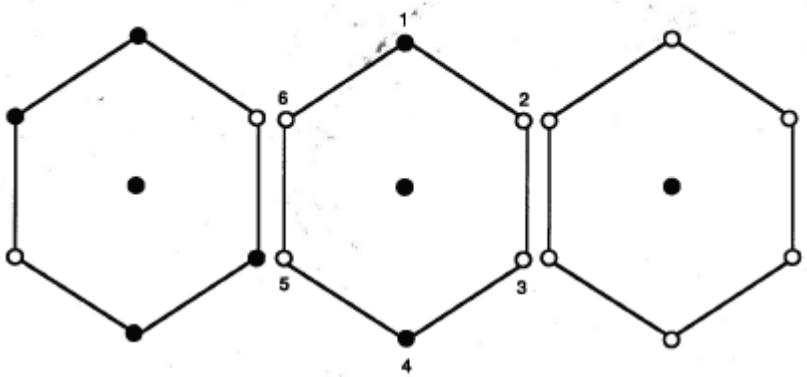


Figure 1. Replacement series of different intercrop treatments. Numbers refer to positions in the hexagonal configuration of plants. Proportions are calculated on a density basis.

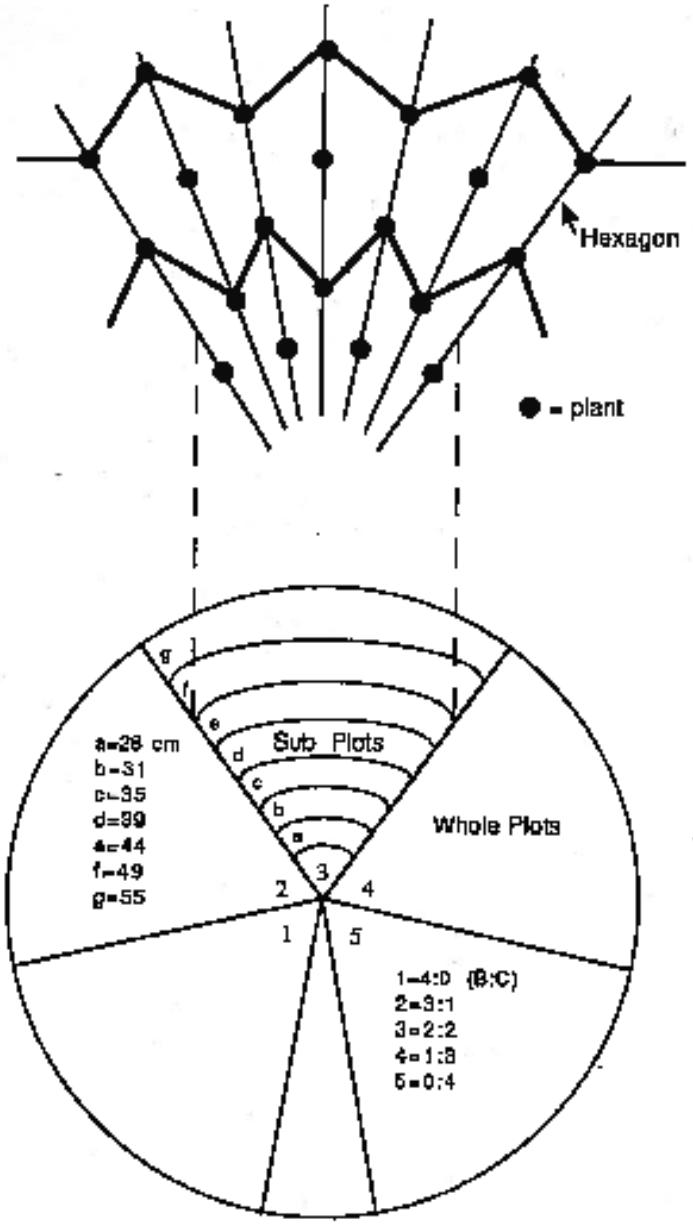
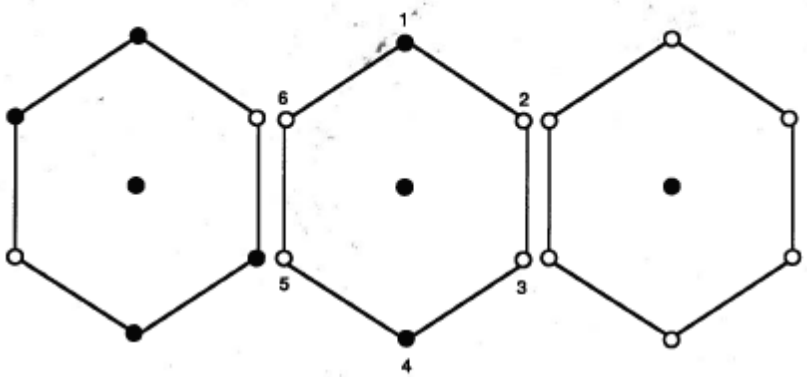


Figure 2. Nelder Fan experimental design with hexa configuration of neighbors around a central plant.

Whole plots = proportion of bean (B):cabbage (C)
Subplots = spacing between plants

Brassica/Beans Intercropping Experiment

- Methodology



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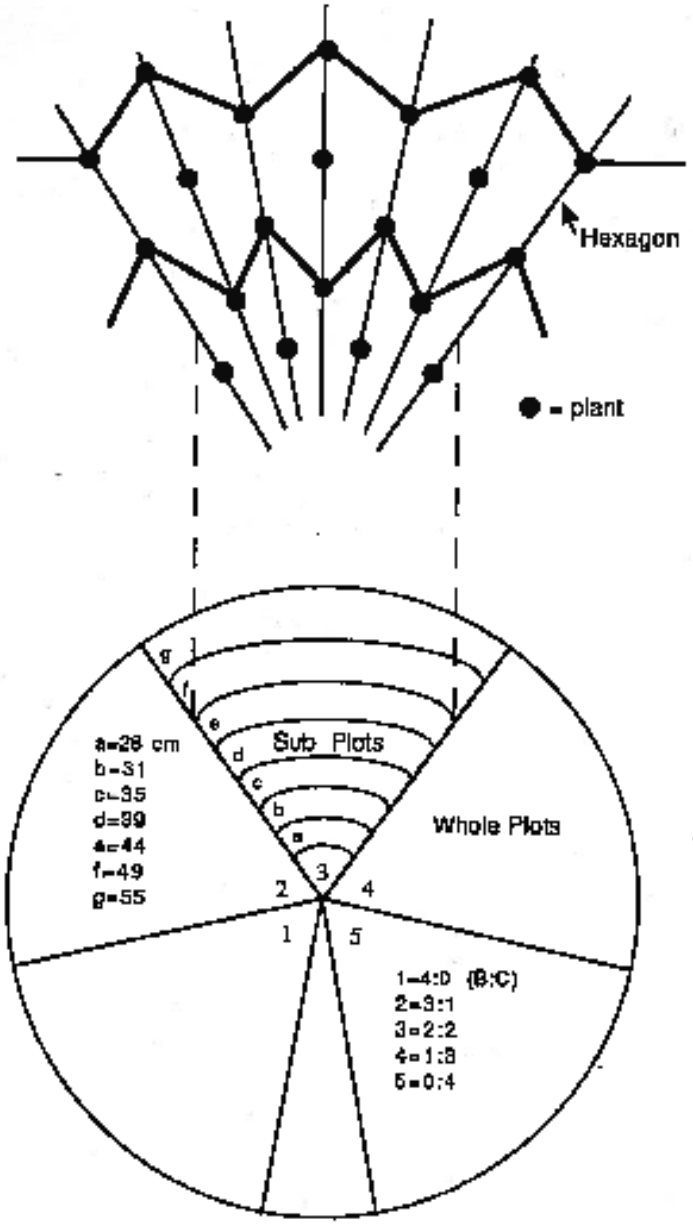

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Brassica/Beans Intercropping Experiment

- Results

Table 3a-c. Cabbage Effects on the Nodule Weight of Bean Plants when Intercropped. Statistical Analyses Done with Orthogonal Contrasts for Response Trends to Proportion and Spacing of Cabbage and for Class Comparisons of Diversity vs Density Effects.

a) Nodule Dry Weight (g plant^{-1})

Bean:Cabbage Relative Proportion	Plant Spacing (cm)							* AVG # 1
	28	31	35	39	44	49	55	
4 : 0	.093	.090	---	.077	.090	.103	.090	.090
3 : 1	---	.063	---	---	.073	.090	.097	.080
2 : 2	---	.110	---	.087	.130	---	.117	.120
1 : 3	.109	.087	---	---	.210	---	.267	.216
AVG # 2	N/A	.090	N/A	N/A	.120	N/A	.143	

* = average for each cabbage proportion (AVG #1) was calculated only with data from pre-selected spacings of 31, 44 & 55 cm.
-- = data was not collected.
N/A = calculation is not appropriate due to uncollected data for each cabbage proportion.

Brassica/Beans Intercropping Experiment

- Results

Table 4a-c. Cabbage Effects on the VAM Infection of Bean Plants when Intercropped. Statistical Analyses Done with Orthogonal Contrasts for Response Trends to Relative Proportion and Plant Spacing of Cabbage in Six Neighboring Plants and for Class Comparisons of Density vs Diversity Effects.

a) VAM Infection (%)

Bean:Cabbage Relative Proportion	Plant Spacing (cm)							* AVG # 1
	28	31	35	39	44	49	55	
4 : 0	71.4	56.1	---	61.2	58.7	64.0	56.5	57.1
3 : 1	---	63.0	---	---	56.7	57.5	63.7	61.1
2 : 2	---	46.6	---	40.3	41.1	---	51.4	44.8
1 : 3	27.9	31.3	---	---	32.4	---	39.2	34.3
AVG # 2	N/A	49.2	N/A	N/A	47.3	N/A	52.7	

See Table 3a for legend.

Brassica/Beans Intercropping Experiment

- Results

Table 15. Bean Effects on Harvest Index and Land Equivalent Ratio of Cabbage When Intercropped.

Harvest index (%) and LER of cabbage market yield

Bean:Cabbage Proportion	Plant Spacing (cm)							AVG # 1
	28	31	35	39	44	49	55	
0 : 4	50.5 .000	49.3 .000	48.9 .000	52.3 .000	56.7 .975	54.0 1.00	57.6 .920	52.8 .965
1 : 3	50.6 .000	45.4 .000	47.8 .000	49.0 .000	51.5 .785	49.1 .647	50.0 .622	49.1 .685
2 : 2	48.4 .000	49.6 .000	50.2 .000	51.8 .000	49.5 .515	51.3 .536	51.3 .421	50.0 .491
3 : 1	50.3 .000	48.3 .000	50.4 .000	56.2 .449	57.6 .365	57.0 .364	57.0 .241	53.4 .323
AVG # 2	49.9 .000	48.2 .000	49.3 .000	52.3 .112	53.8 .660	52.8 .637	52.8 .610	

Top value = harvest index
Bottom value = LER of cabbage only

Where:

Harvest index = ((harvest weight plant^{-1}) ÷ (total weight plant^{-1})) x 100

Minimum market weight = 60 g plant^{-1} of harvest weight due to market size standards

Market weight plant^{-1} = (harvest index) x (total weight plant^{-1})

Market Yield = (market weight plant^{-1}) x (plants hectare^{-1})

LER = (intercrop market yield) ÷ (monocrop market yield)

AVG #1 of LER is based only on values at 44, 49 & 50 cm.

AGRICULTURAL HISTORY OF BRASSICACEAE

Brassica Crops

- Cruciferous vegetables are a major food crop contributing to the diet of millions of people and are of significant importance for agricultural economies worldwide.
- They have been independently domesticated for consumption, industrial products, and medicine in Europe, the Middle East, and Asia.
- Using a combination of molecular phylogenetics, diversification analysis, and historical biogeography, research has shown that brassica crops were developed from hybrids after 20 M years of genetic divergence of parental wild types.

https://www.ncbi.nlm.nih.gov/pubmed/24388963

Brassica Crops

Origin and Domestication

- Wild relatives include kales and other non-heading cabbages, and seakale are thought to be wild forms
- Center of origin – southern Europe and the Mediterranean region
- First domesticated types were annual, and non-heading
- All traditional cultivated types arose as natural mutations or selections

Hybridization & Polyploidization of Weeds Produced Crops!

Rapeseed/canola

B. campestris: turnip
2n = 2x = 20
AA

B. juncea: brown mustard
2n = 4x = 36
AABB

B. napus: rapes, swedes
2n = 4x = 38
AACC

B. nigra: black mustard
2n = 2x = 16
BB

B. oleracea: cabbages, kale
2n = 2x = 18
CC

B. carinata: Ethiopian mustard
2n = 2x = 34
BBCC

Brassica Crop Botany

- Almost all parts of some species of Brassica have been developed for food
  - root (rutabaga, turnips)
  - stems (kohlrabi)
  - leaves (cabbage, collard greens),
  - flowers (cauliflower, broccoli)
  - buds (Brussels sprouts, cabbage)
  - seeds (mustard seed and canola).
- And many species provide food from multiple parts of the same plant

http://edis.ifas.ufl.edu/pi042

Brassica Food Crops

Table 1: Brassicaceae Food Crops		
Common Name	**Scientific Name**	**Plant Part Eaten**
Horseradish	*Armoracia rustica*	Root, leaf, sprouted seed
Upland cress	*Barbarea verna*	Leaf
Mustards	*Brassica juncea*	Leaf, stems and seeds
Rutabaga	*Brassica napus* var. *napobrassica*	Root, leaf
Rape	*Brassica napus* var. *napus*	Leaf, flower stalk
Kale and collards	*Brassica oleracea* var. *acephala*	Leaf
Chinese kale or Chinese broccoli	*Brassica oleracea* var. *alboglabra*	Leaf, flower stalk
Cauliflower	*Brassica oleracea* var. *botrytis*	Immature flower stalk
Cabbage	*Brassica oleracea* var. *capitata*	Leaf
Portuguese cabbage	*Brassica oleracea* var. *costata*	Leaf and inflorescence
Brussels sprouts	*Brassica oleracea* var. *gemmifera*	Axillary bud
Kohlrabi	*Brassica oleracea* var. *gongylodes*	Enlarged stem
Broccoli	*Brassica oleracea* var. *italica*	Immature flower stalk
Savoy cabbage	*Brassica oleracea* var. *sabauda*	Leaf

https://attra.ncat.org/attra-pub/viewhtml.php?id=27

Brassica Food Crops

Bok choi, Pak choi	*Brassica rapa* var. *chinensis*	Leaf
Mizuma	*Brassica rapa* var. *japonica*	Leaf
Kotasuma	*Brassica rapa* var *komatsuma*	Leaf
Rosette pak choi	*Brassica rapa* var. *narinosa*	Leaf
Choi sum, Mock pak choi	*Brassica rapa* var. *parachinensis*	Leaf
Chinese cabbage, nappa	*Brassica rapa* var. *pekinensis*	Leaf
Turnip	*Brassica rapa* var. *rapa*	Enlarged root, leaf
Rapine, Broccoli-raap	*Brassica rapa* var. *ruvo*	Leaf and young flower stalk
Arugula	*Eruca vesicaria*	Leaf
Garden cress	*Lepidium sativum*	Leaf
Watercress	*Nasturtium officinale*	Leaf
Radish	*Raphanus sativus* Radicula group	Root
Daikon	*Raphanus sativus* Daikon group	Root
White mustard	*Sinapis alba*	Leaf and young flower stalk
Wasabi	*Wasabia japonica*	Rhizome, shoots
adapted from: Maynard and Hochmuth, 1997 and Larkcom, 1991.		

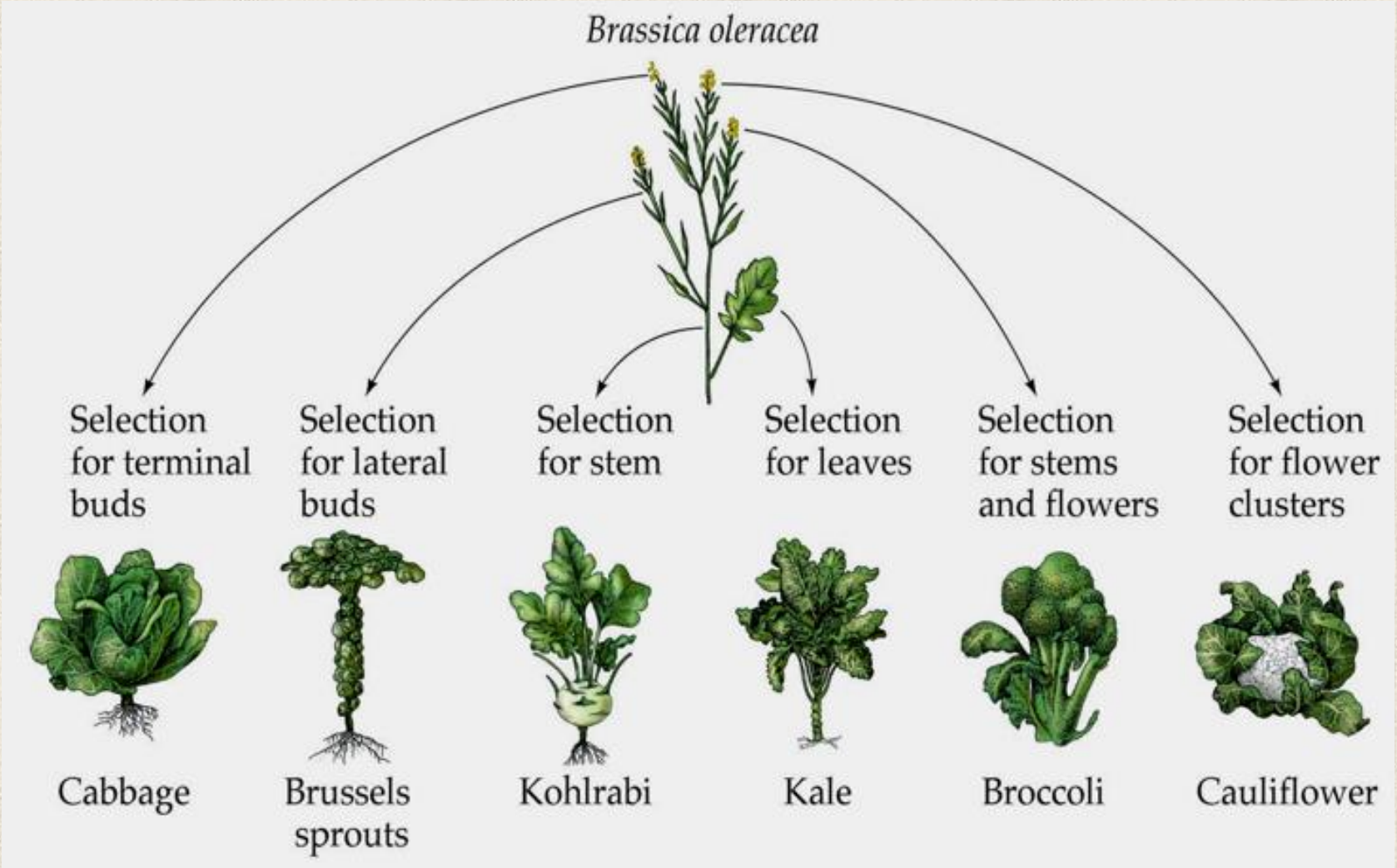
https://attra.ncat.org/attra-pub/viewhtml.php?id=27

What's In A Name?

- Cabbage = from Latin caulis "cabbage" (originally "stem, stalk); also Old French caboche or caboce "head," a diminutive from Latin caput "head"
- Cauliflower = "flowering stem" - originally cole florye, from Italian cavoli fiori "flowered cabbage"
- Broccoli = from the Italian plural of *broccolo*, which means "the flowering crest of a cabbage"
- Kohlrabi - also kohl-rabi, kohl rabi; kohl = cabbage; rabi = root; a turnip cabbage, 1807, from German Kohlrabi
- Kale – from Scottish and northern English for kohl
- Brussel Sprouts - first appeared in northern Europe during the fifth century, later being cultivated in the thirteenth century near Brussels from which they derived their name

https://www.etymonline.com/

What's In A Name?



Brassica Crops

History and Domestication

- Evidence of non-heading forms used in 2500 BC
- Kale – described by Theophrastus in 350 BC
- Kohlrabi possibly appeared around 1 AD
- Soft-head cabbage – described by Pliny in 1 AD
- Broccoli – imported into Rome around 400-600 AD
- Cauliflower first described in 1544 AD
- First written description of brussel sprouts in 1587

Brassica Crops

History and Domestication Example: Cauliflower and Broccoli

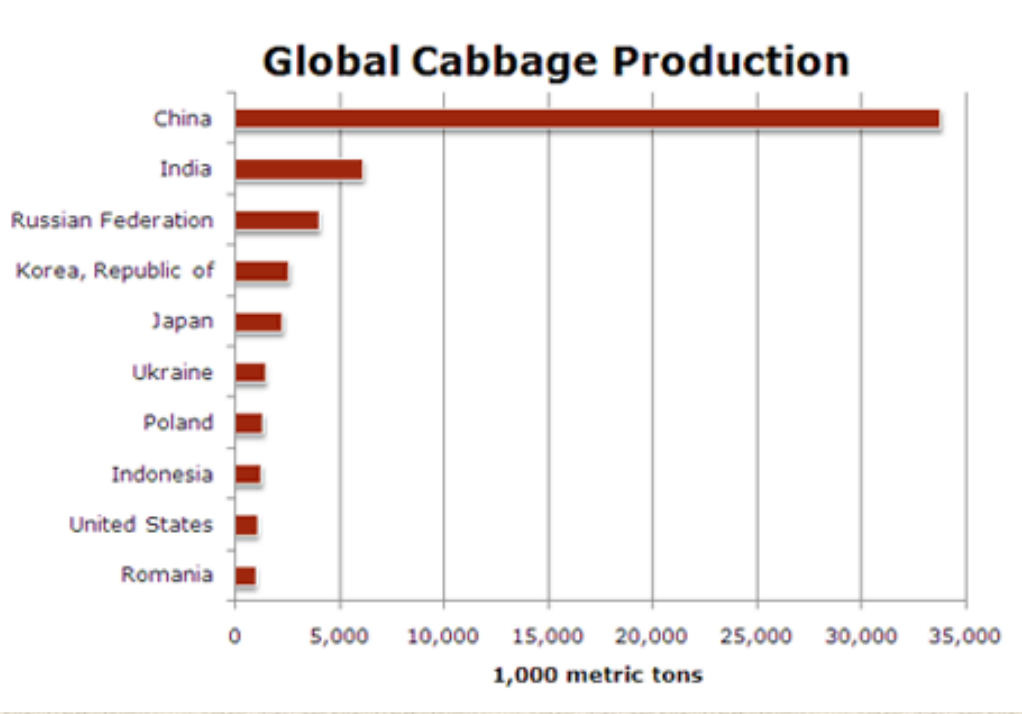
- The evolution of cauliflower and broccoli would seem to have taken place in the Mediterranean basin, in particular in its east coast.
- The intense trading relationships between numerous countries of the Mediterranean area in Roman times supported the spread and exchange of genetic materials in several regions.
- During this period the evolution processes probably led to adaptation to different soil-climatic conditions by the several ssp. of B. oleracea.
- The cultivation and selection of genotypes with interesting agronomical and qualitative traits permitted the identification of several types and forms of cauliflower and broccoli.

https://www.researchgate.net/publication/234154254_Branca_F_2008_Cauliflower_and_broccoli_In_J_Prohens_and_F_Nuez_eds_Vegetables_I_147-182_Springer_New_York

Brassica Crops:

Cabbage

Worldwide Production



- Major producing areas, China, India, northern Europe, North America
- Common in modern-intensive, market garden, and subsistence systems
- Historically very important in the slavic countries

FL Crops Production Statistics

- 2015 value of production for the seven major vegetable crops, potatoes, berries and watermelons totaled $1.50 billion

Rank	Crop
1	Tomatoes
2	Strawberries
3	Bell peppers
4	Sweet corn
5	Potatoes
6	Watermelons
7	Snap beans
8	Cucumbers
9	Cabbage
10	Squash

http://www.freshfromflorida.com/Divisions-Offices/Marketing-and-Development/Education/For-Researchers/Florida-Agriculture-Overview-and-Statistics

FL Cabbage Crop Production Statistics (2010)

- Ranks third nationally in the production of fresh market cabbage, accounting for approximately 13% of U.S. cabbage production.
- Ranks third in terms of harvested acres, accounting for approximately 15% of national cabbage acreage.
- Ranks third in terms of cabbage yield and second in terms of crop value.
- Florida's crop contributes 8% to the total national value of fresh market cabbage

http://edis.ifas.ufl.edu/pi042

FL Cabbage Crop Production Statistics (2010)

- The Hastings area in northeast Florida (Flagler and St. Johns Counties) is the principal cabbage-producing region in the state, representing 20% of the state's cabbage growers and 53.4% of cabbage acreage.
- Palm Beach County, in southeast Florida, is another important cabbage-producing area, accounting for 11% of growers and 12.6% of acreage.
- Remaining cabbage production is found throughout the state.

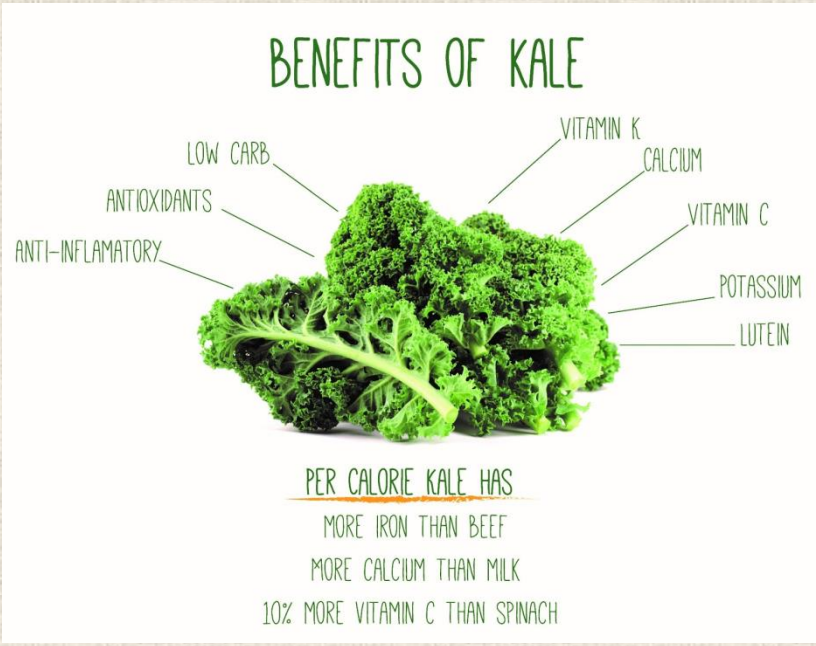
http://edis.ifas.ufl.edu/pi042

Brassica Crops

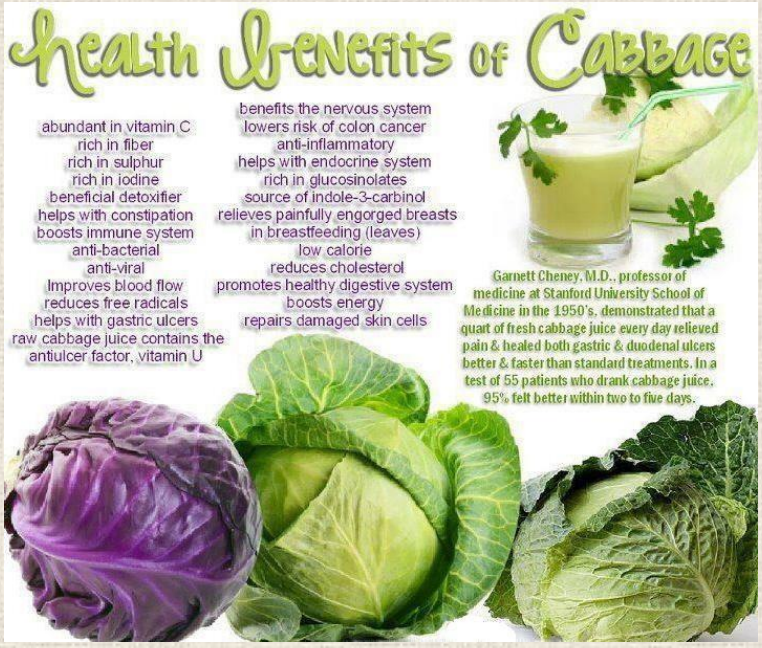
Nutrition & Health Benefits

- Low in carbohydrates, fats, calories
- Good source of protein (balanced), minerals, vitamin A, vitamin C, other vitamins
- Includes antioxidants – ascorbic acid, tocopherols, carotenoids, isothiocyanates, indoles, flavanoids


10 Health Benefits of...
Cauliflower
1. Assists Kidney & Bladder Disorders
2. Contains Many Beneficial Minerals
3. Improves Healthy Cell Growth
4. Blood and Liver Detoxifier
5. Healthy Cholesterol Level
6. Reduce Cancer Risk
7. Purifies Blood
8. Anti-Oxidant
9. Rich in Fibre
10. Anti-Cancer
EatHealthyLiveFit.com


BENEFITS OF KALE
LOW CARB
ANTIOXIDANTS
ANTI-INFLAMATORY
VITAMIN K
CALCIUM
VITAMIN C
POTASSIUM
LUTEIN
PER CALORIE KALE HAS
MORE IRON THAN BEEF
MORE CALCIUM THAN MILK
10% MORE VITAMIN C THAN SPINACH


Health Benefits of
Brussels Sprouts
• fight inflammation
• prevent bladder, breast, colon, lung, prostate, and ovarian cancer
• lower your cholesterol
• prevent constipation
• supports immune function
• good source of folic acid
• detoxify the body
RawForBeauty.com


Health Benefits of Cabbage
abundant in vitamin C
rich in fiber
rich in sulphur
rich in iodine
beneficial detoxifier
helps with constipation
boosts immune system
anti-bacterial
anti-viral
Improves blood flow
reduces free radicals
helps with gastric ulcers
raw cabbage juice contains the antiulcer factor, vitamin U
benefits the nervous system
lowers risk of colon cancer
anti-inflammatory
helps with endocrine system
rich in glucosinolates
source of indole-3-carbinol
relieves painfully engorged breasts in breastfeeding (leaves)
low calorie
reduces cholesterol
promotes healthy digestive system
boosts energy
repairs damaged skin cells
Garnett Cheney, M.D., professor of medicine at Stanford University School of Medicine in the 1950's, demonstrated that a quart of fresh cabbage juice every day relieved pain & healed both gastric & duodenal ulcers better & faster than standard treatments. In a test of 55 patients who drank cabbage juice, 95% felt better within two to five days.

Phytonutrients

- The bioactivity of Glucosinolate breakdown products can be appealing to humans in certain concentrations, as well as deterrent or toxic to unadapted herbivores.
- For example, research with glucosinolates and their isothiocyanate hydrolysis (breakdown) products have demonstrated them as protectors against carcinogenesis, suggesting that greater intakes of these vegetables may lower the risk of several types of cancer.
- With the absence of myrosinase (e.g., when food is cooked and myrosinase is heat inactivated), humans have the ability to efficiently convert glucosinolates to isothiocynates through the action of microflora in the GI tract.

https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Glucosinolate Cancer Research

- The history of these developments can be first traced from the comprehensive review by S.S. Hess (J. of Nutr.,1999) of research involving the carcinogen NNK from cigarettes, and its inhibition by several isothiocyanates.
- Evidence of the inverse association between crucifer consumption and cancer comes from several sources:
  - ✓ Bladder cancer: Michaud and colleagues analyzed 252 cases of bladder cancer that developed in 47,909 health professionals during a 10-y period. They reported the multivariate risk reduction (RR) ratio for cruciferous vegetables consumption was highly significant (J. Natl. Cancer Inst., 1999)

https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Glucosinolate Cancer Research

- Evidence of the inverse association between crucifer consumption and cancer comes from several sources (cont.):
  - ✓ Prostrate cancer: Cohen et al. examined the relationship between fruit and vegetable consumption and prostate cancer incidence in men <65 y of age. Consumption of cruciferous vegetables were clearly protective when risk was adjusted for total vegetable consumption and other variables (J. Natl. Cancer Inst., 2000)
  - ✓ Breast cancer: A case-controlled study in China found that intake of cruciferous vegetables was inversely related to the risk of breast cancer. The quartile with the highest intake had only 50% of the risk of the lowest intake group
  - ✓ Non-Hodgkin's lymphoma: In the Nurses' Health Study, a high intake of cruciferous vegetables was associated with a 33% lower risk.

https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

Brassica Crops

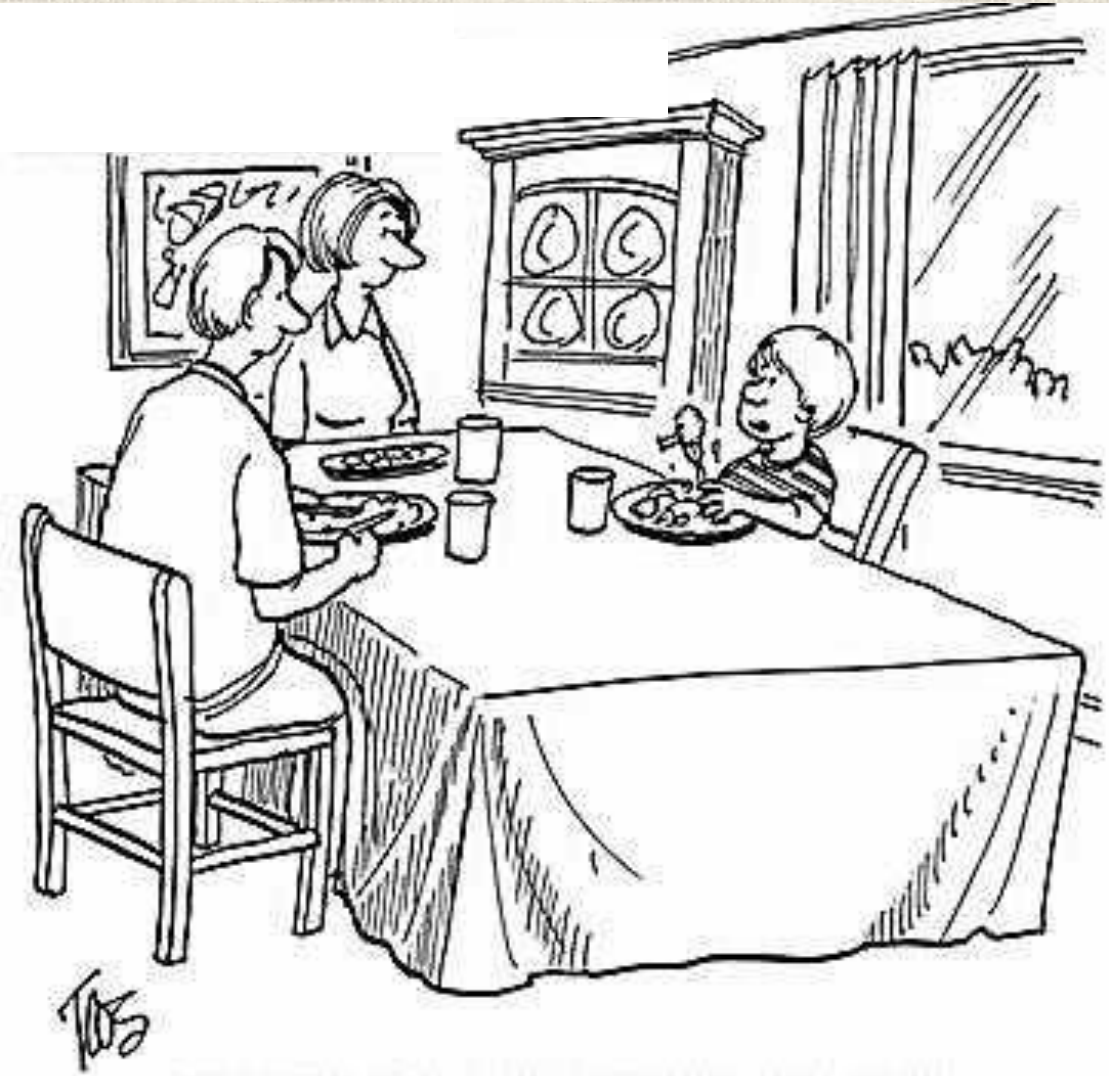
Toxicity

- Contain glucosinolate compounds

  Converted to: isothiocyanates, thiocyanates, nitriles, goitrin

- Possible to interfere with thyroxine production. Associated with goiter (thyroid enlargement)

- Low glucosinolate varieties are bred



"Broccoli is biodegradable, you know,
in case you want to throw it out before I eat it."

Thank You

ACKNOWLEDGEMENT

Stephen L. Love
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1693 S 2700 W, Aberdeen, ID 83210
“Vegetable Crops–PLSC 451/551
Lesson 20, Cole Crops, Cabbage”

Online Resources

• Arias, T., et. al. 2014. Diversification Times Among Brassica (Brassicaceae) Crops Suggest Hybrid Formation After 20 Million Years of Divergence – see https://www.ncbi.nlm.nih.gov/pubmed/24388963

• Branca F., 2008. Cauliflower and broccoli – see https://www.researchgate.net/publication/234154254_Branca_F_2008_Cauliflower_and_broccoli_In_J_Prohens_and_F_Nuez_eds_Vegetables_I_147-182_Springer_New_York

• Edger, P.P., et. al. 2015. The butterfly plant arms-race escalated by gene and genome duplications – see http://www.pnas.org/content/112/27/8362/

• Innes, J. 2016. Our Ancient and Diverse Brassica vegetables – see http://collections.jic.ac.uk/our-ancient-and-diverse-brassica-vegetables/

• Roy, H., S. Lundy, & P. Brantley. Health Benefits of Cruciferous Vegetables – see https://www.pbrc.edu/division-of-education/ppt/Cruciferous_Vegetables.ppt

• Smith, K. 2015. How Kale Went From A Gross Garnish To A Pop Culture Icon, One Salad At A Time – see https://www.buzzfeed.com/kevinsmith/heres-why-kale-is-so-damn-sexy?utm_term=.twe5V0x6y#.hdAKV2mjd

Online Resources

- UF/IFAS EDIS
  - Cole Crops – see http://edis.ifas.ufl.edu/topic_cole_crops
  - Florida Crop/Pest Management Profile: Cabbage – see http://edis.ifas.ufl.edu/pi042