DIAMONDBACK MOTH: ONE OF SEVERAL INSECT PESTS OF CONCERN

Growing Produce

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Cornell AgriTech, Geneva, NY

Cornell AgriTech
New York State Agricultural Experiment Station

OUTLINE

- Define cole crops
- Common pests of cole crops
- Identification of pests
- Management of pests

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WHAT IS A COLE CROP?

- A lot of variation in what is considered cole crop:
  - kale, collards, kohlrabi, cabbage, Brussels sprouts, broccoli, cauliflower, Chinese broccoli, Chinese cabbage, Chinese mustard, oriental, radish, mustard, and turnips

WHAT IS A COLE CROP?

- A lot of variation in what is considered cole crop:
  - **kale, collards, kohlrabi, cabbage, Brussels sprouts, broccoli, cauliflower**, Chinese broccoli, Chinese cabbage, Chinese mustard, oriental, radish, mustard, and turnips
- All members of cole crop family are usually of the same species:
  - *Brassica oleracea*

2013-2015 USDA AG STATISTICS

Fresh-Market Crop	Avg. Acreage	Avg. Value (million $)
Cabbage	8,600	67.8
Snap Bean	16,200	56.6
Potato	10,500	53.3
Sweet Corn	20,300	50.6
Onion	7,700	35.3
Squash	4,500	31.5
Tomato	2,700	29.3
Pumpkin	5,600	20.5
Cucumber	1,900	12.2
Cauliflower	500	2.7
TOTAL	78,500	359.8

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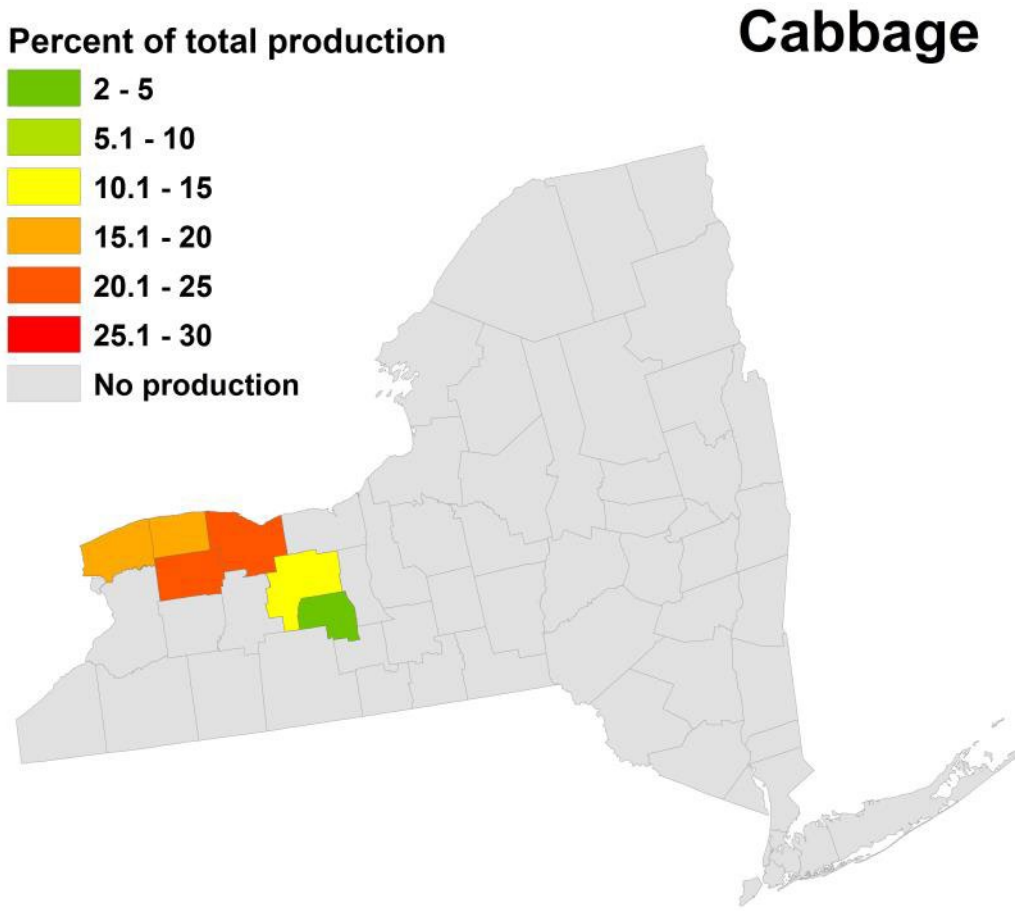
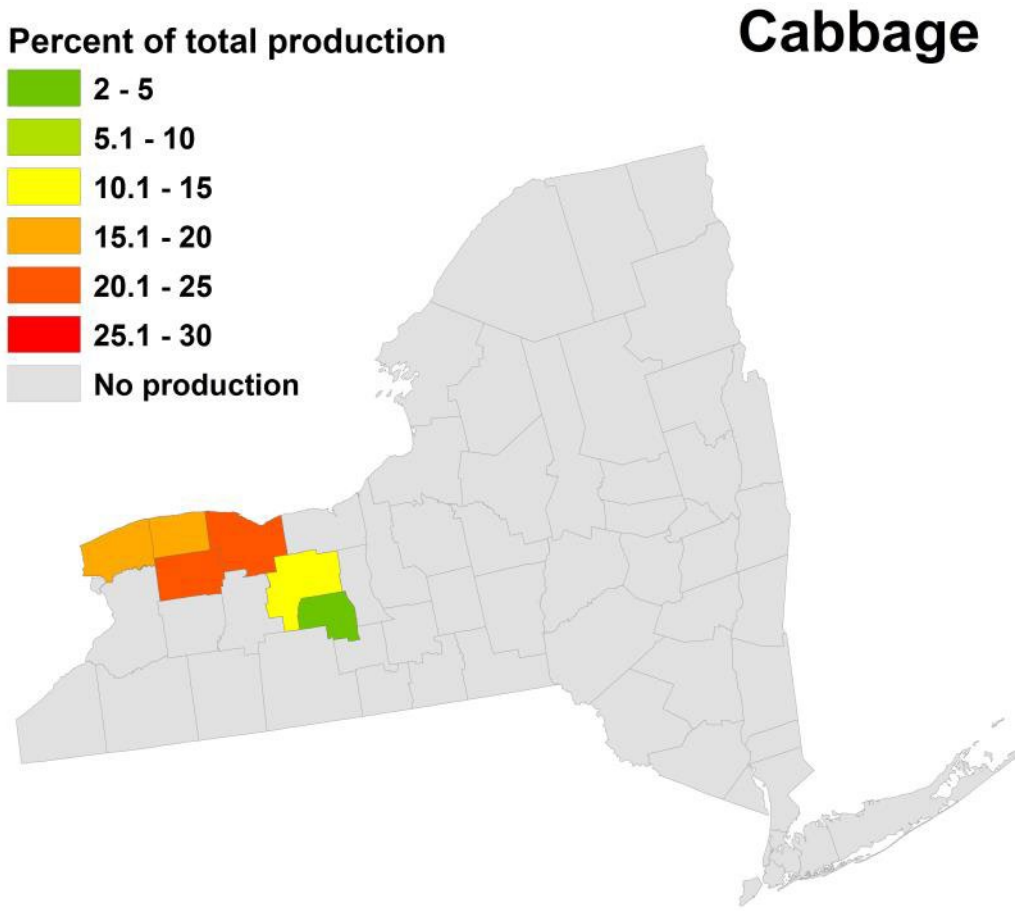
NEW YORK STATE CABBAGE STATISTICS, 2019

- 11,700 acres harvested
- $82 million

CABBAGE PRODUCTION IN NY



CABBAGE PRODUCTION IN NY



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COMMON PESTS OF COLE CROPS

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  - **Time of concern**: at planting (May-June)

COMMON PESTS OF COLE CROPS

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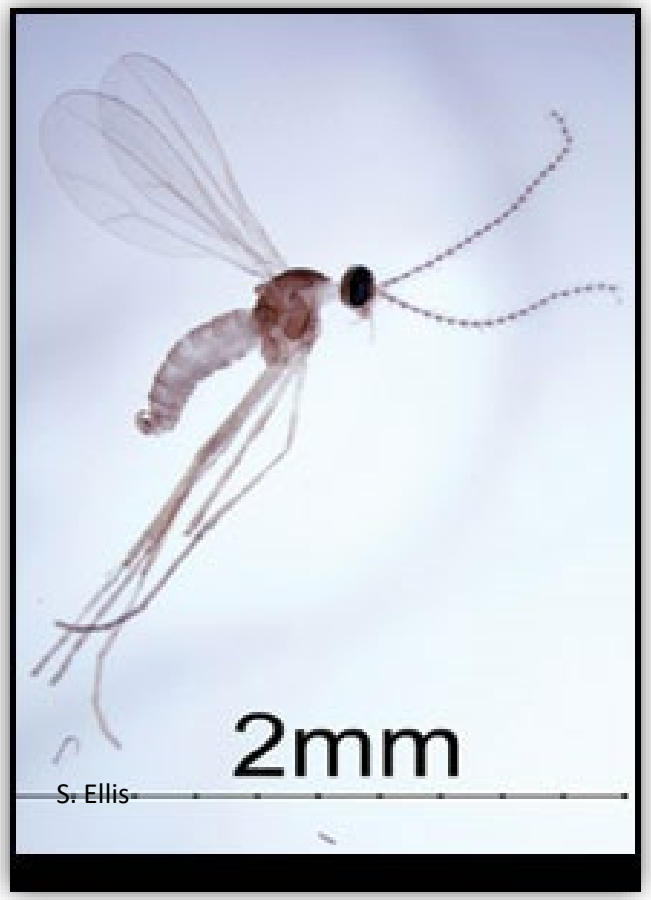
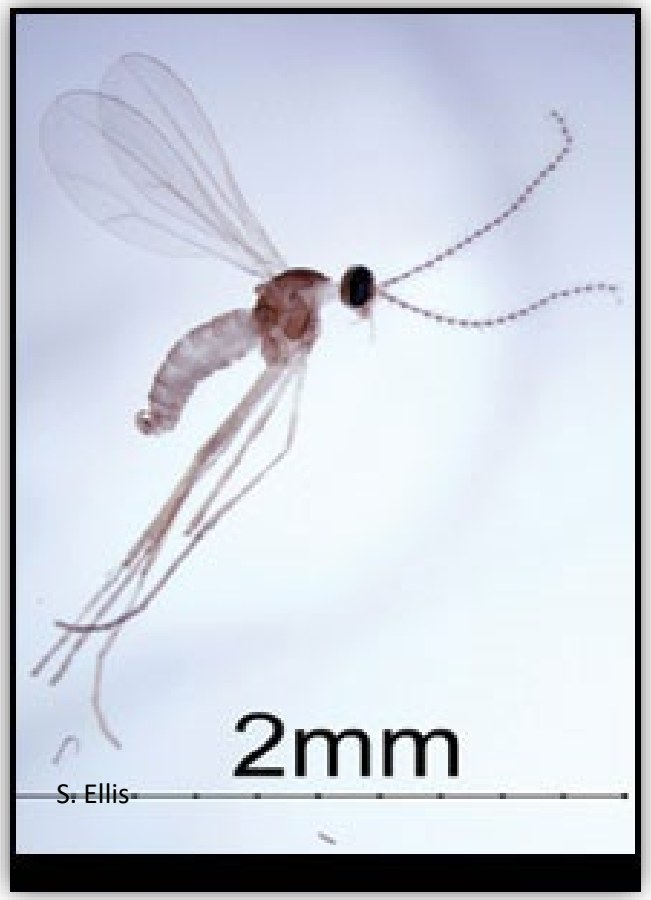
- **Swede midge**
  (*Contarinia nasturtii)*



COMMON PESTS OF COLE CROPS

- Cabbage maggot
- **Swede midge** (*Contarinia nasturtii)*
  - **Time of concern**: few weeks after planting (June-September)



COMMON PESTS OF COLE CROPS

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- Swede midge
- **Onion thrips (*Thrips tabaci)***

COMMON PESTS OF COLE CROPS

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- Swede midge
- **Onion thrips (*Thrips tabaci)***
  - **Time of concern**: head formation through harvest (August-September)

COMMON PESTS OF COLE CROPS

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  - **Imported cabbage worm (ICW)**

  (*Pieris rapae*)

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    - **Time of concern**:

      June through August

COMMON PESTS OF COLE CROPS

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  - **Cabbage looper (CL)** (*Trichoplusia ni*)

COMMON PESTS OF COLE CROPS

- Worm pests of cole crops:
  - Imported cabbage worm (ICW)
  - **Cabbage looper (CL)** (*Trichoplusia ni*)
    - **Time of concern**: migrate from south, August-September

COMMON PESTS OF COLE CROPS

- Worm pests:
  - Imported cabbage worm (ICW)
  - Cabbage looper (CL)
  - **Diamondback moth (DBM)** *(Plutella xylostella)*

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- Worm pests:
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IDENTIFICATION: CABBAGE MAGGOT

- **Pupae**: overwinters in soil

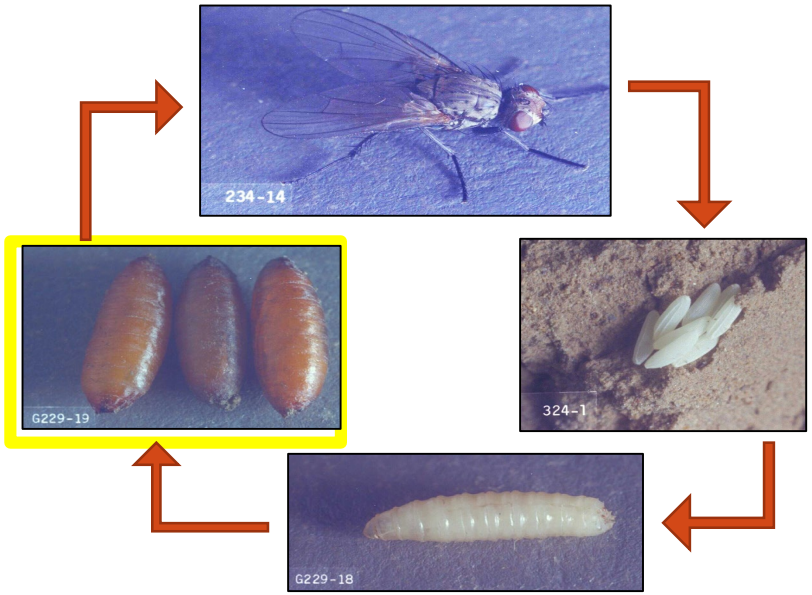

Photo credits: Ken Gray

IDENTIFICATION:
CABBAGE MAGGOT

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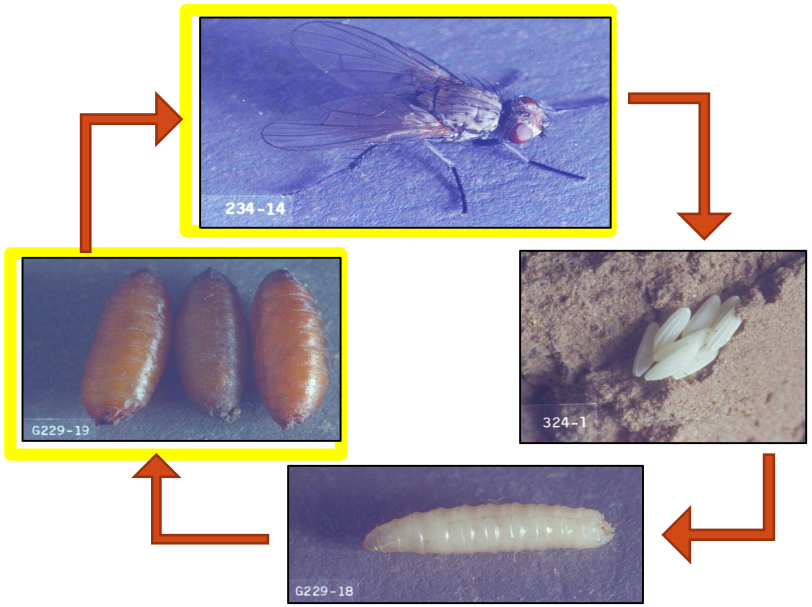

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IDENTIFICATION:
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- **Pupae**: overwinters in soil
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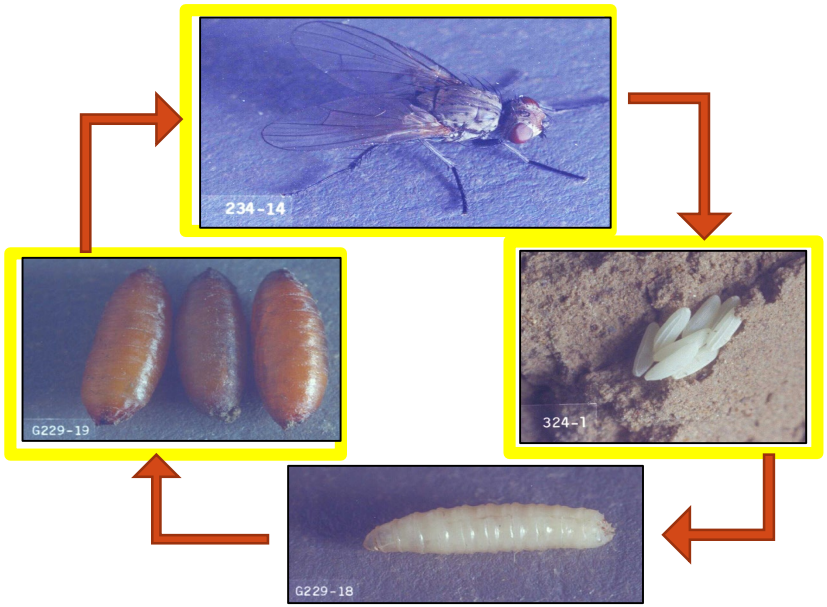

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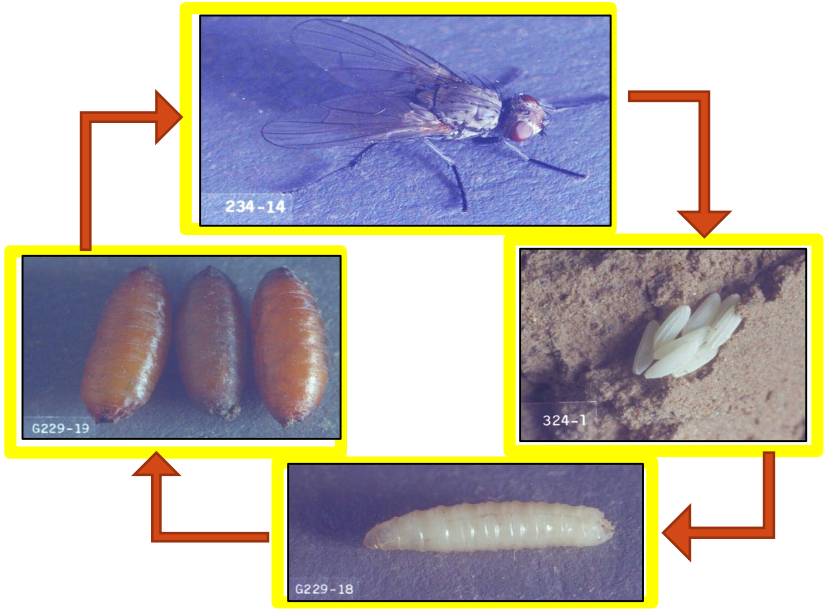

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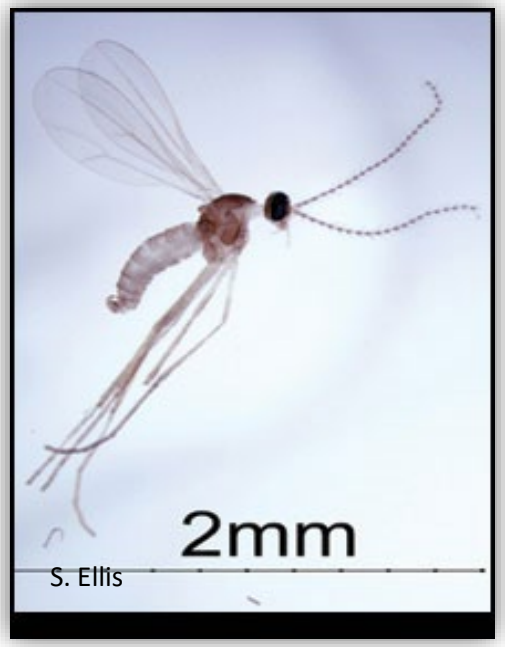
IDENTIFICATION:
CABBAGE MAGGOT

- **Pupae**: overwinters in soil
- **Adults**: emerge in spring
- **Eggs**: laid at base of cole crop plants
- **Larvae**: develop on or near base of plant
- **Damage**: Wilting and reduced vigor

IDENTIFICATION: SWEDE MIDGE

- **Adults**: tiny light brown flies, midge-like



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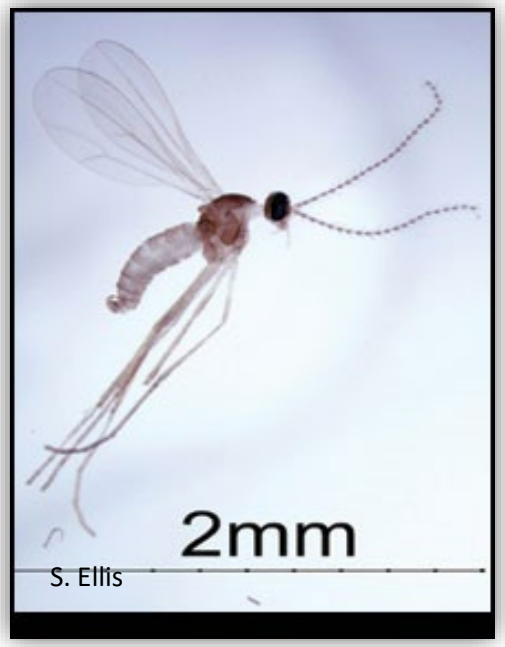

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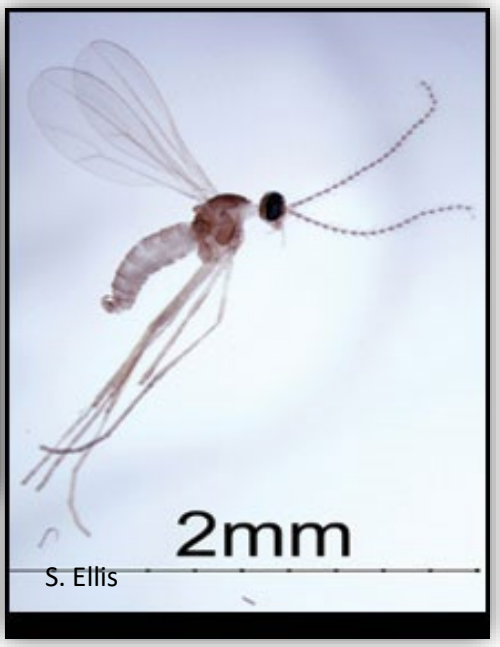

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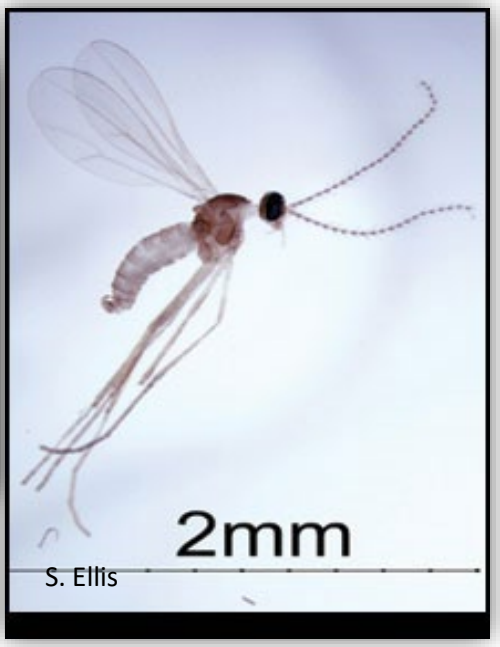

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IDENTIFICATION: ONION THRIPS

- **Adult**: tan-brown, fast


I. Yannuzzi


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- **Adult**: tan-brown, fast
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- **Larvae**: 2 instars on plant
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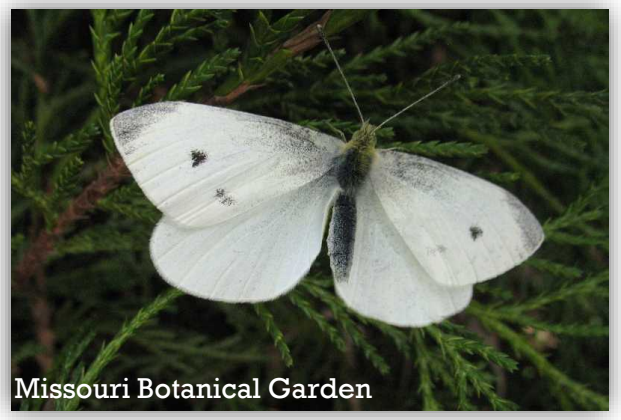
- **Damage**: bronzing on leaves

IDENTIFICATION: IMPORTED CABBAGE WORM

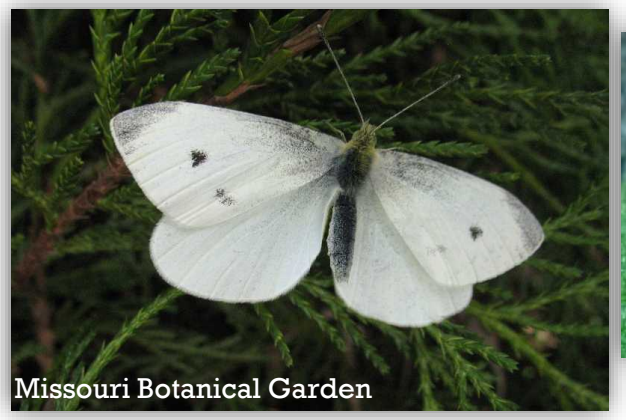

Missouri Botanical Garden

- **Adults**: white butterfly


Missouri Botanical Garden

IDENTIFICATION:
IMPORTED CABBAGE WORM

- **Adults**: white butterfly
- **Eggs**: bullet-shaped, 0.5 mm



IDENTIFICATION:
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- **Adults**: white butterfly
- **Eggs**: bullet-shaped, 0.5 mm
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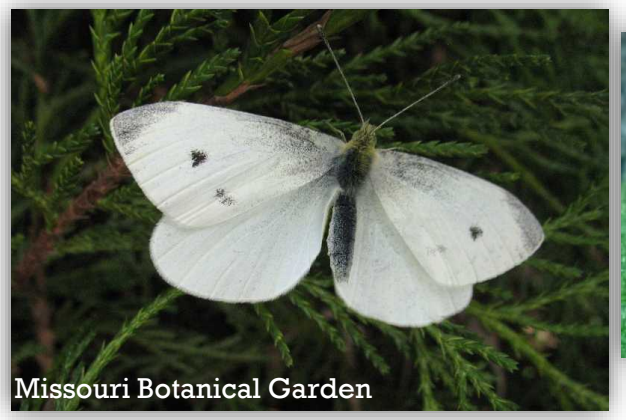

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- **Damage**: complete defoliation leaving stems and veins

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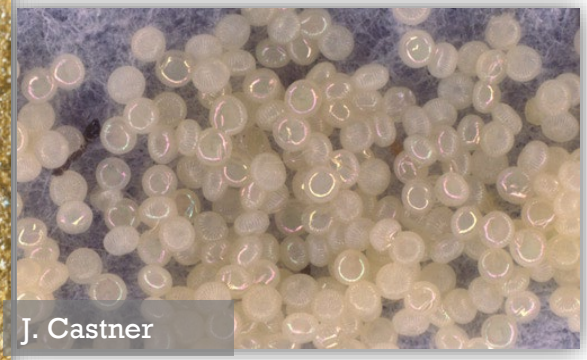
J. Castner

IDENTIFICATION:
CABBAGE LOOPER

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- **Larvae**: make loop when prodded


L. Buss


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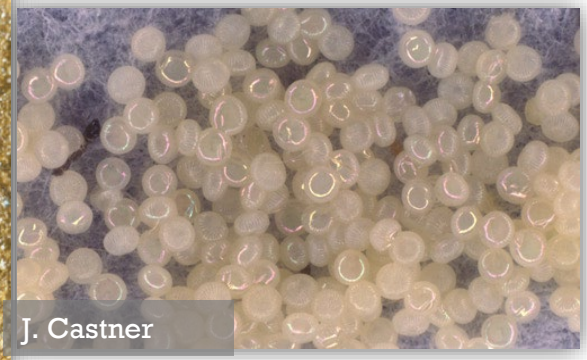
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- **Larvae**: make loop when prodded
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L. Buss


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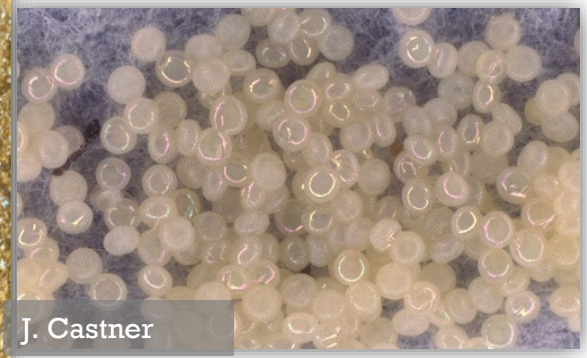
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- **Damage**: not as destructive, wrapper leaves and head


L. Buss


Missouri Botanical Garden

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- **Damage**: window-paning

OUTLINE

- Define cole crops
- Common pests of cole crops
- Identification of pests
- Management of pests

MANAGEMENT: CABBAGE MAGGOT

Product	Active Ingedient	IRAC group
Diazinon AG500	Diazinon	1B-organophosphate
Capture LFR	Bifenthrin	3A-pyrethroid
Verimark	cyantraniliprole	28-diamide
Coragen SC	chlorantraniliprole	28-diamide
Entrust SC	spinosad	5-spinosyn
Radiant	spinetoram	5-spinosyn

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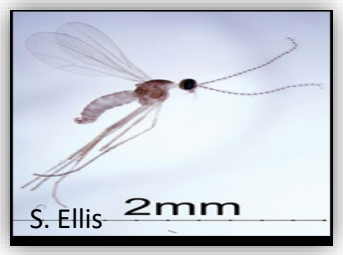
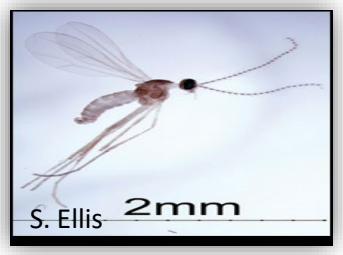
- Other tactics:
  - Avoid animal and green manure
  - Crop rotation
  - Row cover

MANAGEMENT: SWEDE MIDGE



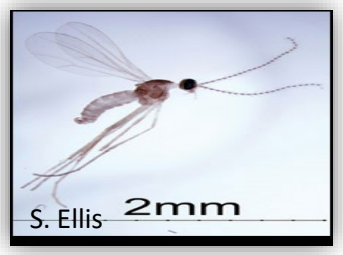
Product	Active Ingredient	IRAC Group
Assail 30SG	acetamiprid	4A-neonicotinoid
Admire Pro	imidacloprid	4A-neonicotinoid
Warrior II w/ Zeon Tech	lambda-cyhalothrin	3A-pyrethroid
Movento	spirotetramat	23-tetronic and tetramic acid deriv.

MANAGEMENT: SWEDE MIDGE



- Prevent population build-up

MANAGEMENT: SWEDE MIDGE



- Prevent population build-up
  - Transplants SM free
  - Pheromone traps, monitor SM populations
  - Exclusion netting
  - Post-harvest culling
  - Crop rotation

MANAGEMENT: ONION THRIPS


I. Yannuzzi

Product	Active Ingredient	IRAC Group
Asana XL	esfenvalerate	3A-pyrethroid
Baythroid XL	beta-cyfluthrin	3A-pyrethroid
Hero	bifenthrin + zeta-cypermethrin	3A-pyrethroid
Mustang MAXX	zeta-cypermethrin	3A-pyrethroid
Warrior II w/ Zeon Tech	lambda-cyhalothrin	3A-pyrethroid
Admire Pro	imidacloprid	4A-neonicotinoid
Assail 30 SG	acetamiprid	4A-neonicotinoid
Platinum 75 SG	thiamethoxam	4A-neonicotinoid
Endigo ZC	lambda-cyhalothrin + thiamethoxam	3A-pyrethroid 4A-neonicotinoid
Leverage 2.7	imidacloprid+cyfluthrin	4A-neonicotinoid 3A-pyrethroid
Entrust SC	spinosad	5- spinosyn
Radiant SC	spinetoram	5 - spinosyn
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Assail 30 SG	acetamiprid	4A-neonicotinoid
Platinum 75 SG	thiamethoxam	4A-neonicotinoid
Endigo ZC	lambda-cyhalothrin + thiamethoxam	3A-pyrethroid 4A-neonicotinoid
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I. Yannuzzi

- Other options:
  - Tolerant varieties
  - Natural enemies
  - Aware of nearby alternate host crops

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

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CHEMICAL

IPM

CULTURAL CONTROL

HOST PLANT RESISTANCE

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

CHEMICAL

IPM

CULTURAL CONTROL

HOST PLANT RESISTANCE

CHEMICAL MANAGEMENT: CORNELL GUIDELINES

Product	Active Ingredient	IRAC Group
Lannate LV	methomyl	**1A** – carbamate
Baythroid XL	beta-cyfluthrin	**3A**-pyrethroid
Hero	bifenthrin + zeta-cypermethrin	**3A**-pyrethroid
Mustang MAXX	zeta-cypermethrin	**3A**-pyrethroid
Perm-Up	permethrin	**3A**-pyrethroid
Warrior II Zeon Technology	lambda-cyhalothrin	**3A** - pyrethroid
Endigo ZC	lambda-cyhalothrin + thiamethoxam	**3A**-pyrethroid **4A**-neonicotinoid
Besiege	chlorantraniliprole + lambda-cyhalothrin	**28** - diamide **3A** - pyrethroid
Entrust SC	spinosad	**5**- spinosyn
Radiant SC	spinetoram	**5** - spinosyn
Proclaim	emamectin benzoate	**6** - avermectin
Biobit HP/ Dipel DF/ Javelin	*Bacillus thuringinesis var. kurstaki*	**11A**-Bt proteins
XenTari/ Agree WG	*Bacillus thuringinesis var. aizawai*	**11A**-Bt proteins
Avaunt	indoxacarb	**22A** - oxadiazin
Coragen	chlorantraniliprole	**28** - diamide
Exirel	cyantraniliprole	**28**- diamide

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

CHEMICAL

IPM

CULTURAL CONTROL

HOST PLANT RESISTANCE

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

IPM

CHEMICAL

CULTURAL CONTROL

HOST PLANT RESISTANCE

Cornell AgriTech

New York State Agricultural Experiment Station

HOST PLANT RESISTANCE

- Glossy wax genotypes resistant

Low epicuticular waxes

Resistance

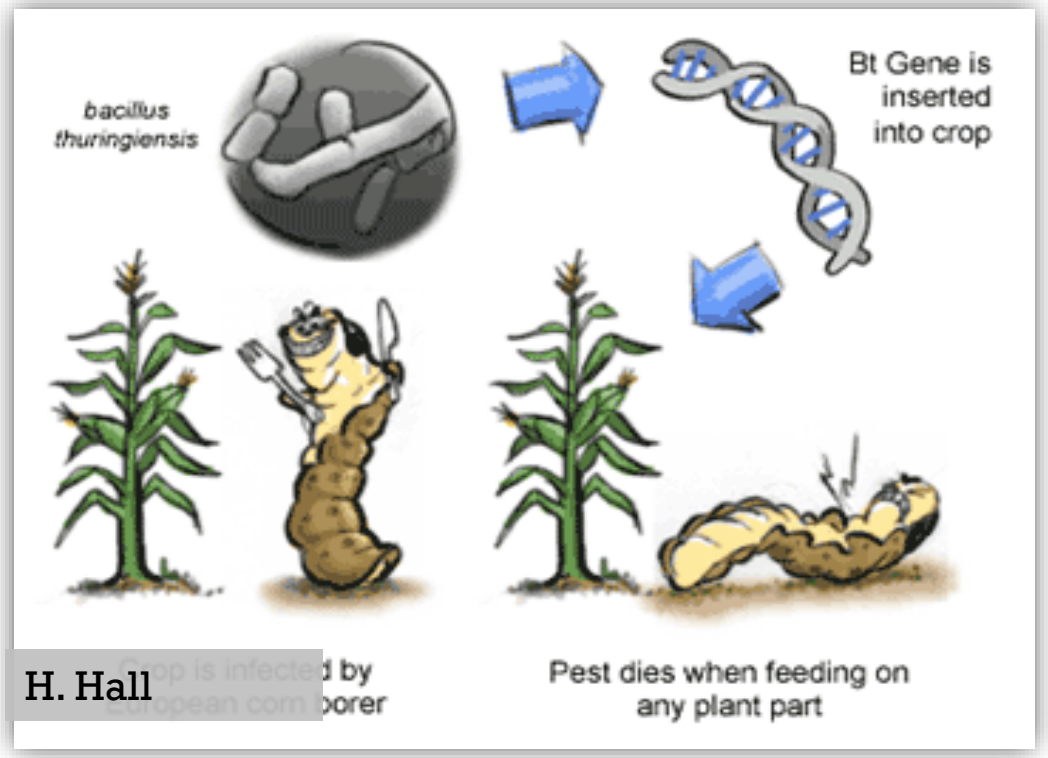
High epicuticular waxes

HOST PLANT RESISTANCE

- Glossy wax genotypes resistant
  - Low epicuticular waxes
  - Low larval survival

GENETICALLY MODIFIED ORGANISM (GMO)

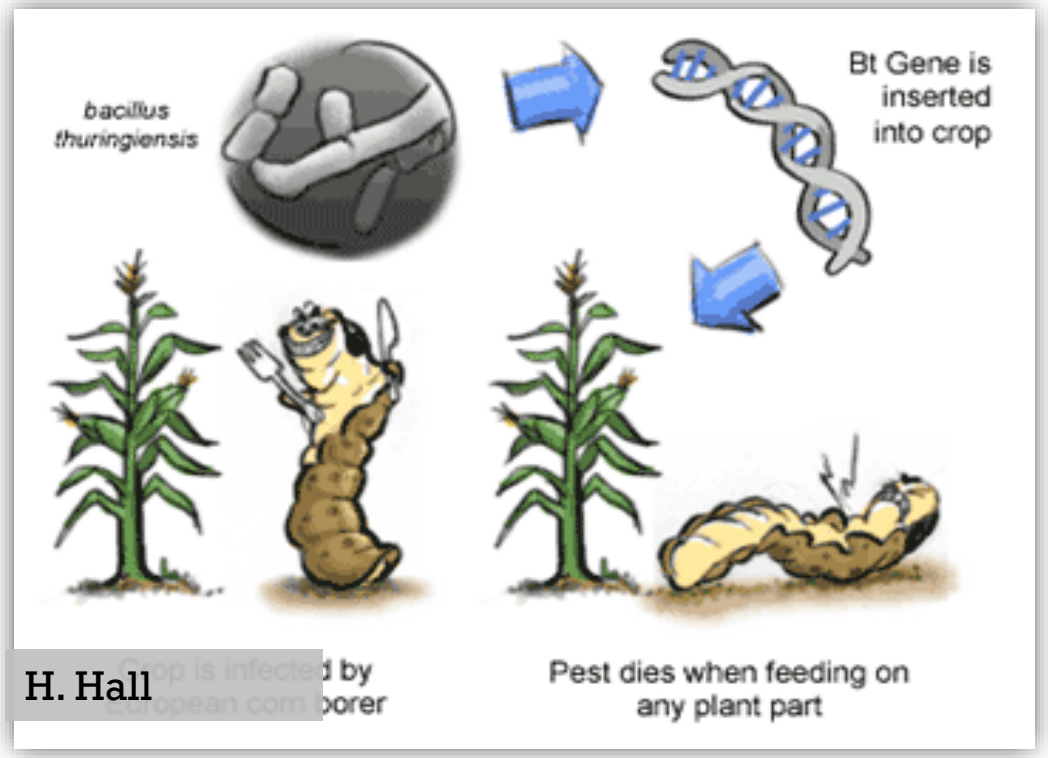
1. Insertion of gene into host plant that encodes for protein



H. Hall

GENETICALLY MODIFIED ORGANISM (GMO)

1. Insertion of gene into host plant that encodes for protein
2. Protein product *Bacillus thuringiensis (Bt)*



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GENETICALLY MODIFIED ORGANISM (GMO)

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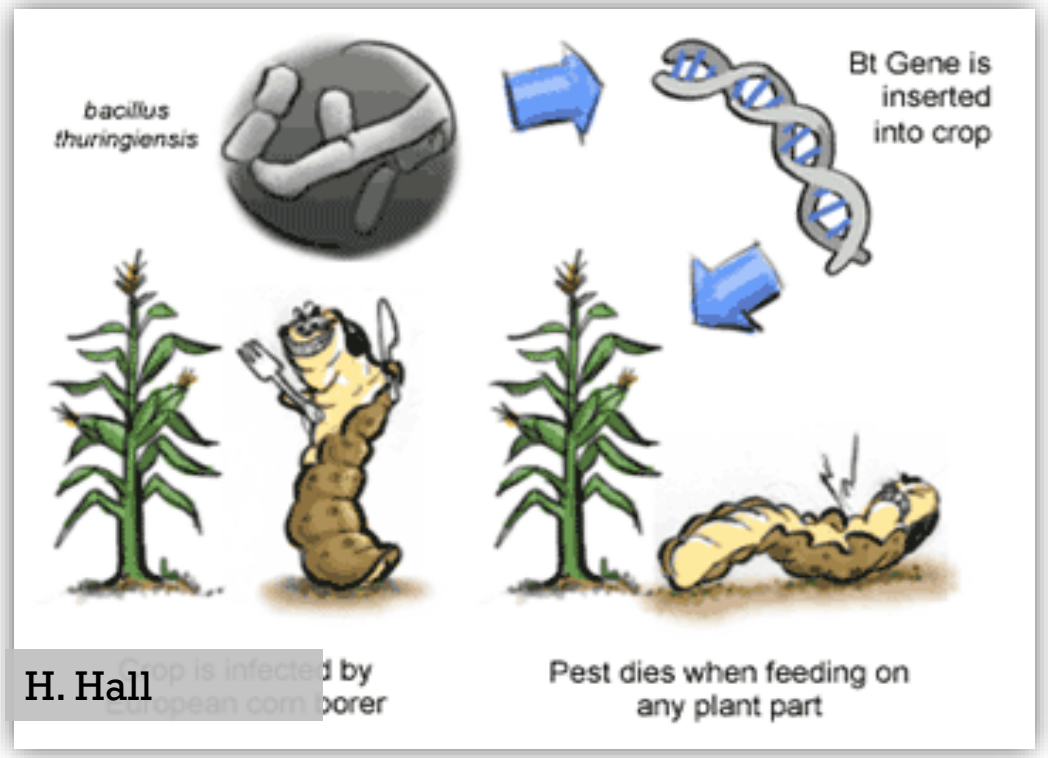
3. Selectively toxic to lepidopterans



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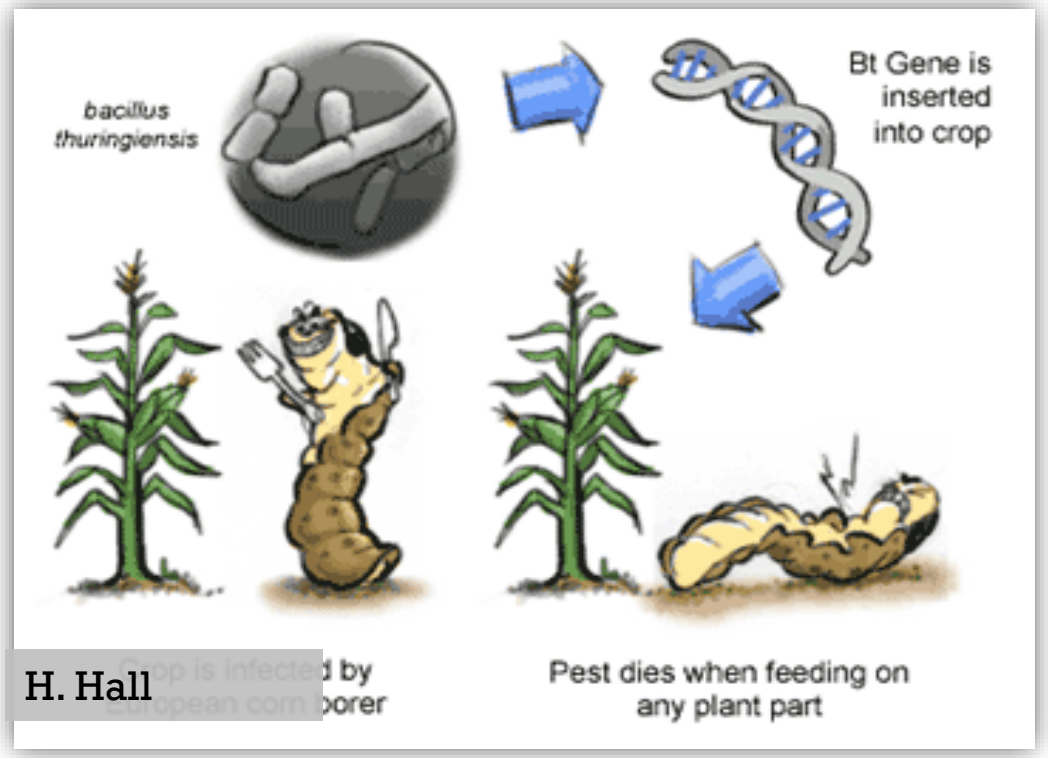

H. Hall

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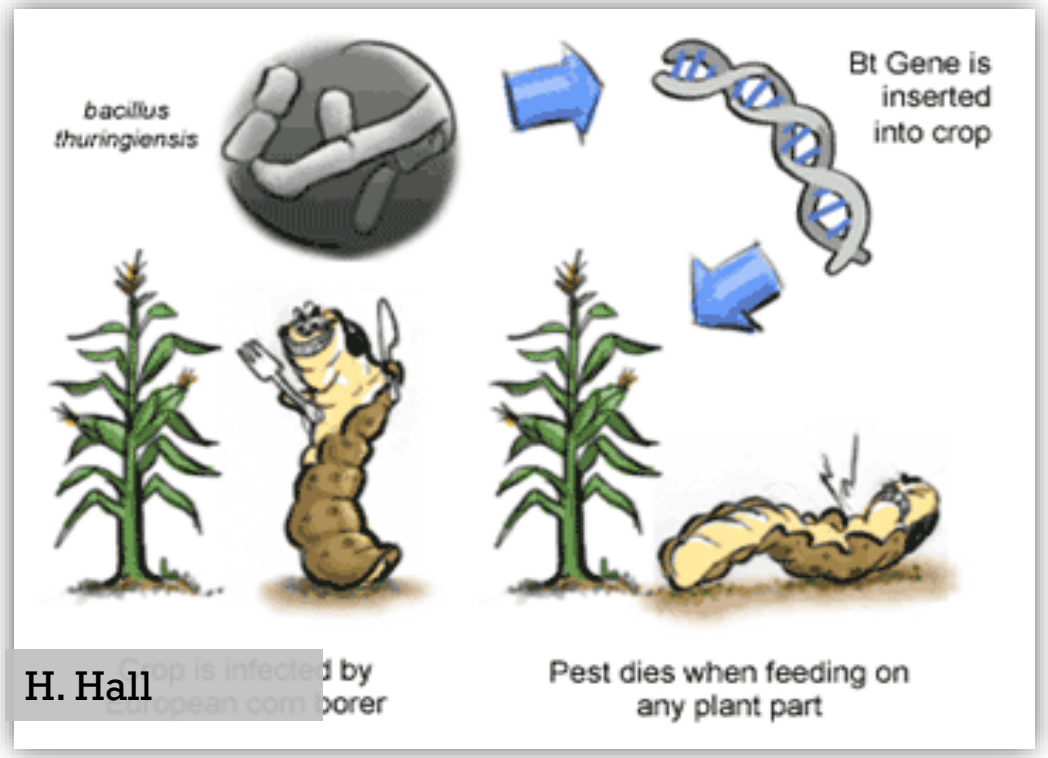

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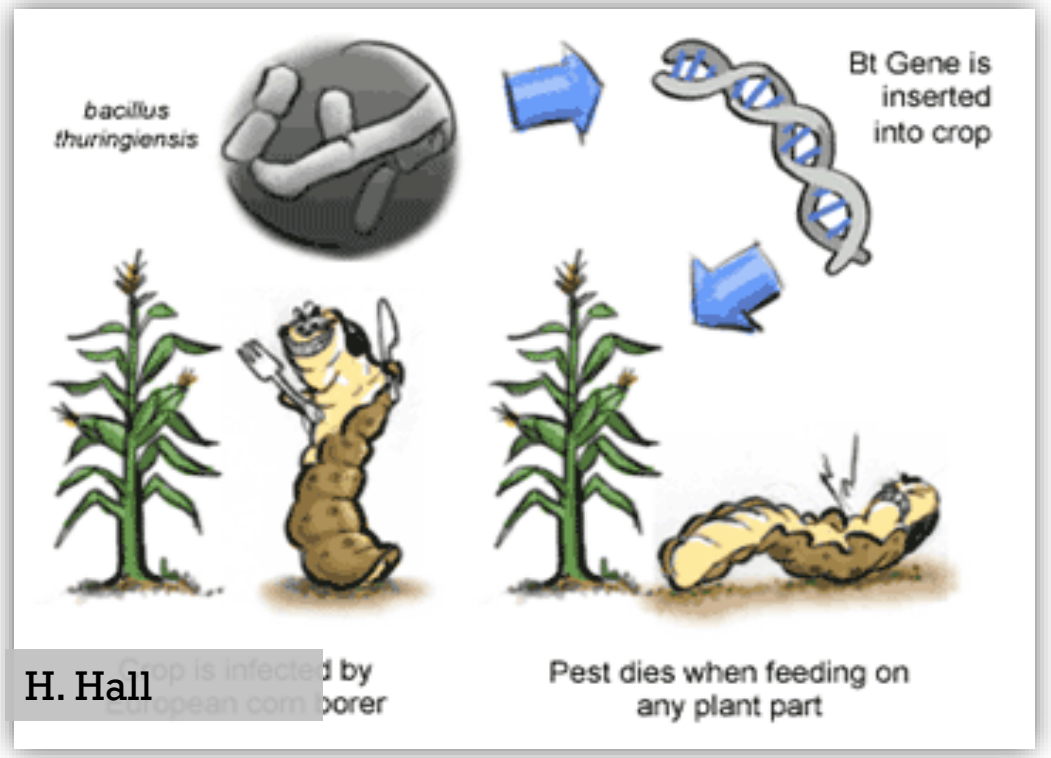
2. Protein product *Bacillus thuringiensis (Bt)*
3. Selectively toxic to lepidopterans
4. Kills larvae when it feeds on plant
5. Not registered in US, high potential
   - Control Bt eggplants in Bangladesh



H. Hall

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

CULTURAL CONTROL

IPM

CHEMICAL

HOST PLANT RESISTANCE

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

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CHEMICAL

CULTURAL CONTROL

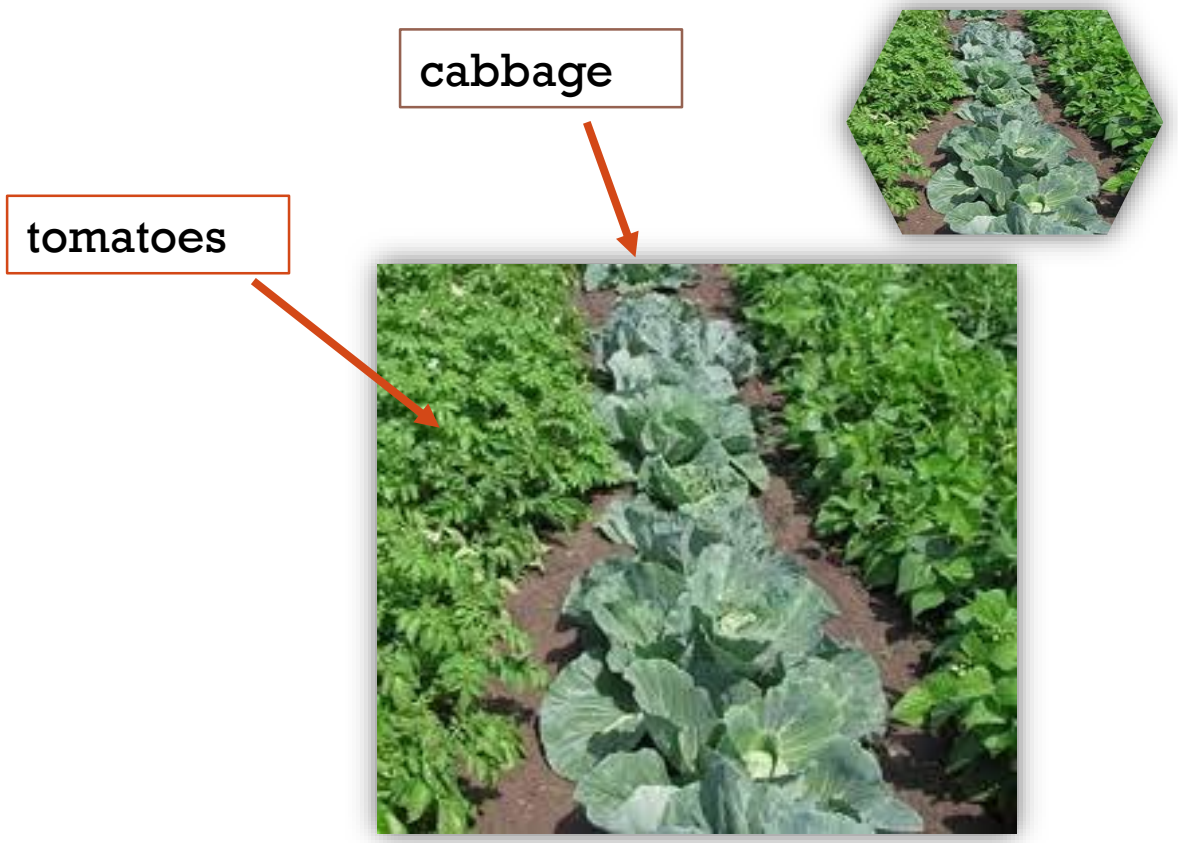
HOST PLANT RESISTANCE

Cornell AgriTech

New York State Agricultural Experiment Station

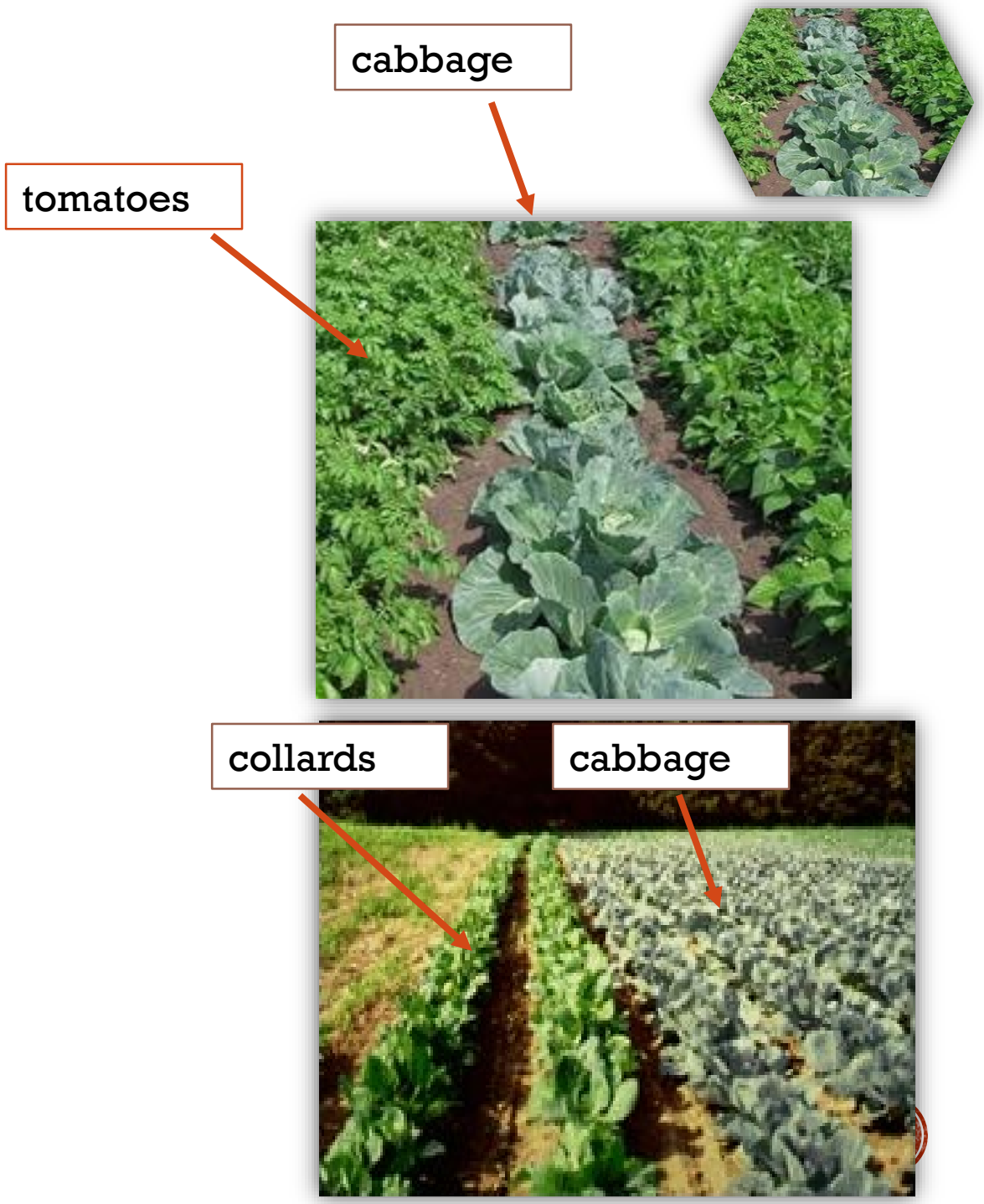
CULTURAL CONTROL

- Intercropping



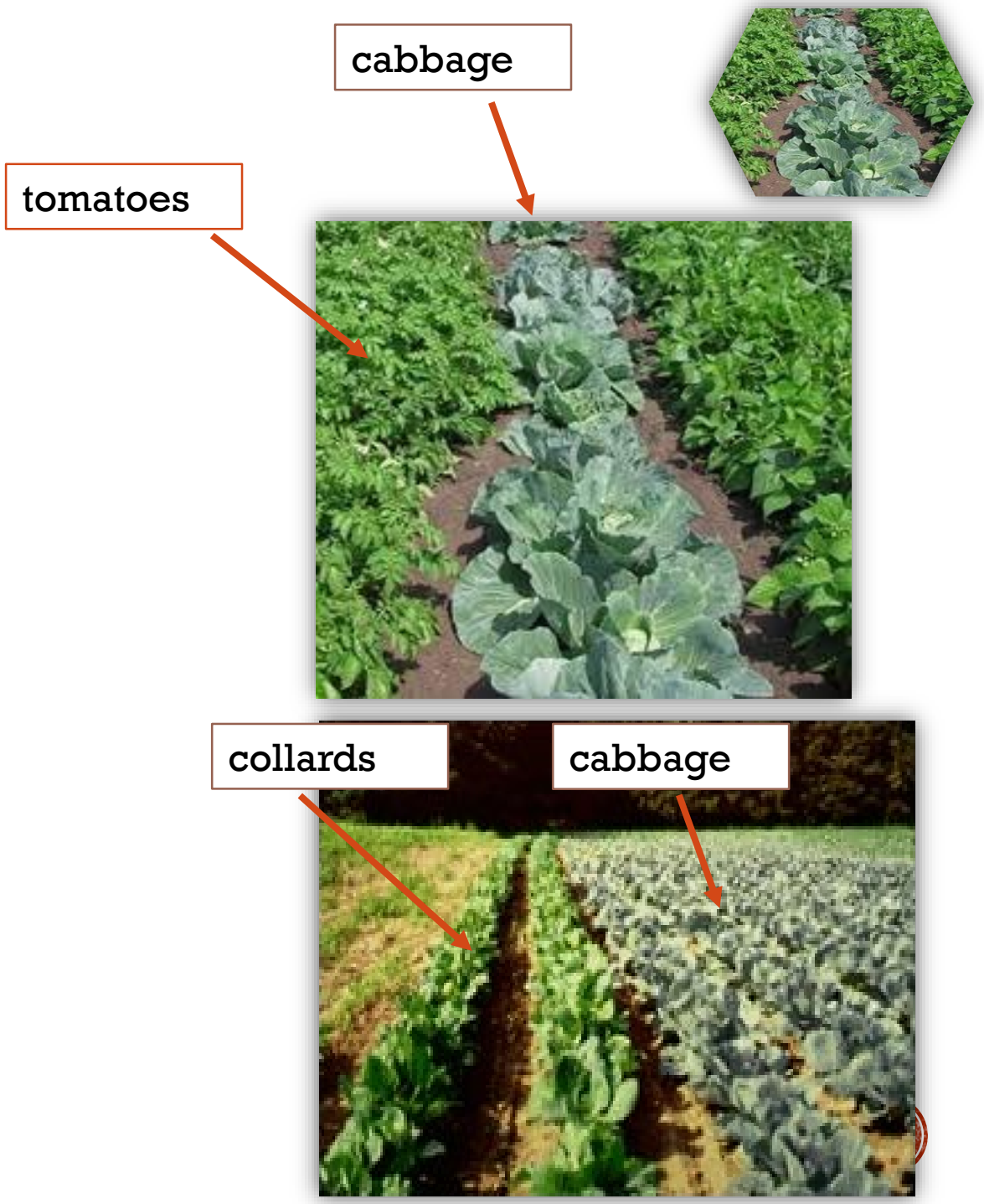
CULTURAL CONTROL

- Intercropping
- Trap cropping



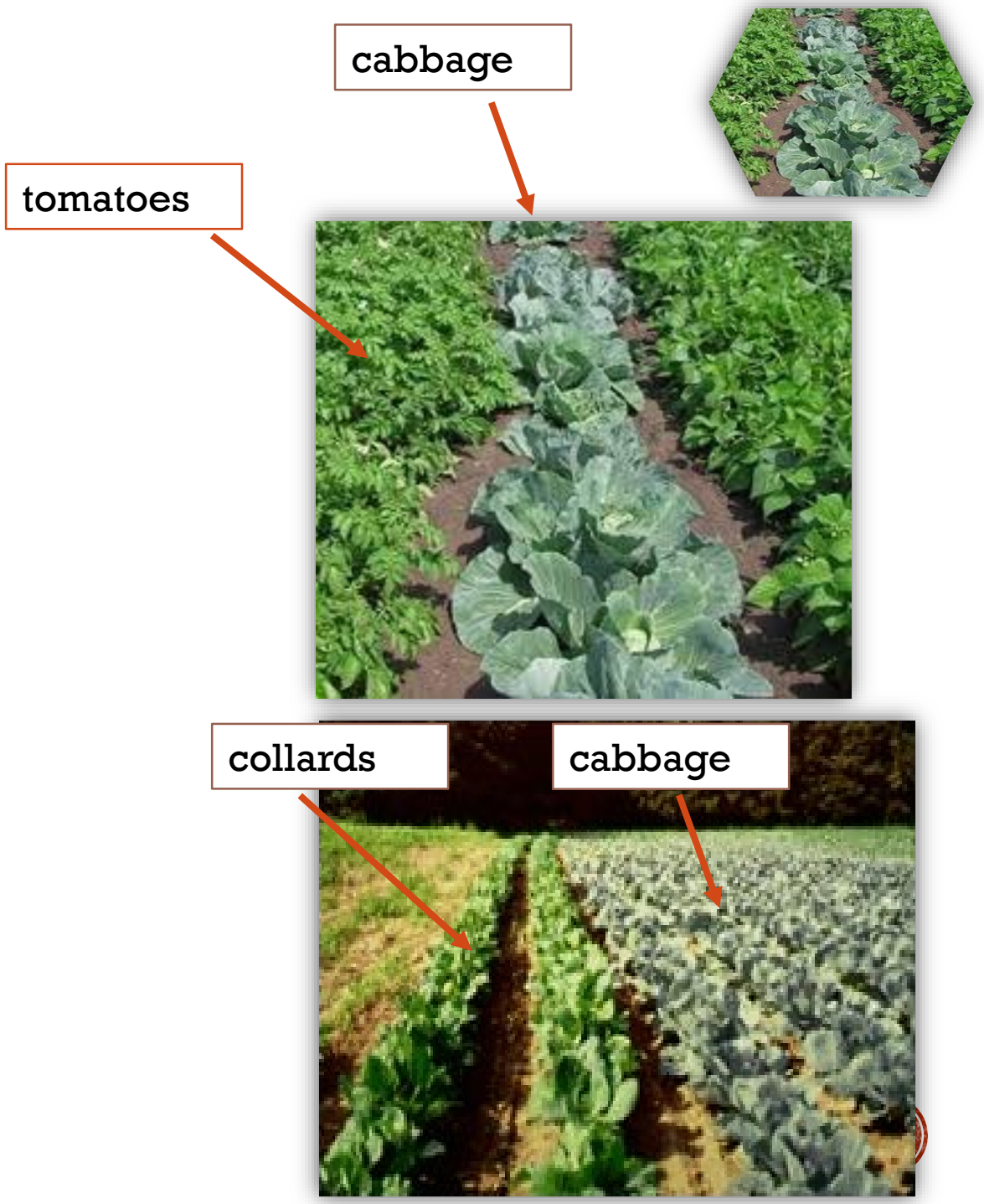
CULTURAL CONTROL

- Intercropping
- Trap cropping
- Limitations:



CULTURAL CONTROL

- Intercropping
- Trap cropping
- Limitations:
  - Only small diversified
  - timing



INTEGRATED PEST MANAGEMENT: WORM COMPLEX

INTEGRATED PEST MANAGEMENT: WORM COMPLEX

BIOLOGICAL CONTROL

IPM

CHEMICAL

CULTURAL CONTROL

HOST PLANT RESISTANCE

Cornell AgriTech

New York State Agricultural Experiment Station

BIOLOGICAL CONTROL

- Natural enemy conservation

BIOLOGICAL CONTROL

- Natural enemy conservation
  - Avoid use broad spectrum insecticides

BIOLOGICAL CONTROL

- Natural enemy conservation
  - Avoid use broad spectrum insecticides
- Parasitic wasps

BIOLOGICAL CONTROL

- Natural enemy conservation
  - Avoid use broad spectrum insecticides
- Parasitic wasps
- Vespid wasps

BIOLOGICAL CONTROL

- Natural enemy conservation
  - Avoid use broad spectrum insecticides
- Parasitic wasps
- Vespid wasps
- Ground beetles

SUMMARY OF LEPIDOPTERAN MANAGEMENT

- ICW and CL are generally more susceptible to insecticides

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SUMMARY OF LEPIDOPTERAN MANAGEMENT

- ICW and CL are generally more susceptible to insecticides
- DBM is the hardest to control
  - Resistant to numerous classes insecticides
  - Multiple generations

IPM PROGRAM FOR COLE CROP CRITTERS

Typical growing season

Month	At Planting	July				August				September				October			
Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DBM	Generation 1					Generation 2				Generation 3							

IPM PROGRAM FOR COLE CROP CRITTERS

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Month	At Planting	July				August				September				October			
Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DBM	Generation 1																
MOA	MOA 1																
Insecticide App		Spray 1				Spray 2											
IRAC	28	11A				11A											
Trade name	Verimark	Agree, Xentari, Dipel				Agree, Xentari, Dipel											
Other Control	CM, DBM	ICW, smCL				ICW, smCL											

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Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DBM		Generation 1				Generation 2											
MOA		MOA 1				MOA 2											
Insecticide App		Spray 1		Spray 2		Spray 3		Spray 4									
IRAC	28	11A		11A		5		5									
Trade name	Verimark	Agree, Xentari, Dipel		Agree, Xentari, Dipel		Radiant		Radiant									
Other Control	CM, DBM	ICW, smCL		ICW, smCL		ICW, CL, thrips		ICW, CL, thrips									

IPM PROGRAM FOR COLE CROP CRITTERS

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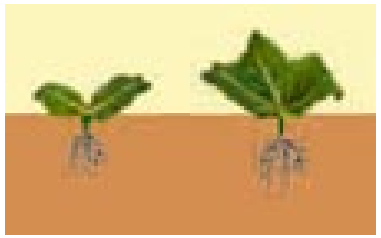
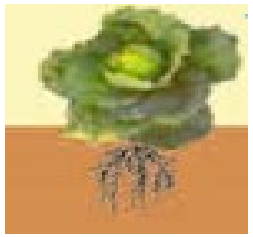
DBM	Generation 1					Generation 2				Generation 3							
MOA	MOA 1					MOA 2				MOA 3							
Insecticide App		Spray 1		Spray 2		Spray 3		Spray 4		Spray 5				Spray 6			
IRAC	28	11A		11A		5		5		6				6			
Trade name	Verimark	Agree, Xentari, Dipel		Agree, Xentari, Dipel		Radiant		Radiant		Proclaim				Proclaim			
Other Control	CM, DBM	ICW, smCL		ICW, smCL		ICW, CL, thrips		ICW, CL, thrips		ICW, CL				ICW, CL			

IPM PROGRAM FOR COLE CROP CRITTERS

Difficult growing season

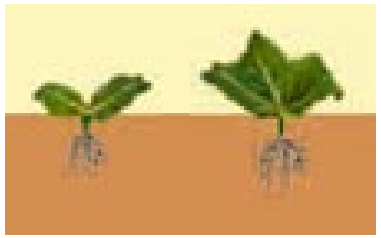


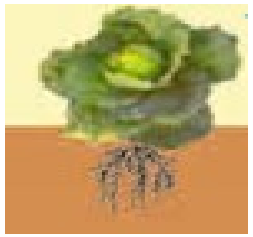


Month	At Planting	July				August				September				October			
Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DBM	Generation 1					Generation 2 & 3?				Generation 3 & 4?							

IPM PROGRAM FOR COLE CROP CRITTERS

Difficult growing season





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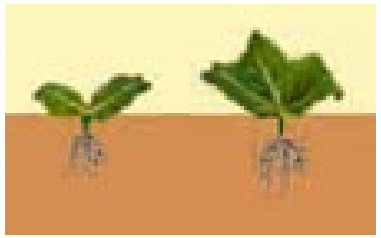
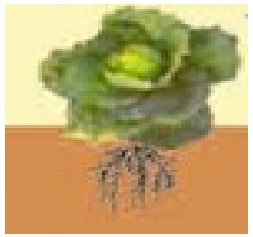
DBM	Generation 1																
MOA	MOA 1					MOA 2											
Insecticide App		Spray 1	Spray 2			Spray 3				Spray 4							
IRAC	28	11A	11A			5				5							
Trade name	Verimark	Agree, Xentari, Dipel	Agree, Xentari, Dipel			Radiant				Radiant							
Other Control	CM, DBM	ICW, smCL	ICW, smCL			ICW, CL, OT				ICW, CL, OT							

IPM PROGRAM FOR COLE CROP CRITTERS

Difficult growing season





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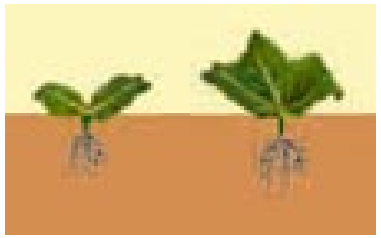
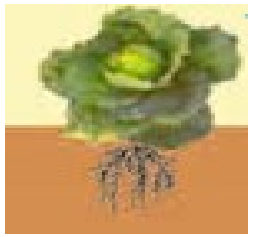
MOA		MOA 1			MOA 2	MOA 3		MOA 4									
Insecticide App		Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6	Spray 7	Spray 8								
IRAC	28	11A	11A	5	5	6	6	28	28								
Trade name	Verimark	Agree, Xentari, Dipel	Agree, Xentari, Dipel	Radiant	Radiant	Proclaim	Proclaim	Coragen Besiege (+3A) Exirel	Coragen Besiege (+3A) Exirel								
Other Control	CM, DBM	ICW, smCL	ICW, smCL	ICW, CL, OT	ICW, CL, OT	ICW, CL	ICW, CL	ICW, CL, OT, FB	ICW, CL, OT, FB								

IPM PROGRAM FOR COLE CROP CRITTERS

Difficult growing season





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Insecticide App		Spray 1	Spray 2	Spray 3	Spray 4	Spray 5	Spray 6	Spray 7	Spray 8	Spray 9	Spray 10			Spray 11			
IRAC	28	11A	11A	5	5	6	6	28	28	22A	22A			3A			
Trade name	Verimark	Agree, Xentari, Dipel	Agree, Xentari, Dipel	Radiant	Radiant	Proclaim	Proclaim	Coragen Besiege (+3A) Exirel	Coragen Besiege (+3A) Exirel	Avaunt	Avaunt			Warrior, etc.			
Other Control	CM, DBM	ICW, smCL	ICW, smCL	ICW, CL, OT	ICW, CL, OT	ICW, CL	ICW, CL	ICW, CL, OT, FB	ICW, CL, OT, FB	ICW, CL	ICW, CL			ICW, smCL, OT, FB			

THANK YOU

Cornell AgriTech

New York State Agricultural Experiment Station

http://nault.entomology.cornell.edu/

- https://www.missouribotanicalgarden.org/gardens-gardening/your-garden/help-for-the-home-gardener/advice-tips-resources/pests-and-problems/insects/caterpillars/imported-cabbageworm.aspx
- https://gardeningsolutions.ifas.ufl.edu/plants/edibles/vegetables/cole-crop-confusion.html
- https://quickstats.nass.usda.gov/results/44E04DF2-1314-3A0A-95CC-7BF2DCAE73B6
- https://extension.unh.edu/resource/cabbage-looper-fact-sheet
- http://entnemdept.ufl.edu/creatures/veg/leaf/diamondback_moth.htm
- http://entnemdept.ufl.edu/creatures/veg/leaf/imported_cabbageworm.htm
- http://entnemdept.ufl.edu/creatures/veg/leaf/cabbage_looper.htm
- https://extension.umd.edu/hgic/topics/imported-cabbageworm-vegetables