

Reduced Risk Approaches to Manage Maggot Pests in Cole Crops in Central Coast

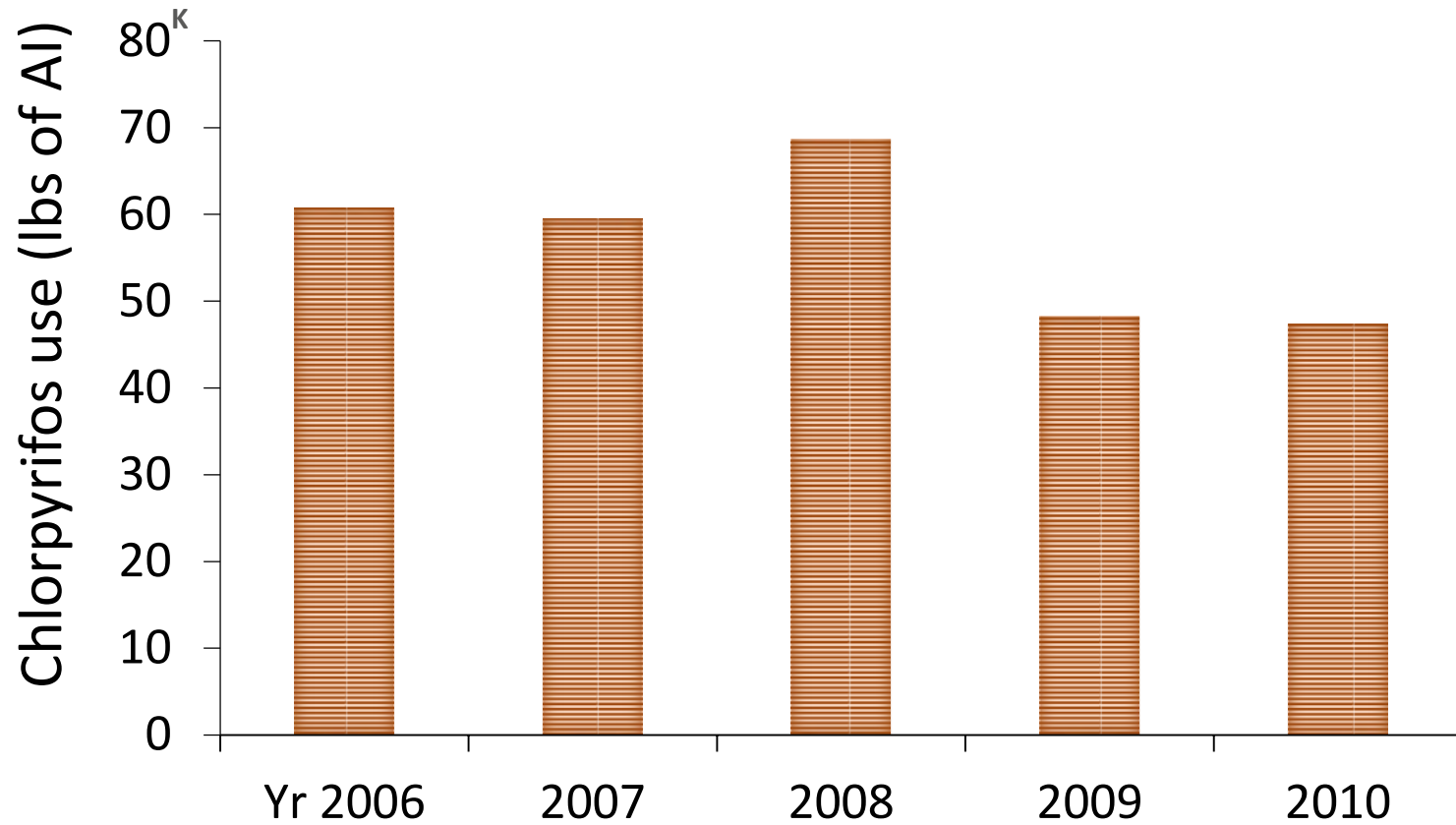


Shimat Joseph¹ (PI) and Larry Godfrey² (Co-PI)

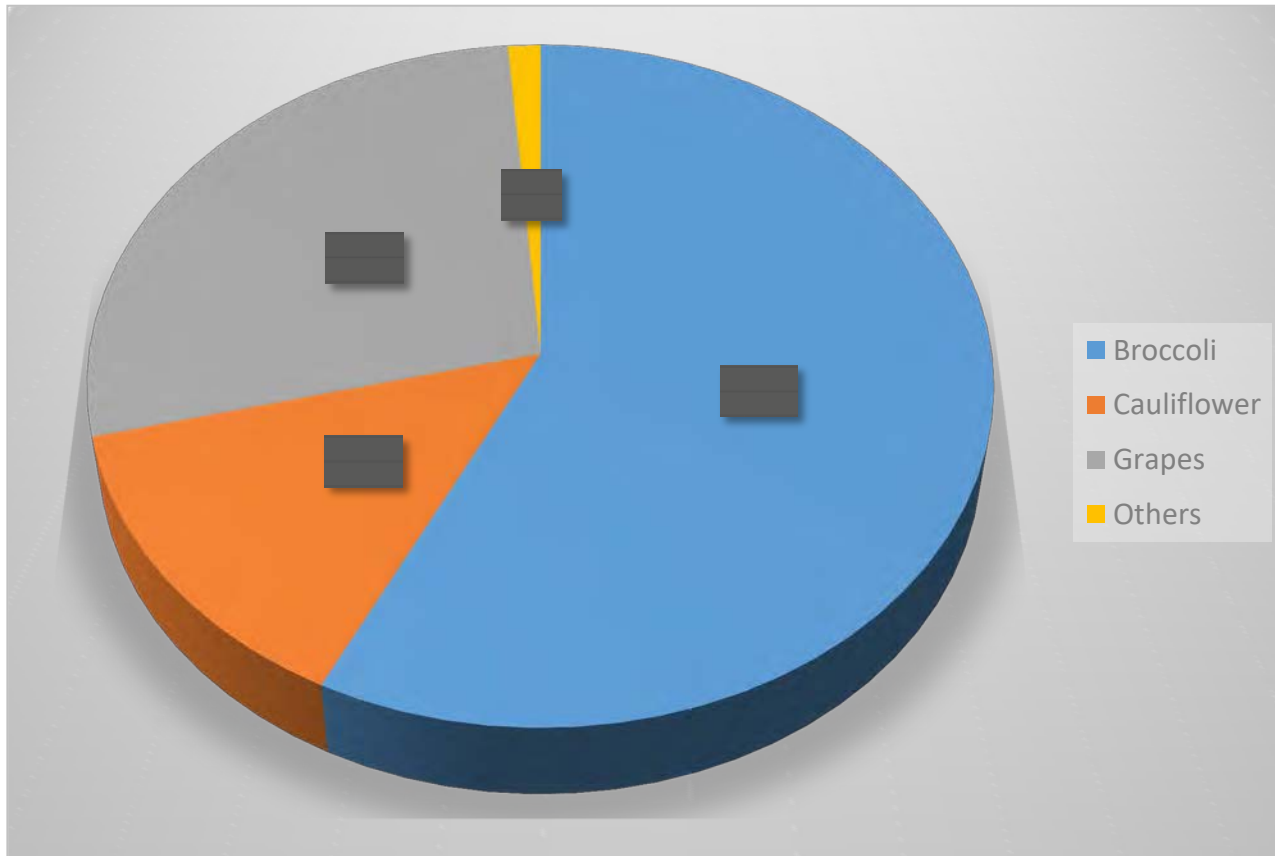
¹UC Cooperative Extension

²UC-Davis

Chlorpyrifos use in Salinas Valley



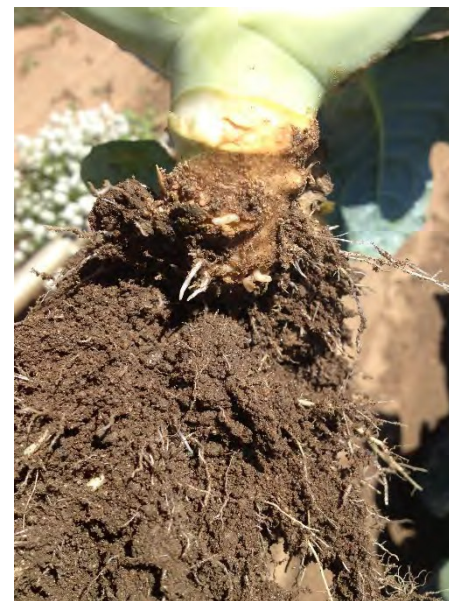
Chlorpyrifos use in Salinas Valley



284,541 lb of chlorpyrifos from 2006 to 2010

Cabbage maggot on *Brassicas*

- *Brassica* value: > \$485 million
- *Brassicas* grown: 85,200 acre
 - Broccoli: 60,840 acre
 - Cauliflower: 24,640 acre
- Cabbage maggot (CM) is a major persistent pest of brassica crops in the Salinas Valley of CA
- Majority of *Brassica* acreage is affected by root maggots



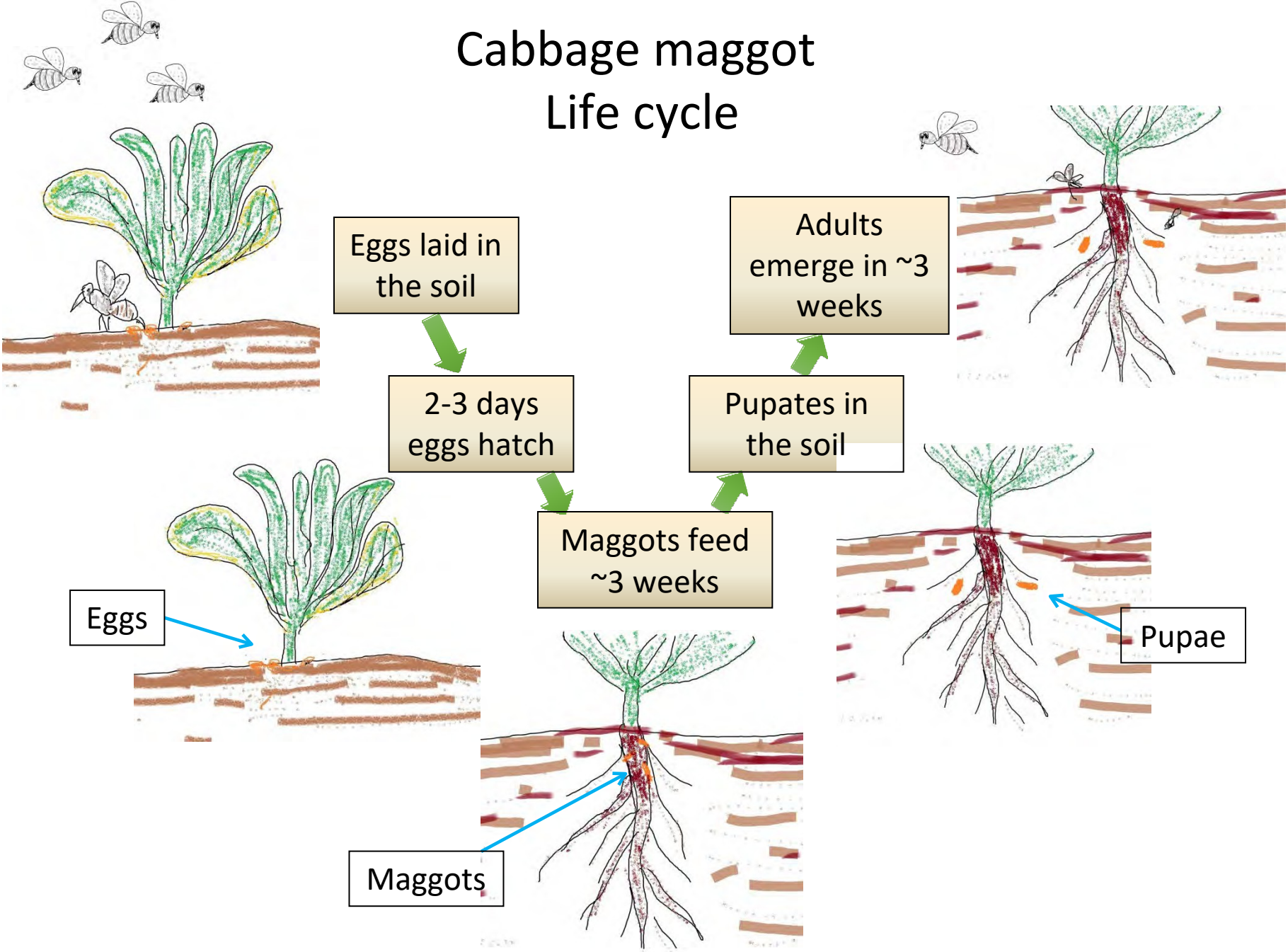
Cabbage maggot injury in cauliflower



Cabbage maggot injury in broccoli



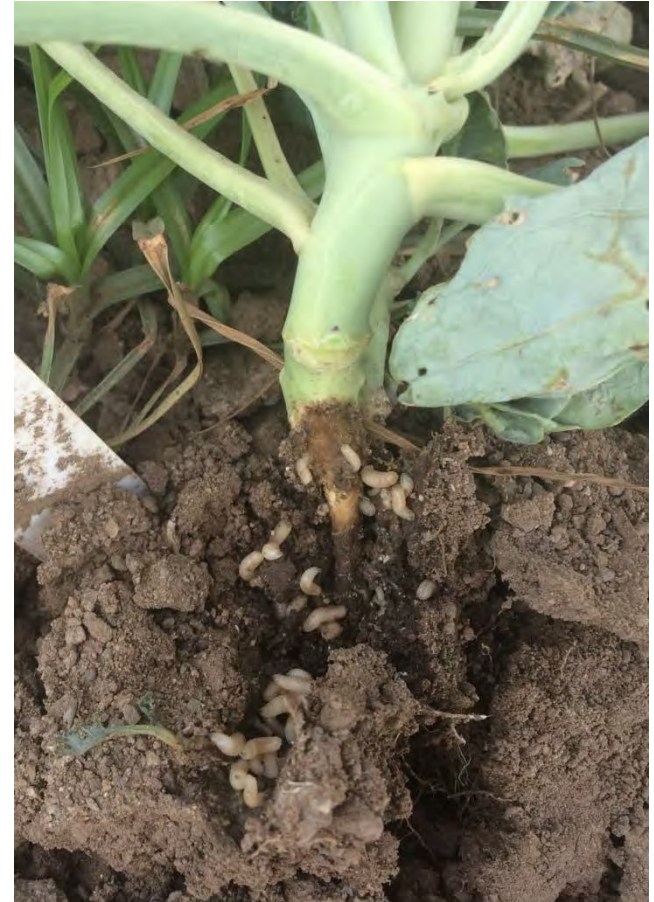
Cabbage maggot Life cycle



Goals

Little was known about cabbage maggot biology and management in the Central Coast

- 1) Understand the relative susceptibility of crops to maggot attack
- 2) Compare the level of resistance /tolerance present in the commercial cultivars
- 3) Understand the effects of temporal spacing between crops on maggot fly infestation on the successive *Brassica* crop
- 4) Identify effective low-risk active ingredients to maggot pests and their mode of delivery or placement, timing



Goals

- 1) Understand the relative susceptibility of crops to maggot attack
 - a) Relative susceptibility of Brassica hosts to Cabbage maggot
 - b) Effect of CM infestation on various growth stages of broccoli



Method

- Experiment was conducted in the USDA ARS in Salinas in fall 2013 and 2014
- 3 or 4 crops: turnip, lettuce, and cauliflower were planted side-by-side with broccoli on two seed line in 40-inch bed
- Four treatments: turnip: broccoli, lettuce : broccoli, cauliflower : broccoli and broccoli : broccoli (check) were replicated five times in a Randomized Complete Block Design (RCBD)



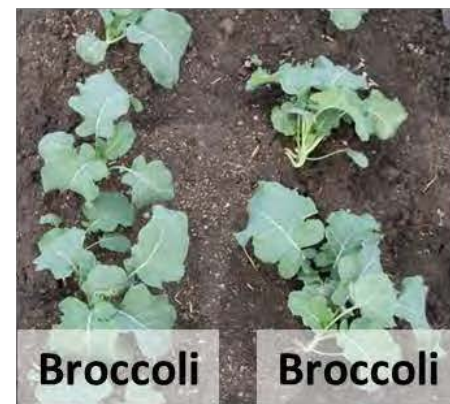
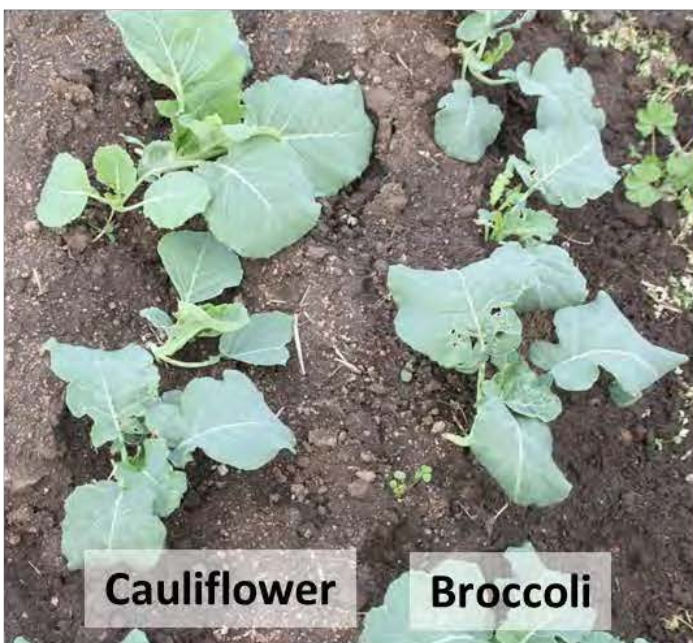
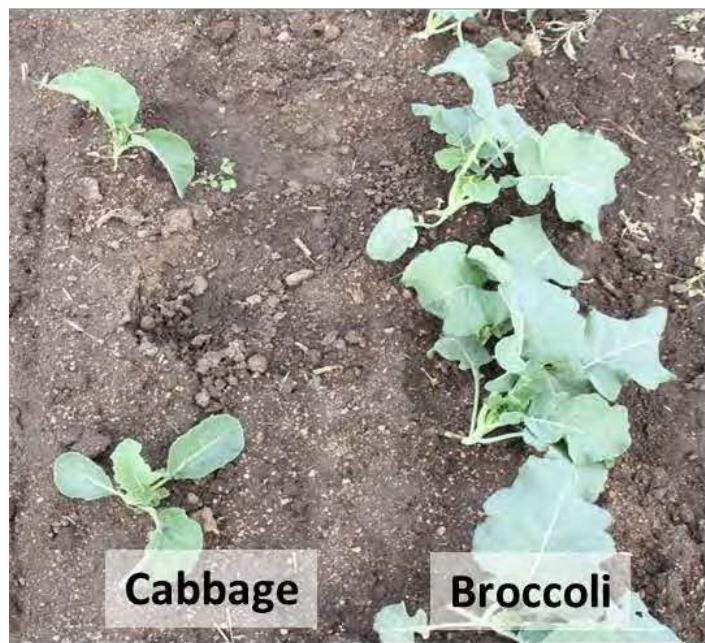
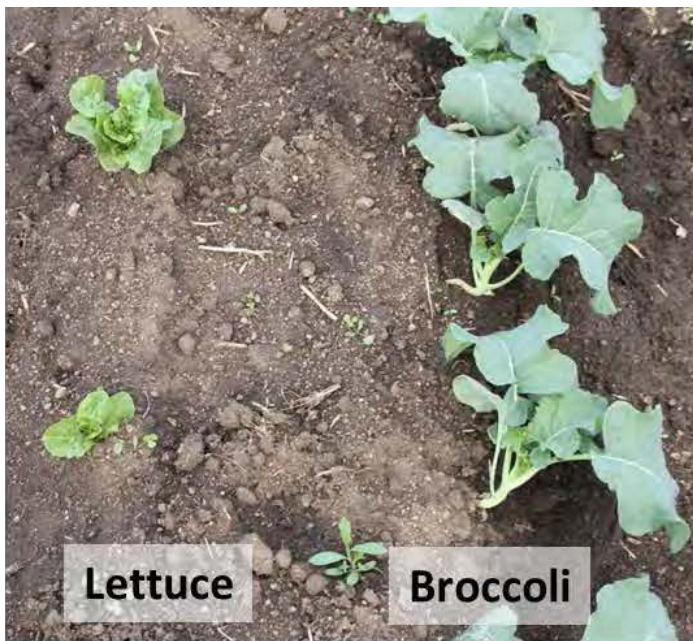
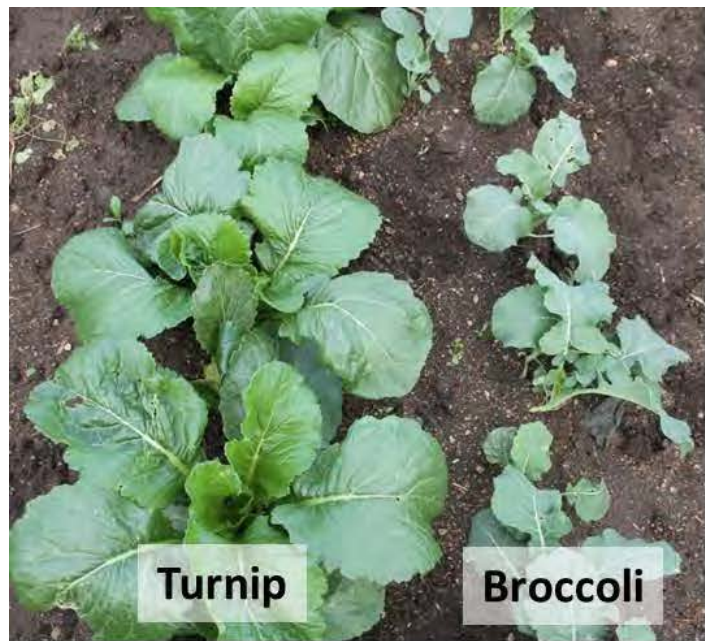
Method

- Ten soil and plant root samples -
- Eggs and CM infestation starting 3rd week after plant emergence
- Four yellow sticky traps were deployed to monitor activity of maggot fly
- Severity of injury was evaluated using a scale system 0 to 9: 0 = not infested; 9 = severely infested



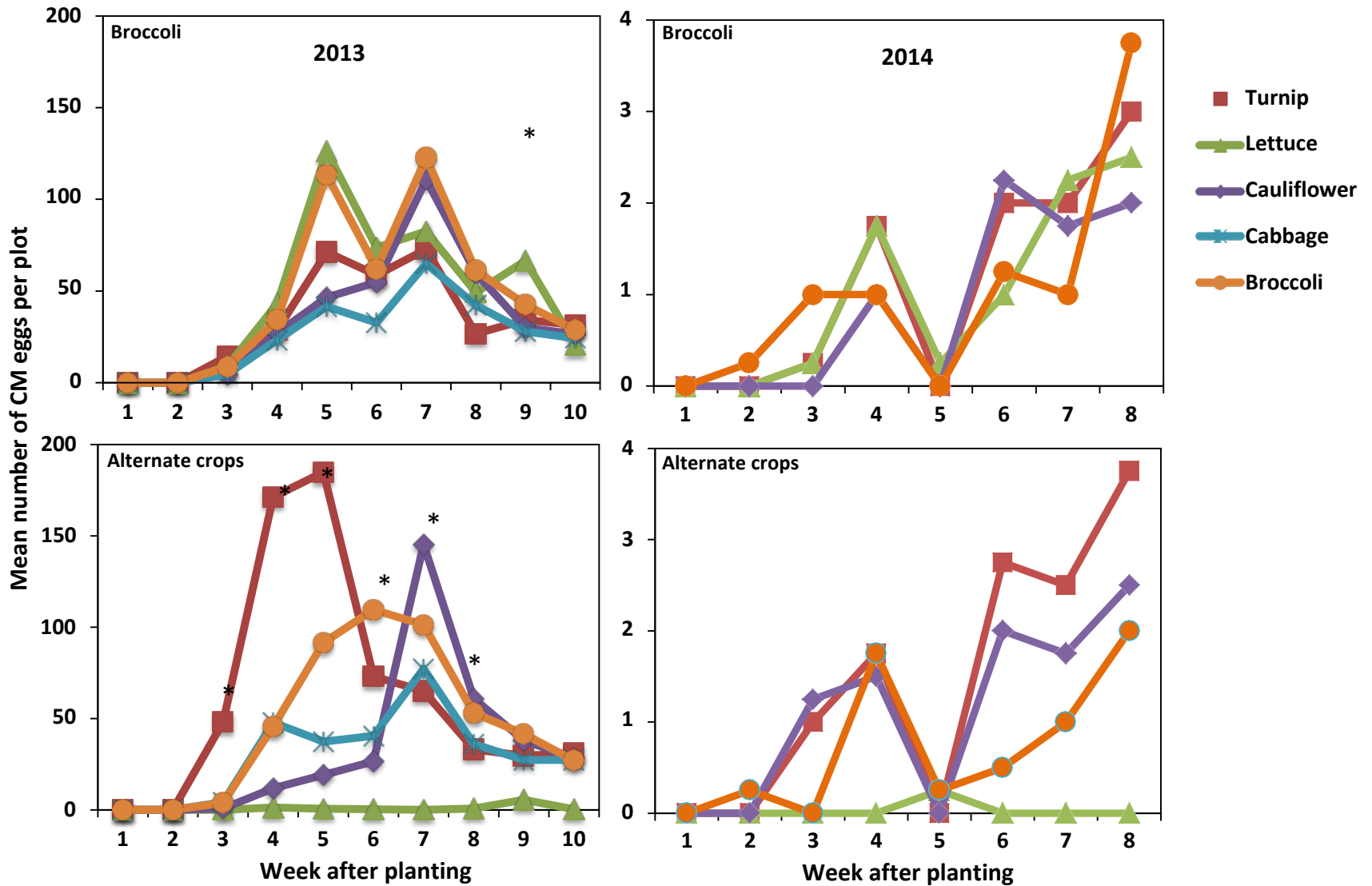
Root health rating



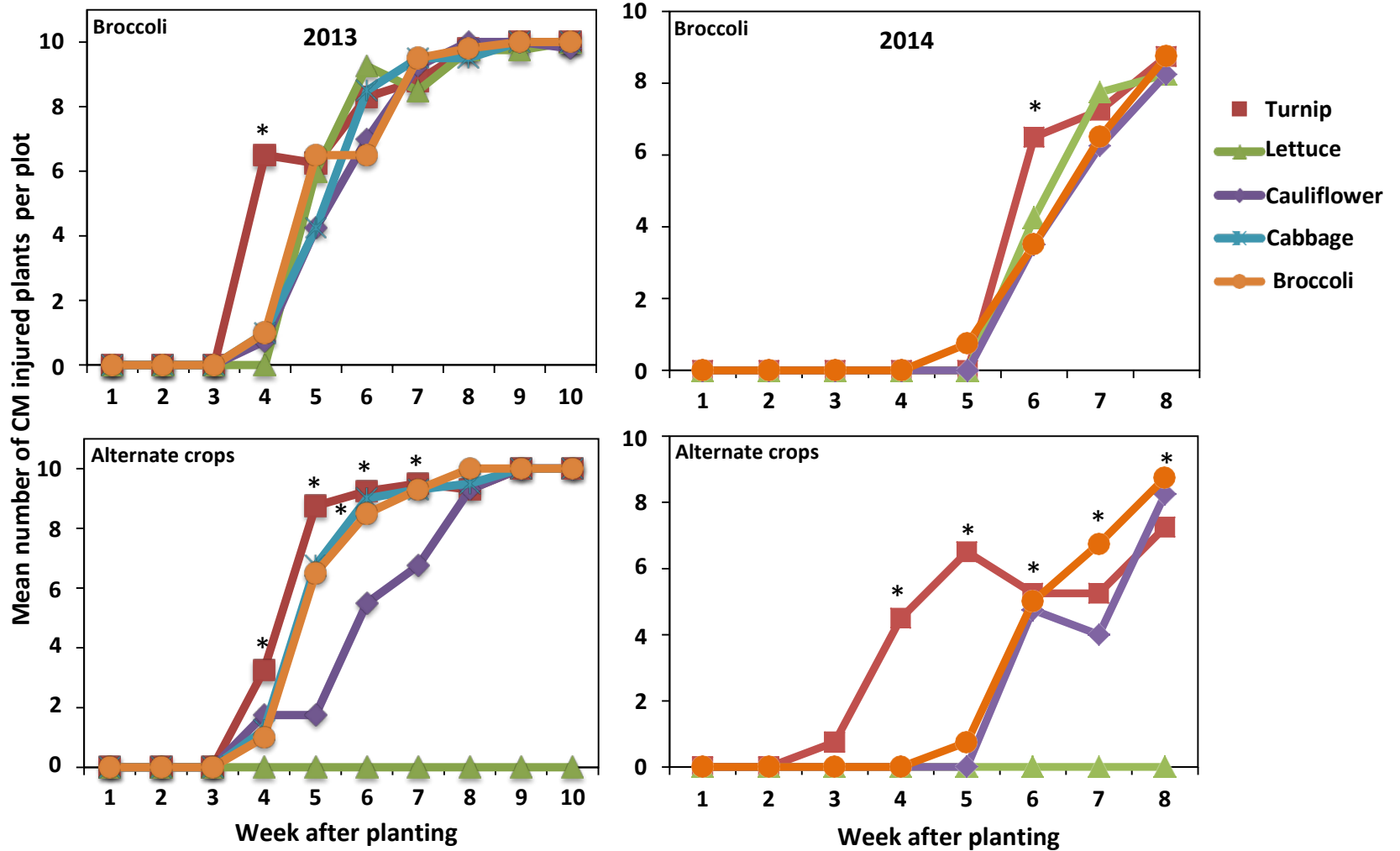




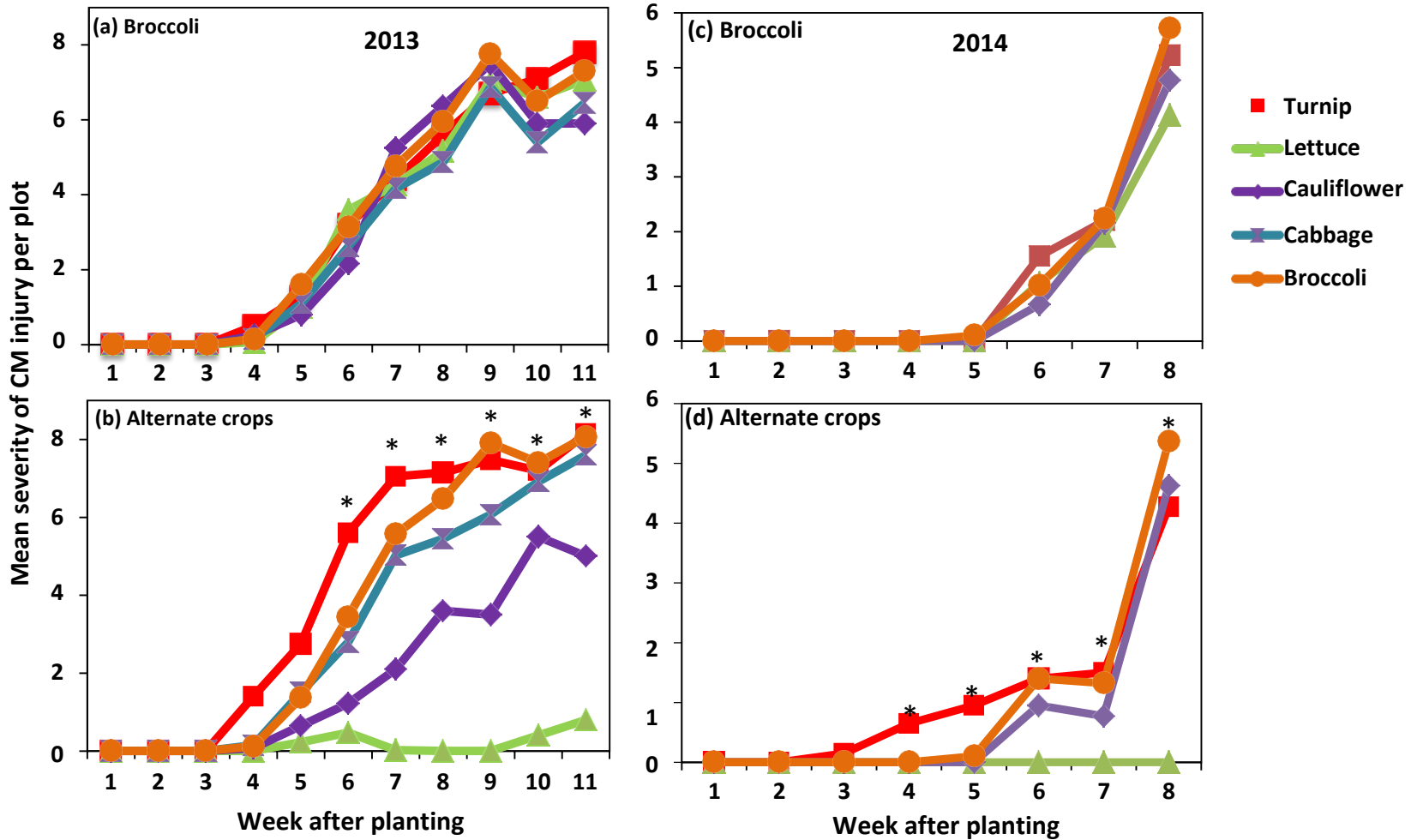
Eggs



Plants injured



Severity of injury



Summary

- CM flies laid significantly more number of eggs at the base of turnip than broccoli starting third week after planting (WAP)
- During fourth and fifth WAP, number of eggs on turnip was more than twice compared with broccoli
- Severity of cabbage maggot feeding injury was greater on turnip than any crops when broccoli was planted on its side
- On non-host crop (lettuce), number of eggs, injured plants, severity of injury was none or minimum relative to other crops
- Number of eggs, injured plants and severity of injury was lower on cauliflower than any other brassica crops when broccoli was planted on its side



Goals/objectives

- 1) Understand the relative susceptibility of crops to maggot attack
- 2) Compare the level of resistance /tolerance present in the commercial cultivars
 - Vulnerable stage of broccoli to CM
 - Presence of tolerance/ resistance in broccoli and cauliflower varieties



Method

- Direct seeded broccoli (21 Aug 14)
- Plants caged at emergence
- 3 weeks old plants were used
- Five sets of plants were selected for the study
- Sets of plants were inoculated at discrete stage plant development
- Inoculated week interval at 3, 5, 7, and 9 weeks after planting (treatment)
- 15 reps per treatment



Method

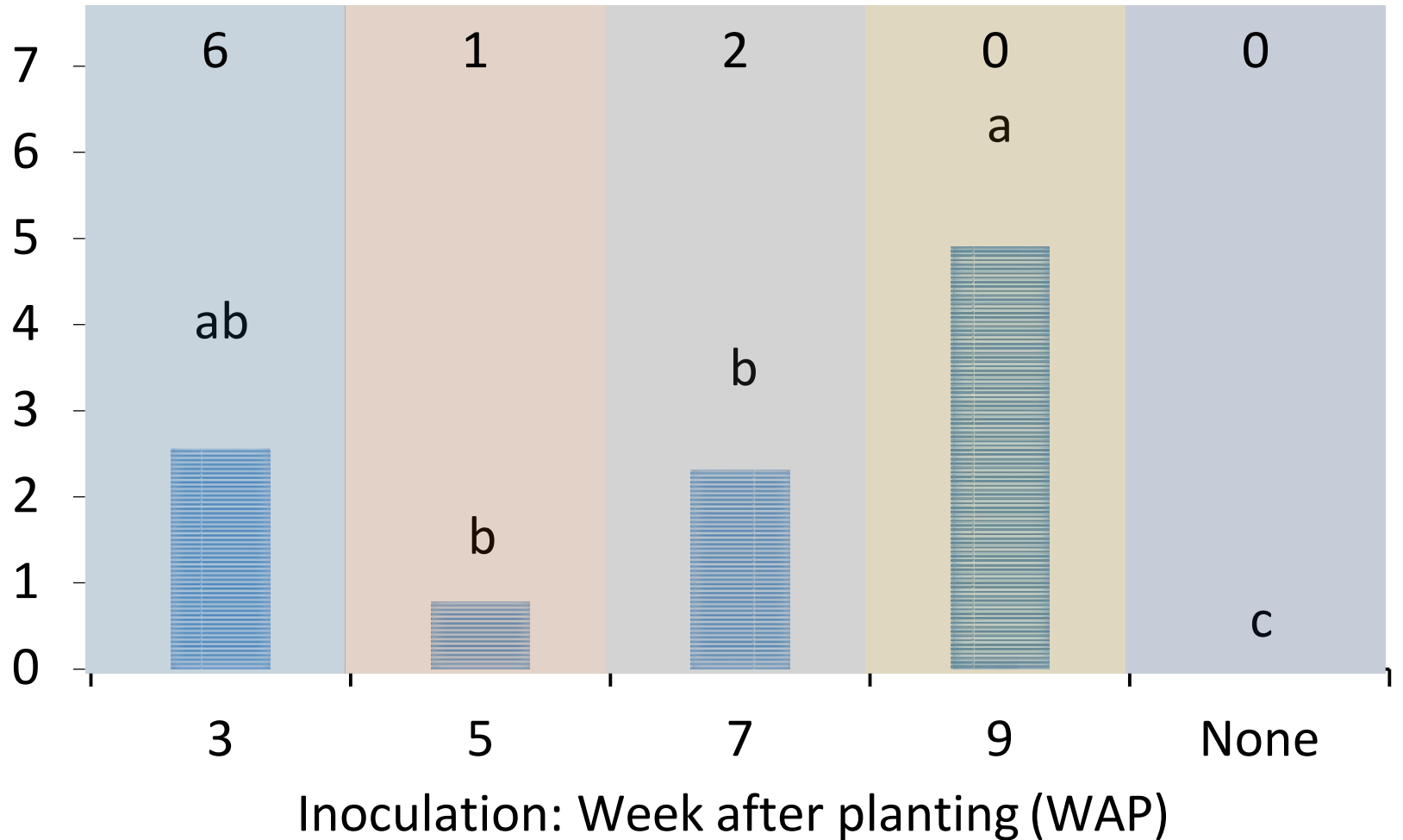
- CM larvae (2nd-3rd instars) were field collected
- Inoculation: 15 maggots per plant
- Evaluation: All the plants (all treatments) were evaluated two weeks after final inoculation
- Plant health was monitored using plant health scale up to 5 days following the inoculation





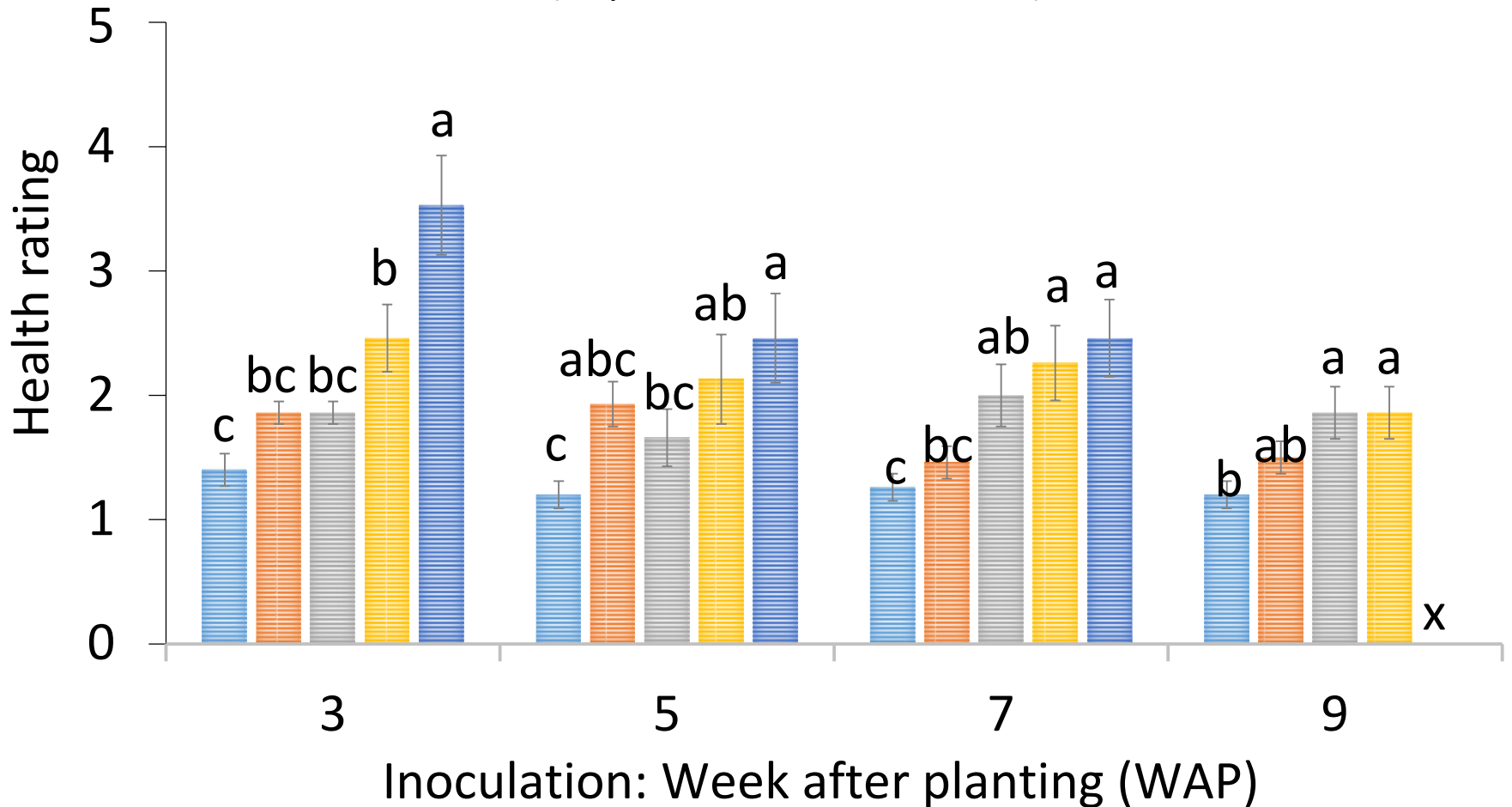
Severity of Injury after 11 WAP

Severity of cabbage maggot injury



Health rating after release

1-DAI 2-DAI 3-DAI 4-DAI 5-DAI
(Days After Inoculation = DAI)



Summary

- Plant mortality was greater at 3 WAP infestation treatment
- At 11 WAP, severity of CM feeding injury on roots was not different between 3 and 9 WAP
- Plant health ratings suggested that plant health deteriorated sharply at 3 WAP



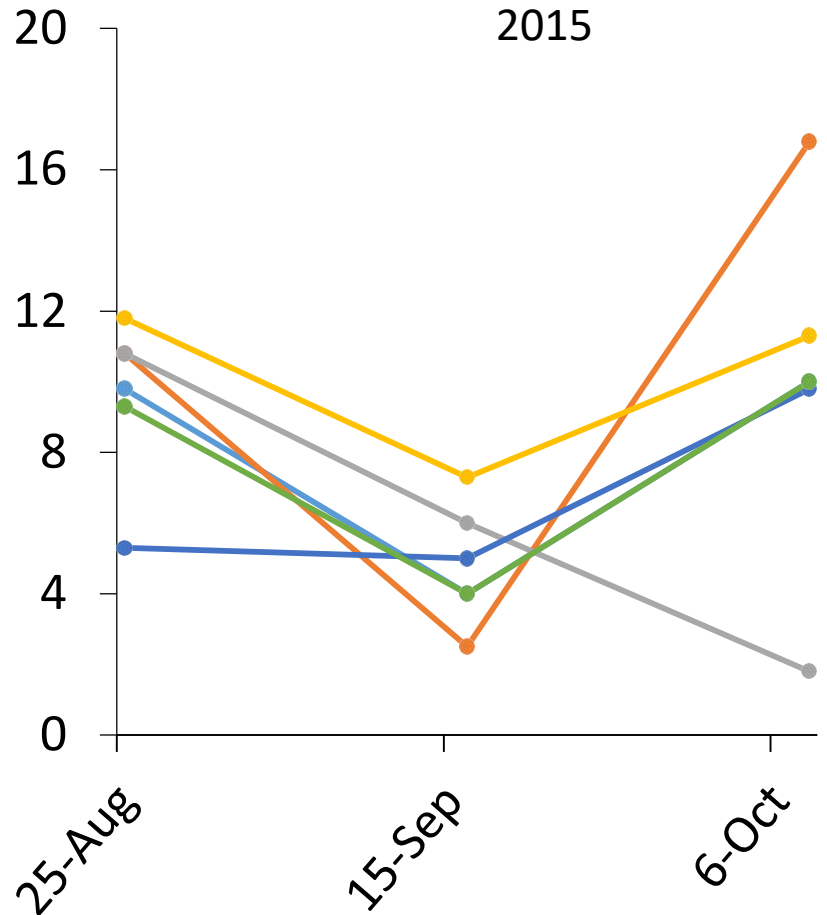
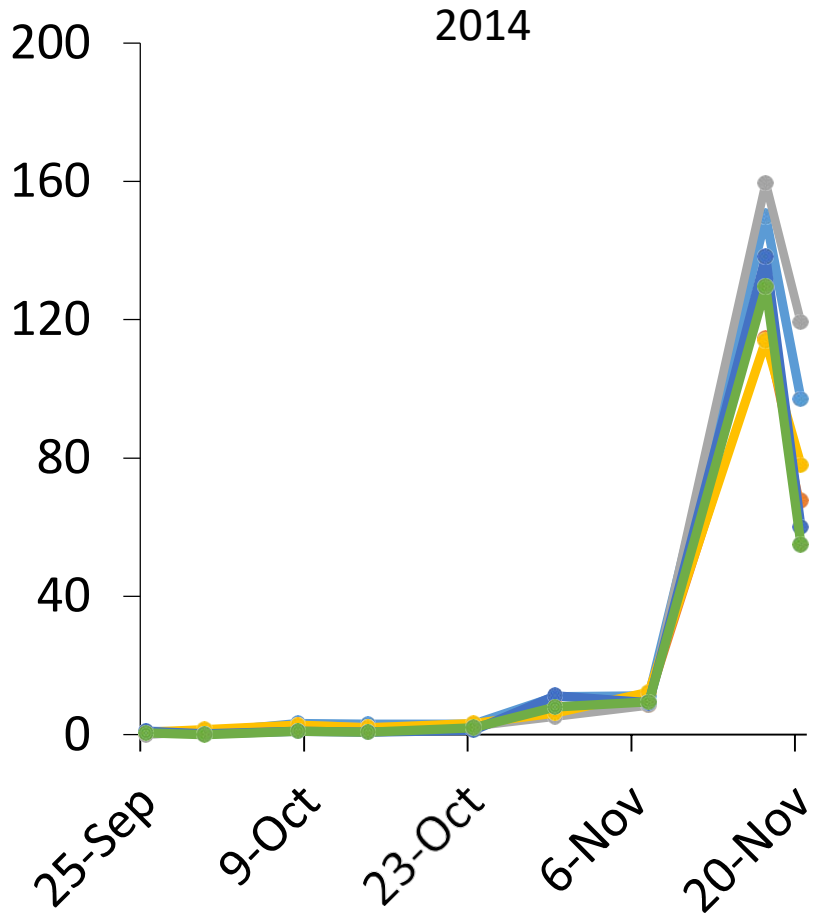
Method- cauliflower

- Five varieties: Nat1, Casper, Symphony, Ravella, Neeblina, Grower standard (Casper)
- Direct-seeded broccoli planted on 40-inch beds
- Treatments assigned based on CRBD
- Replicated 4 times
- Samples collected at 14 d interval until harvest
- Evaluation: Incidence and severity of cabbage maggot injury on roots



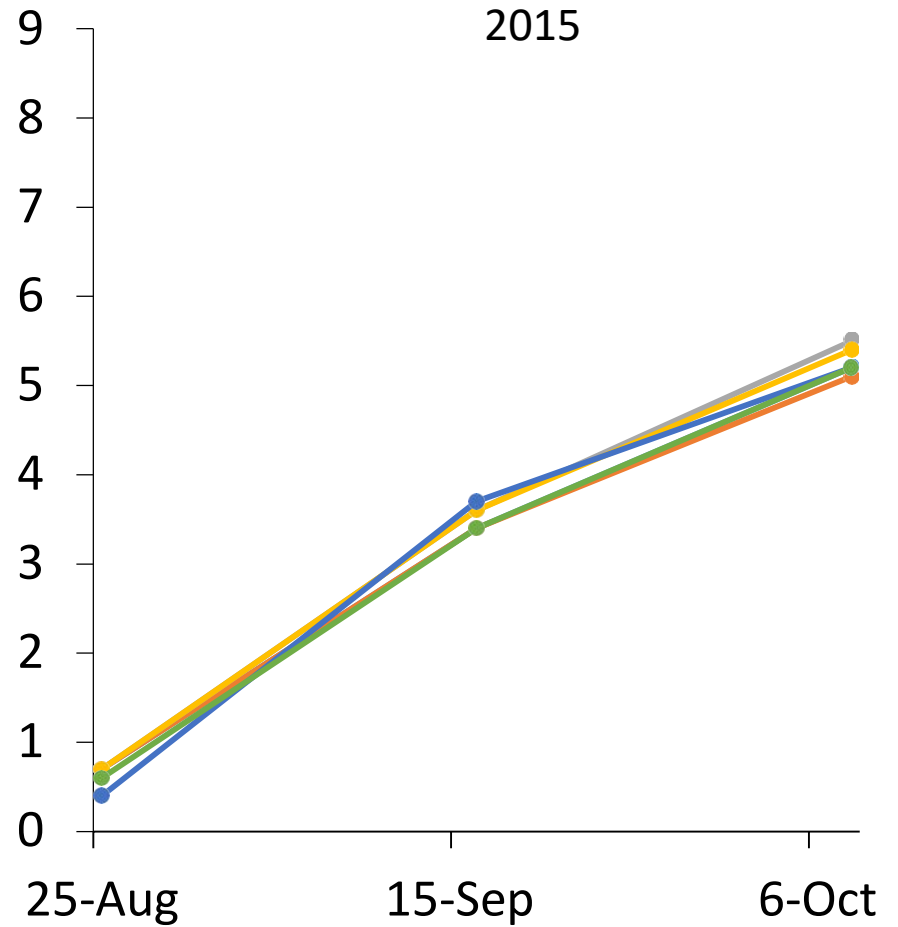
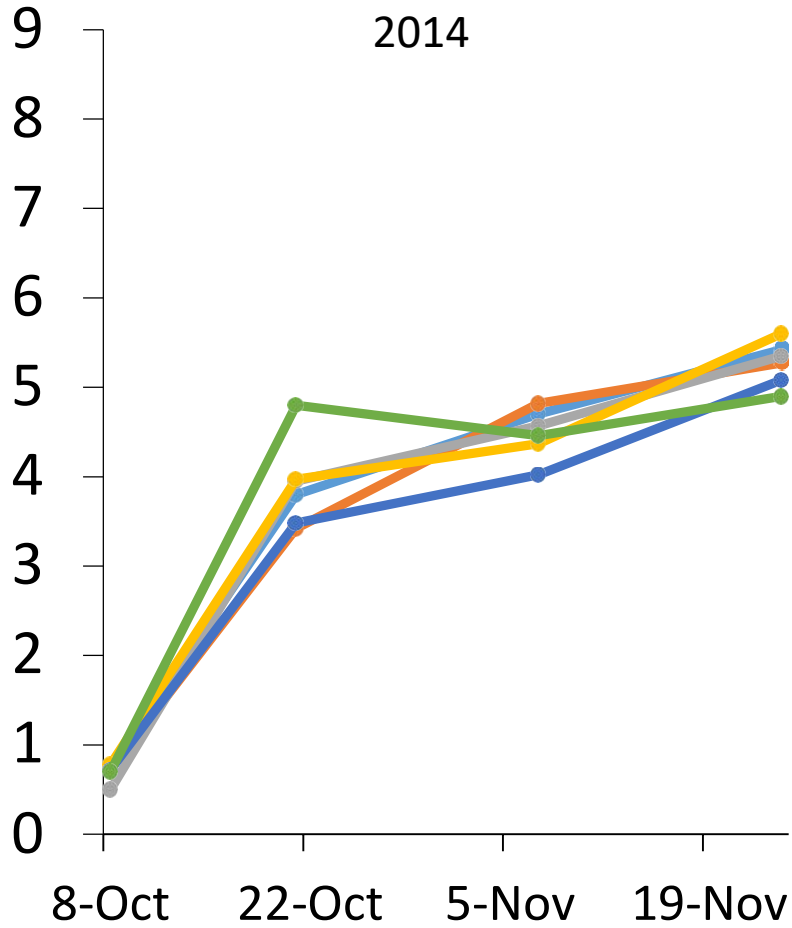
Eggs

- Nat1
- Casper
- Symphony
- Ravella
- Neeblina
- Grower var



Severity of injury

Nat1 Casper Symphony
Ravella Neeblina Grower var



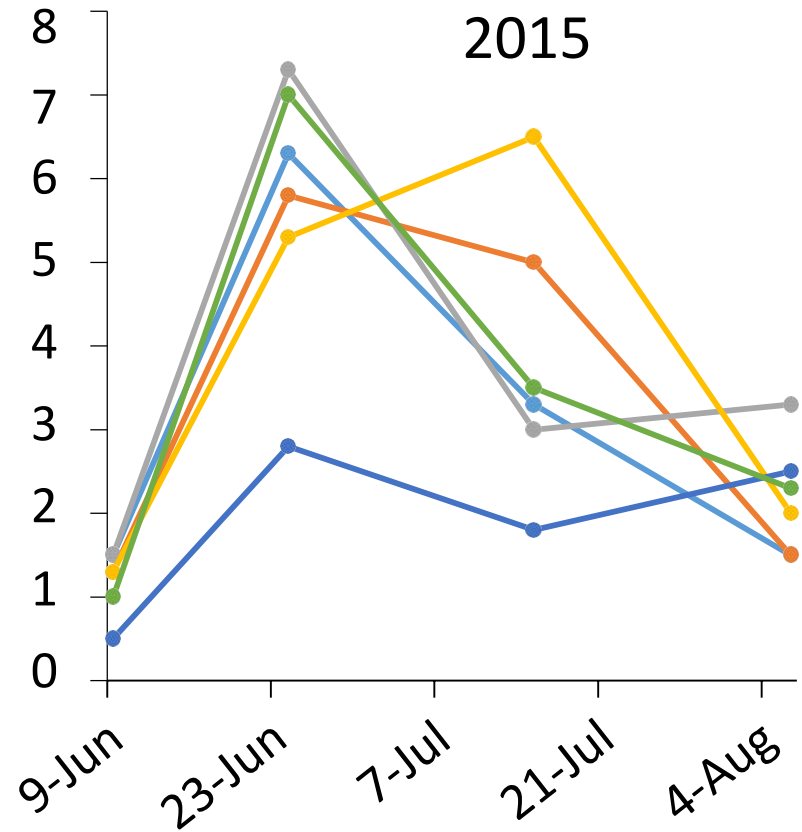
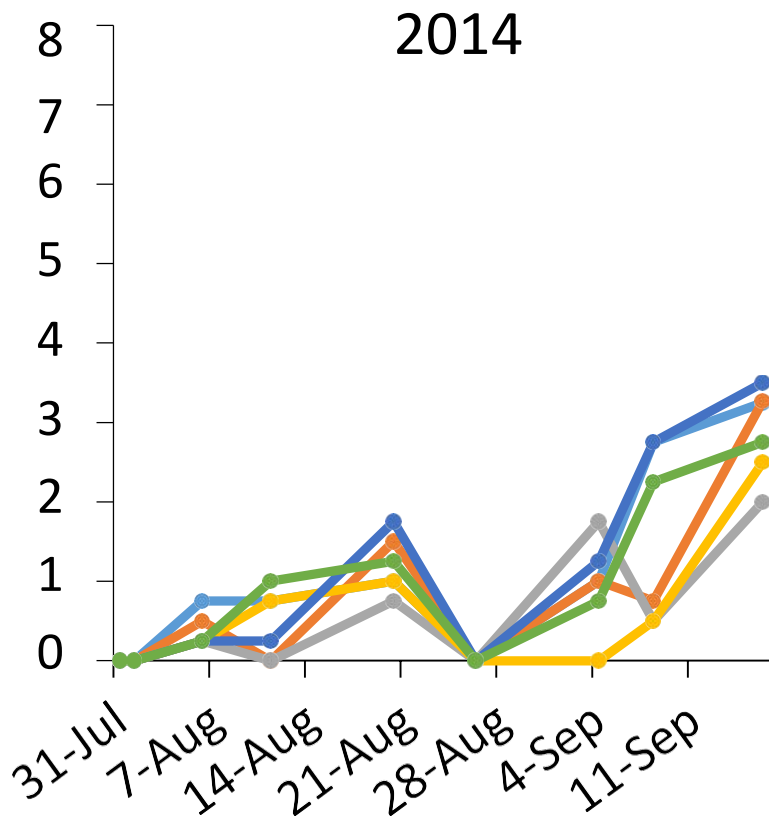
Method-broccoli

- Six varieties: Centennial, Marathon, Patron, Imperial, Black Magic, and Heritage
- Direct-seeded broccoli planted on 40-inch beds
- Treatments assigned based on RCBD with 4 replications
- Samples collected at 14 or 21 d interval until harvest
- Evaluation: Eggs, larvae and severity of CM injury on roots



Eggs

- Centenial
- Marathon
- Patron
- Imperial
- Green magic
- Heritage



Larvae

Centenial

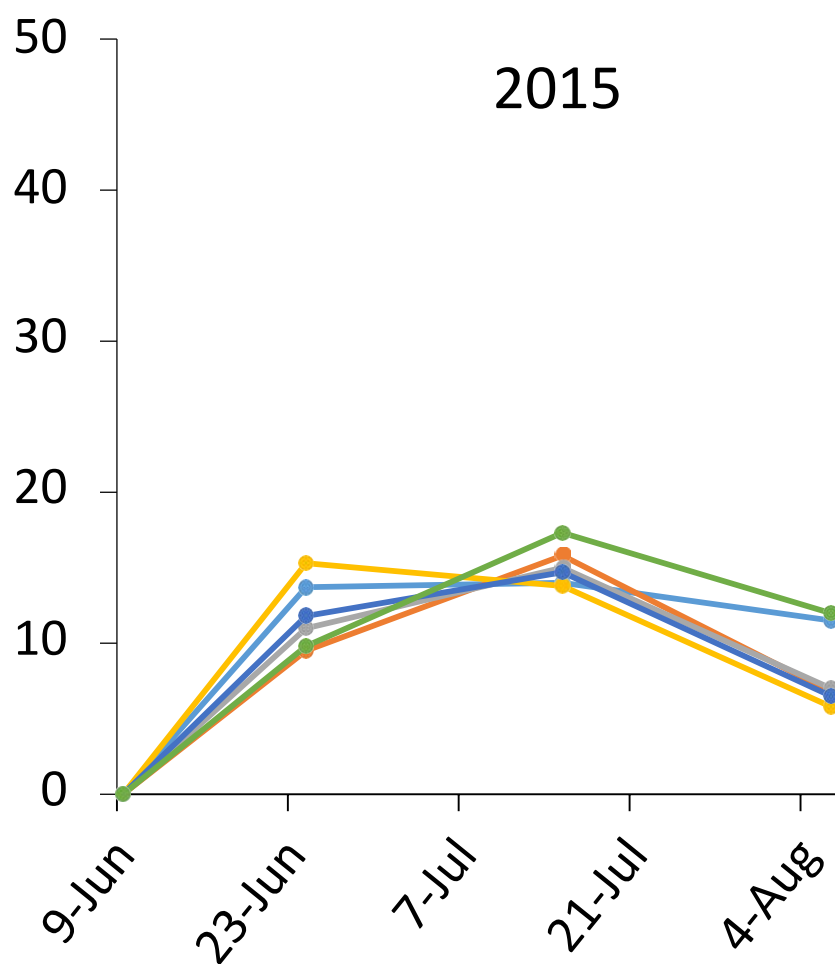
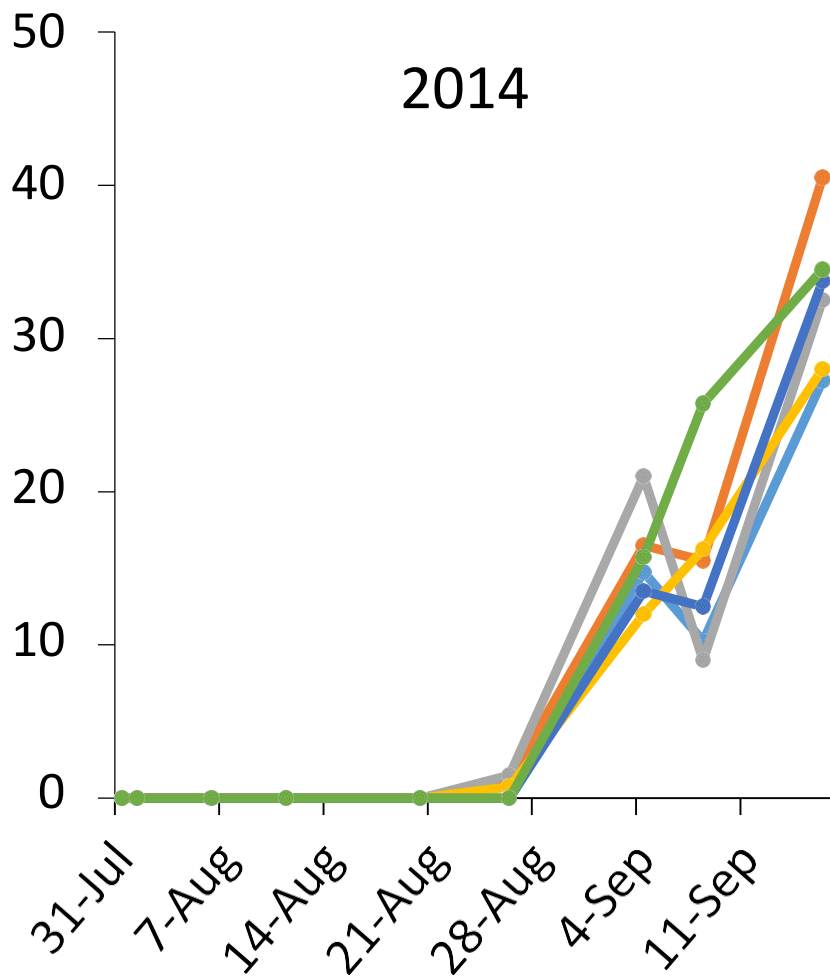
Marathon

Patron

Imperial

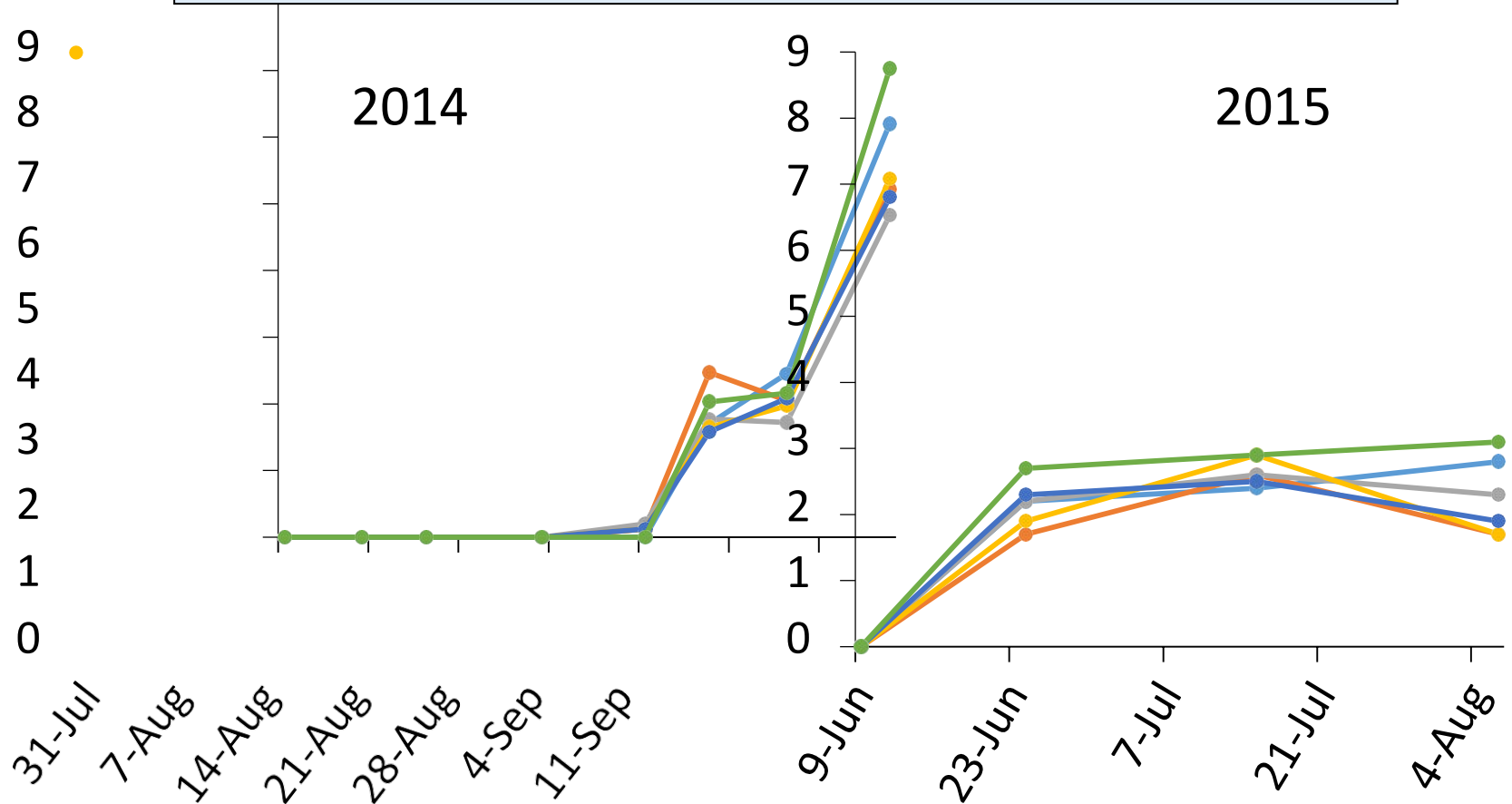
Green magic

Heritage



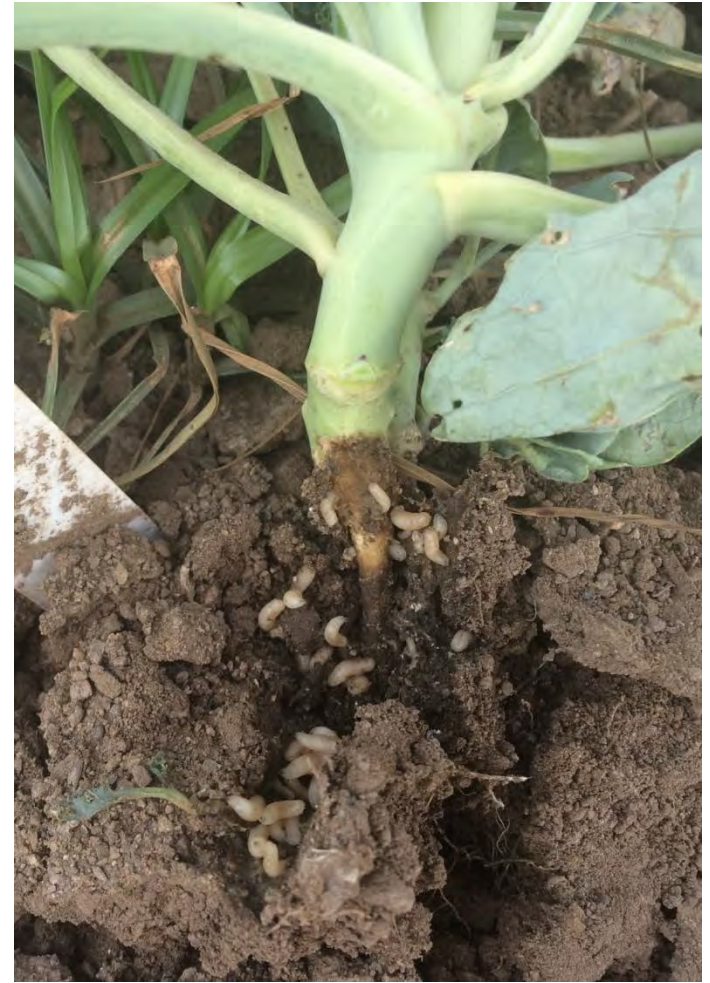
Severity of Injury

Overall, no effects were observed among broccoli and cauliflower cultivars



Goals/objectives

- 1) Understand the relative susceptibility of crops to maggot attack
- 2) Compare the level of resistance /tolerance present in the commercial cultivars
- 3) Understand the effects of temporal spacing between crops on maggot fly infestation on the successive *Brassica* crop



Method

- First crop – Lettuce (direct seeded)
 - Planted at two week intervals
 - Plot size: ten 40-inch bed × 100 feet
 - Four (plantings) treatments replicated four times in RCBD
- Second crop – direct seeded broccoli
 - Planted on all the beds – a week after harvesting the last treatment of lettuce

Treatments

Lettuce planting

i

T1



T2



T3



T4





Soil incorporation of lettuce

2014			2015		
Harvest date	Days between crops	Broccoli planted	Harvest date	Days between crops	Broccoli planted
1 July	48	18 Aug	24 Jun	49	12 Aug
15 July	33	18 Aug	8 Jul	36	12 Aug
29 July	20	18 Aug	22 Jul	21	12 Aug
11 Aug	7	18 Aug	5 Aug	7	12 Aug

Evaluation

- Number of eggs from 10 plant base (10-cm diameter) per plot every week
- Larvae and severity of CM infestation on roots every week

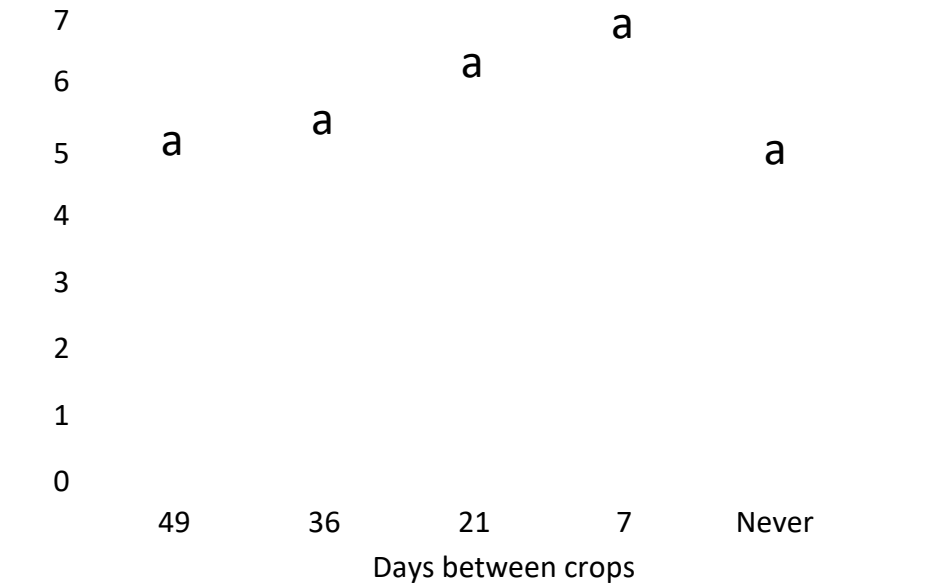
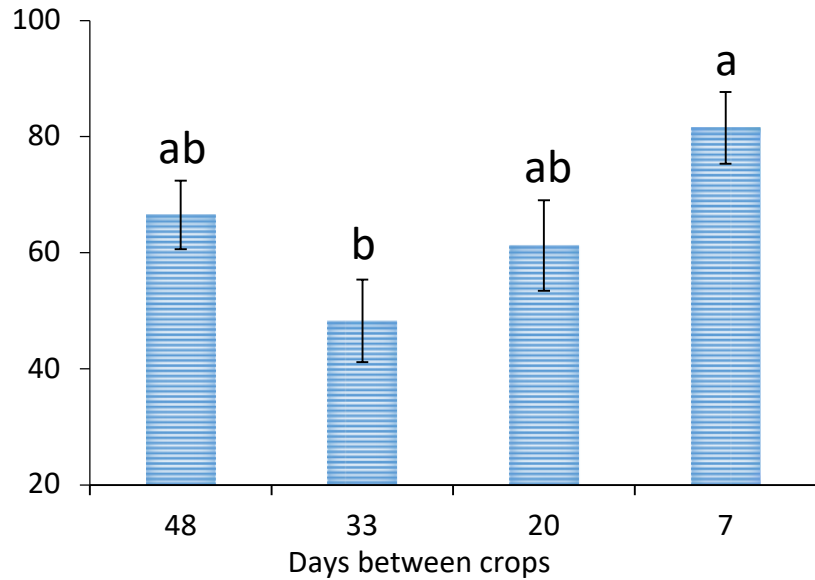
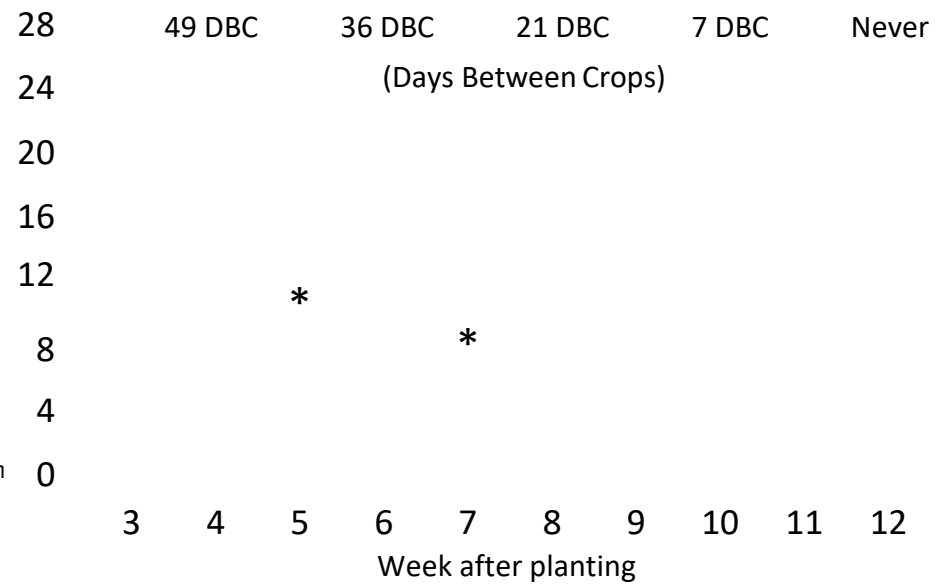
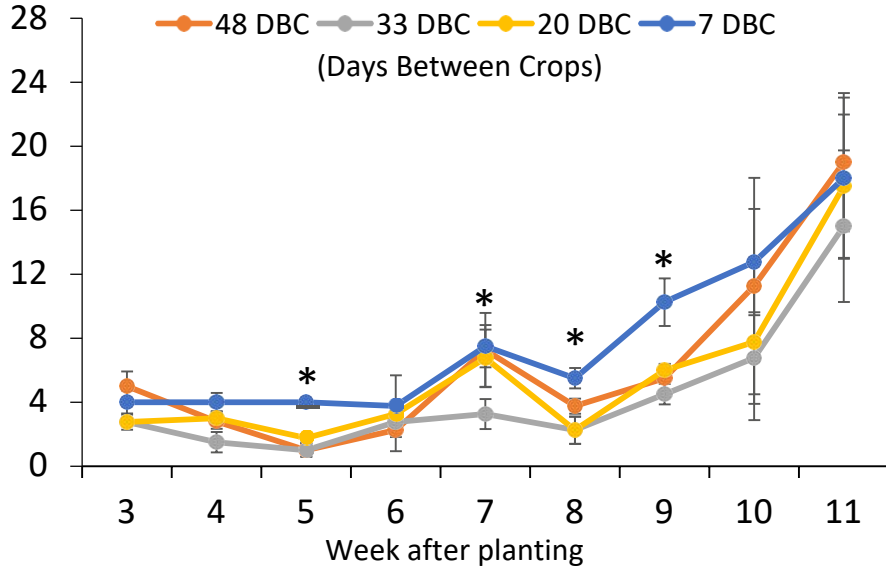


Eggs

No. eggs per plot

2014

2015

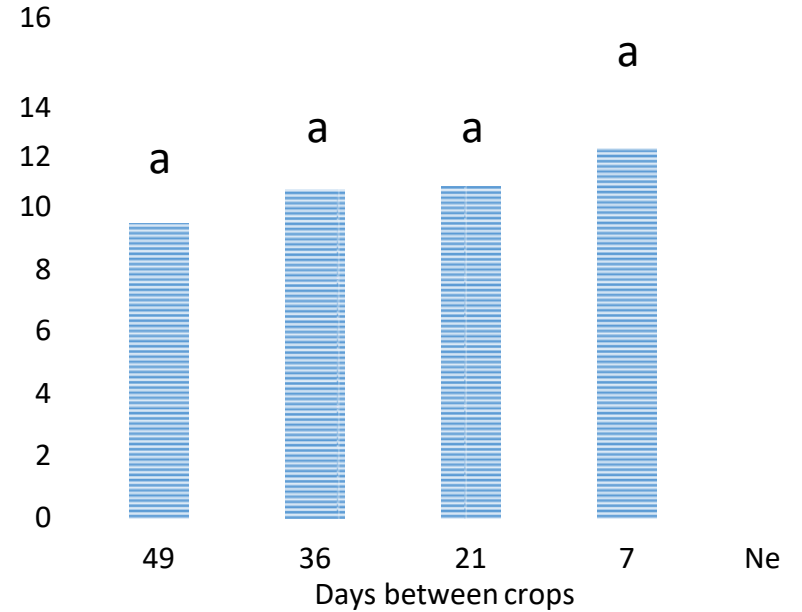
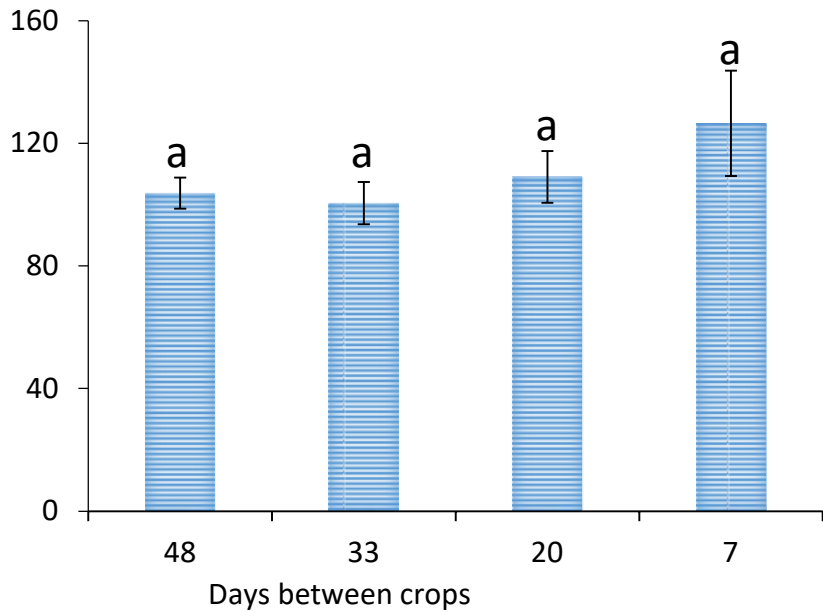
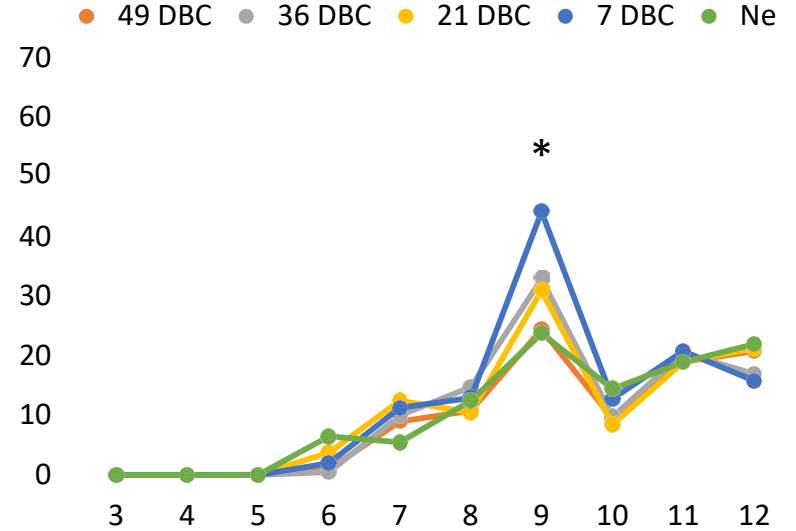
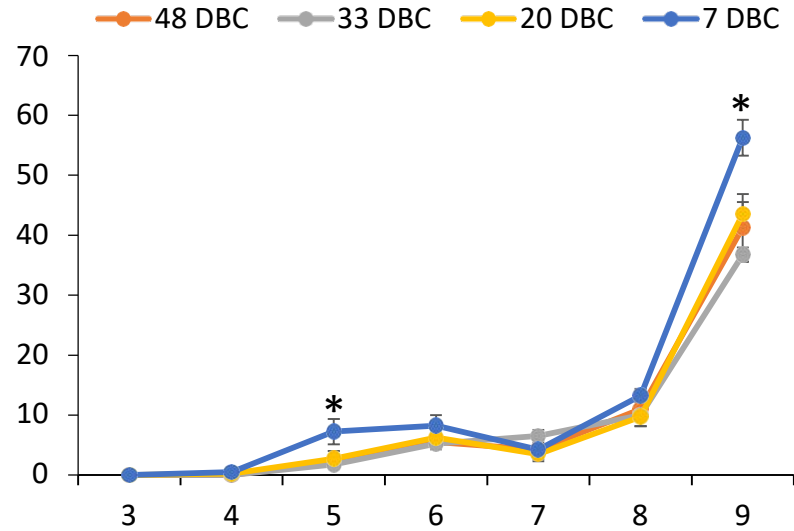


Larvae

No. larvae per plot

2014

2015



Severity of injury

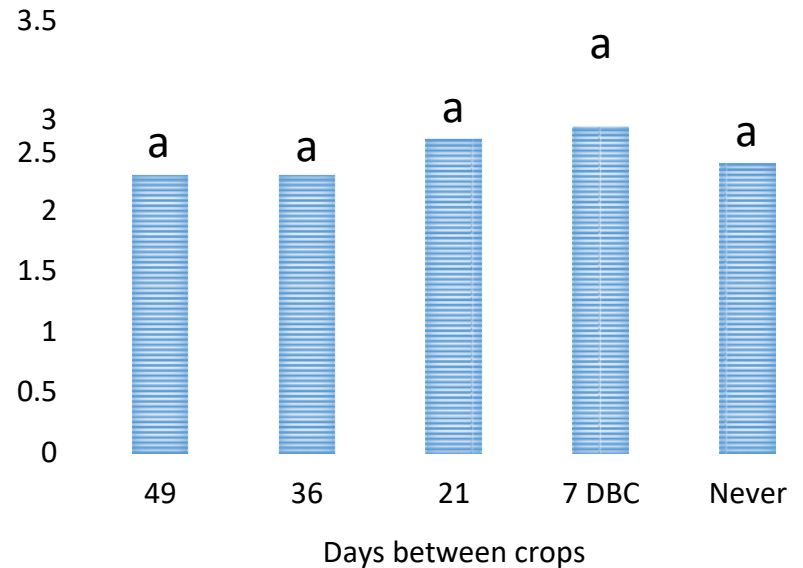
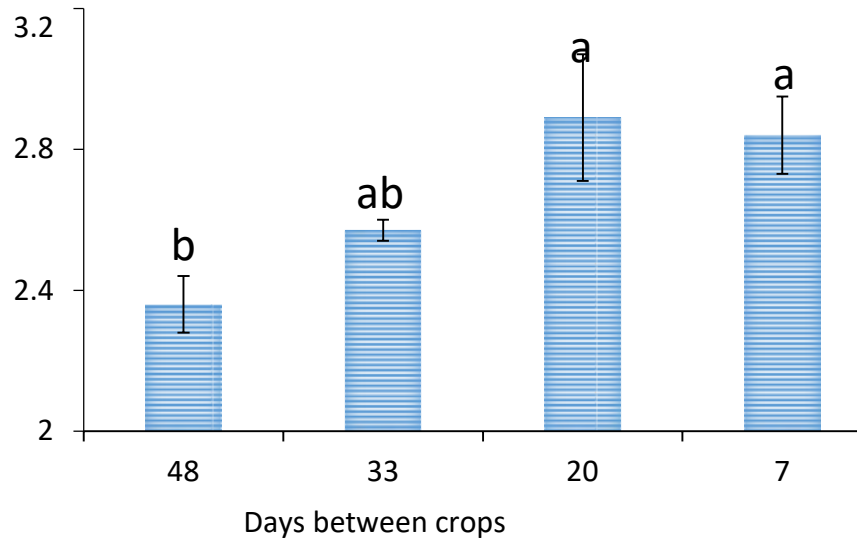
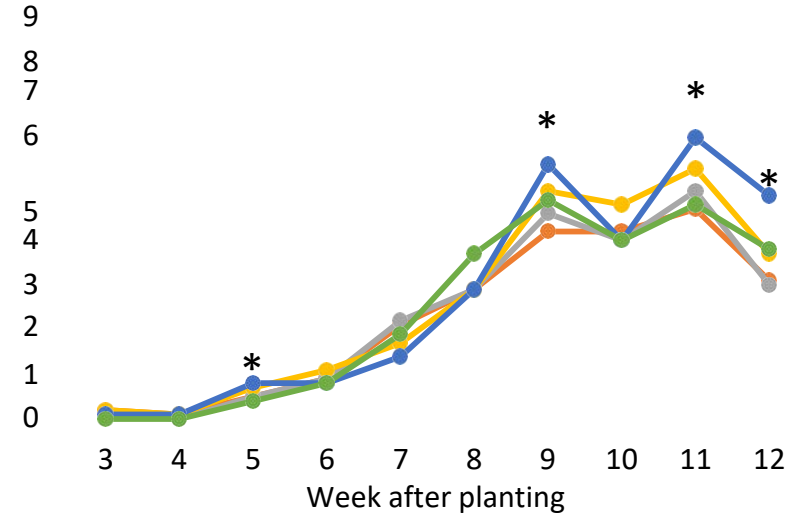
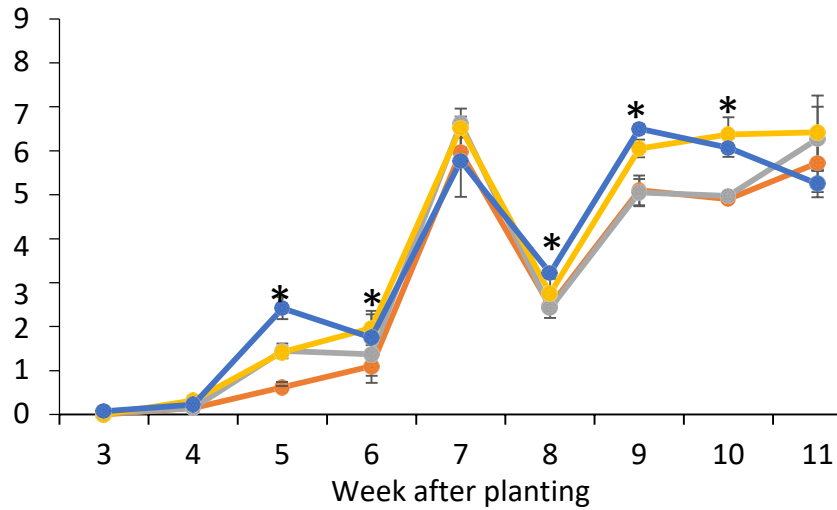
Injury severity per plot

2014

2015

48 DBC 33 DBC 20 DBC 7 DBC

49 DBC 36 DBC 21 DBC 7 DBC Never



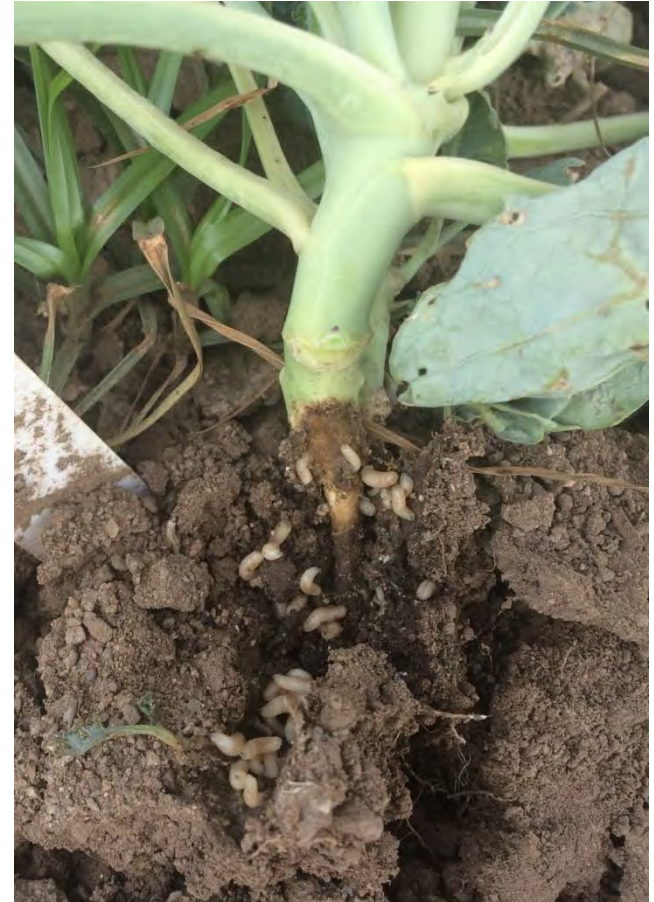
Summary

- Number of eggs was greater in 7-d than 48-d gap between crops
- Based on severity of injury, 48 days between crops had significantly less severe CM injury than a week
- Number of CM larvae tend to be lower in the greater interval between crops



Goals/objectives

- 1) Understand the relative susceptibility of crops to maggot attack
- 2) Compare the level of resistance /tolerance present in the commercial cultivars
- 3) Understand the effects of temporal spacing between crops on maggot fly infestation on the successive *Brassica* crop
- 4) Identify effective low-risk active ingredients to maggot pests and their mode of delivery or placement, timing
 - Efficacy of insecticides
 - Placement of insecticides



Method

- Crop: Seeded broccoli
- Design: RCBD with 4 times
- Plot size: 50 linear feet – two 25 feet long 40” beds (2 lines/bed)
- Seeds planted: 7 August 2013
- Two applications at 3 and 4 WAP

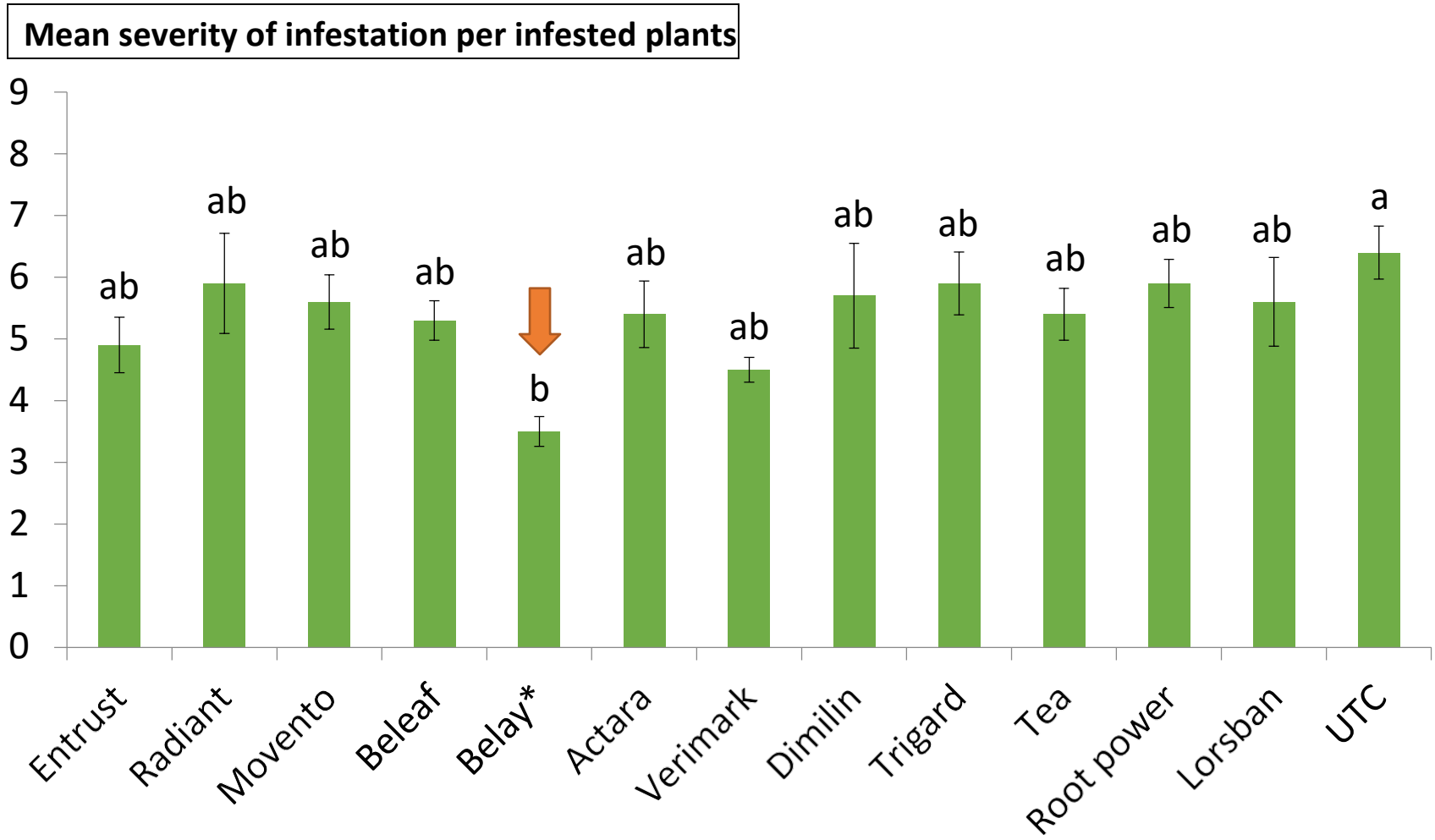


Treatments

Treatment	AI	Amt formulated/acre	Application dates
Entrust	Spinosad	10 fl oz	29 Aug; 5 Sep
Radiant	Spinetoram	10 fl oz	29 Aug; 5 Sep
Movento	Spirotetramat	4 fl oz	29 Aug; 5 Sep
Beleaf	Flonicamid	2.8 oz	29 Aug; 5 Sep
Belay*	Clothianidin	6 fl oz	7 Aug; 29 Aug; 5 Sep
Actara	Thiamethoxam	6.5 oz	29 Aug; 5 Sep
Verimark	Cyantraniliprole	13.5 fl oz	29 Aug; 5 Sep
Dimilin	Diflubenzuron	4 fl oz	29 Aug; 5 Sep
Trigard	Cyomazine	2.66 oz	29 Aug; 5 Sep
Tea	Vermiculture	50 v/v	29 Aug; 5 Sep
Root power	-	16 fl oz	29 Aug; 5 Sep
Lorsban	Chlorpyrifos	2.75 fl oz	29 Aug; 5 Sep
Untreated check	-		29 Aug; 5 Sep

*at planting

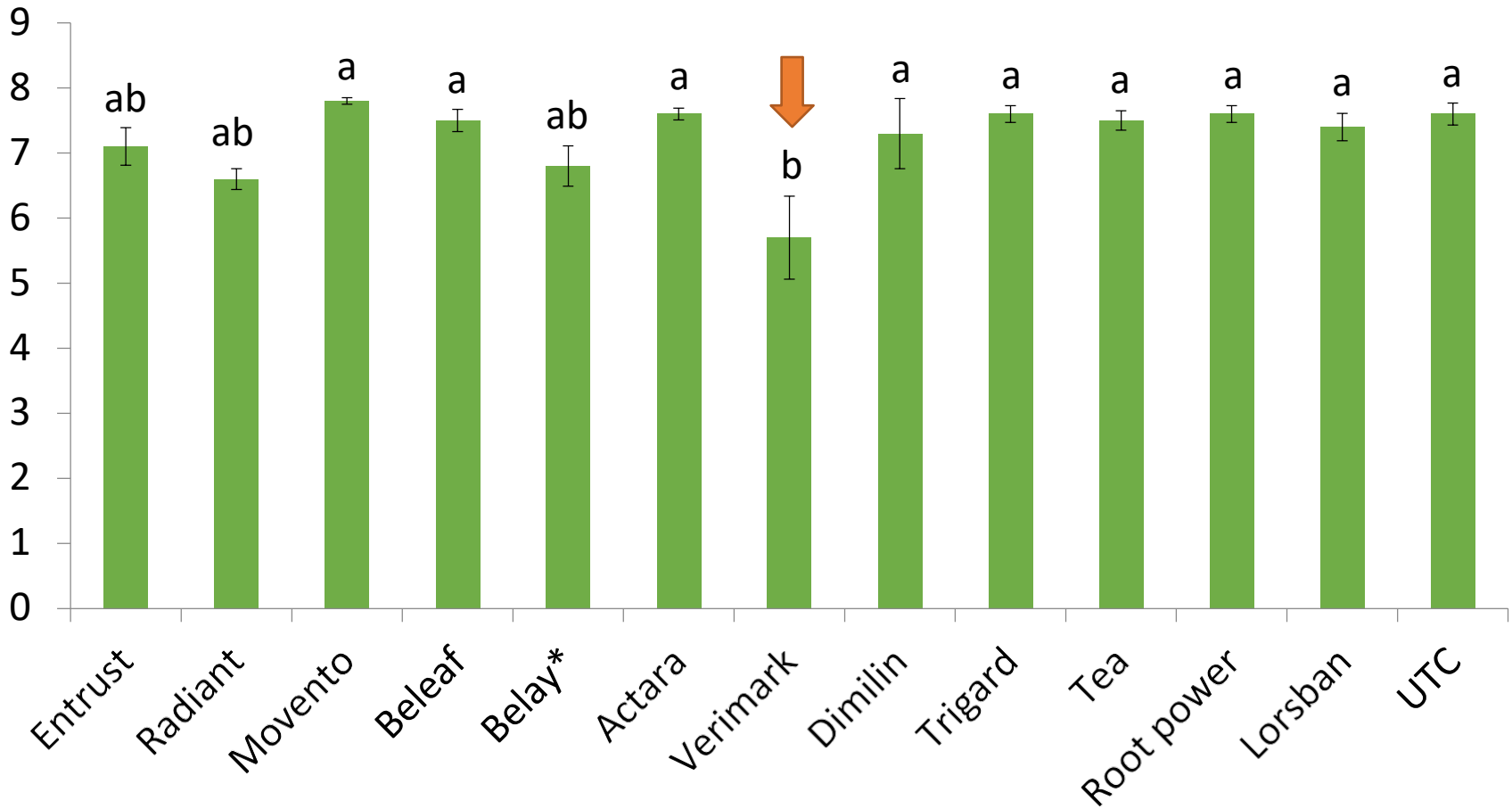
Results: Severity (5 WAP)



Sampled: 12 Sep; planted: 7 Aug

$F = 2.2; df = 12, 36; P = 0.036$

Results: Severity (7 WAP)



Sampled: 12 Sep; planted: 7 Aug

$F = 4.1; df = 12, 36; P = 0.001$

Comparison of application methods

Treatment
1 No insecticide
2 Insecticide in drip
3 Seed treatment + insecticide in drip
4 Seed treatment only
5 Spray at plant + insecticide in drip
6 Spray at plant only

Methods

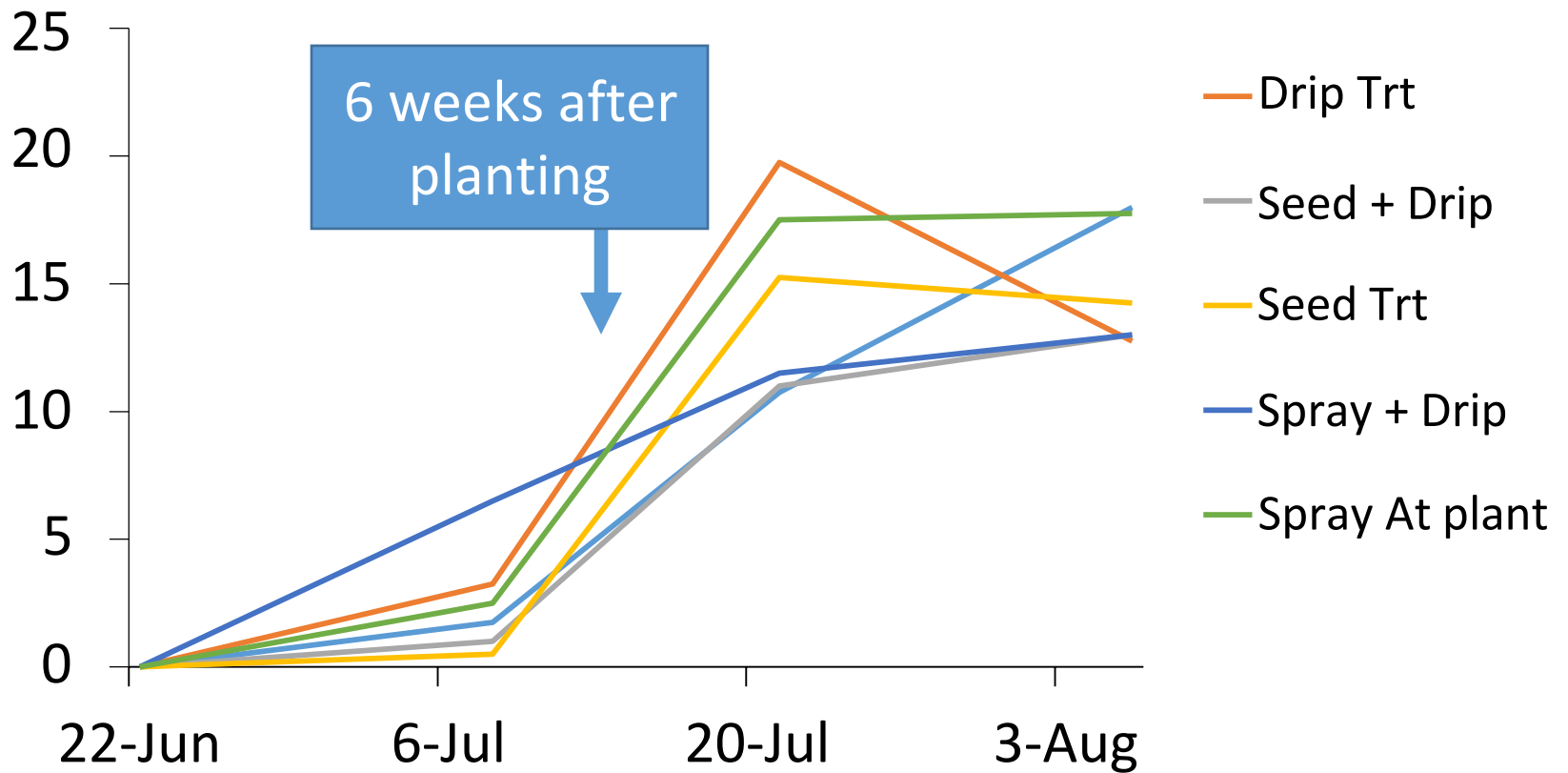
- Insecticide – Belay (clothianidin)
- Sprayed: two applications
 - at plant (8 fl oz/acre)
 - delayed (4 fl oz/acre)
- Seed treatment – NipsIt
- Chemigation - Belay
 - Delayed application – 12 fl oz /acre
 - 6 weeks after planting: Experi. 1
 - 3 weeks after planting: Experi. 2





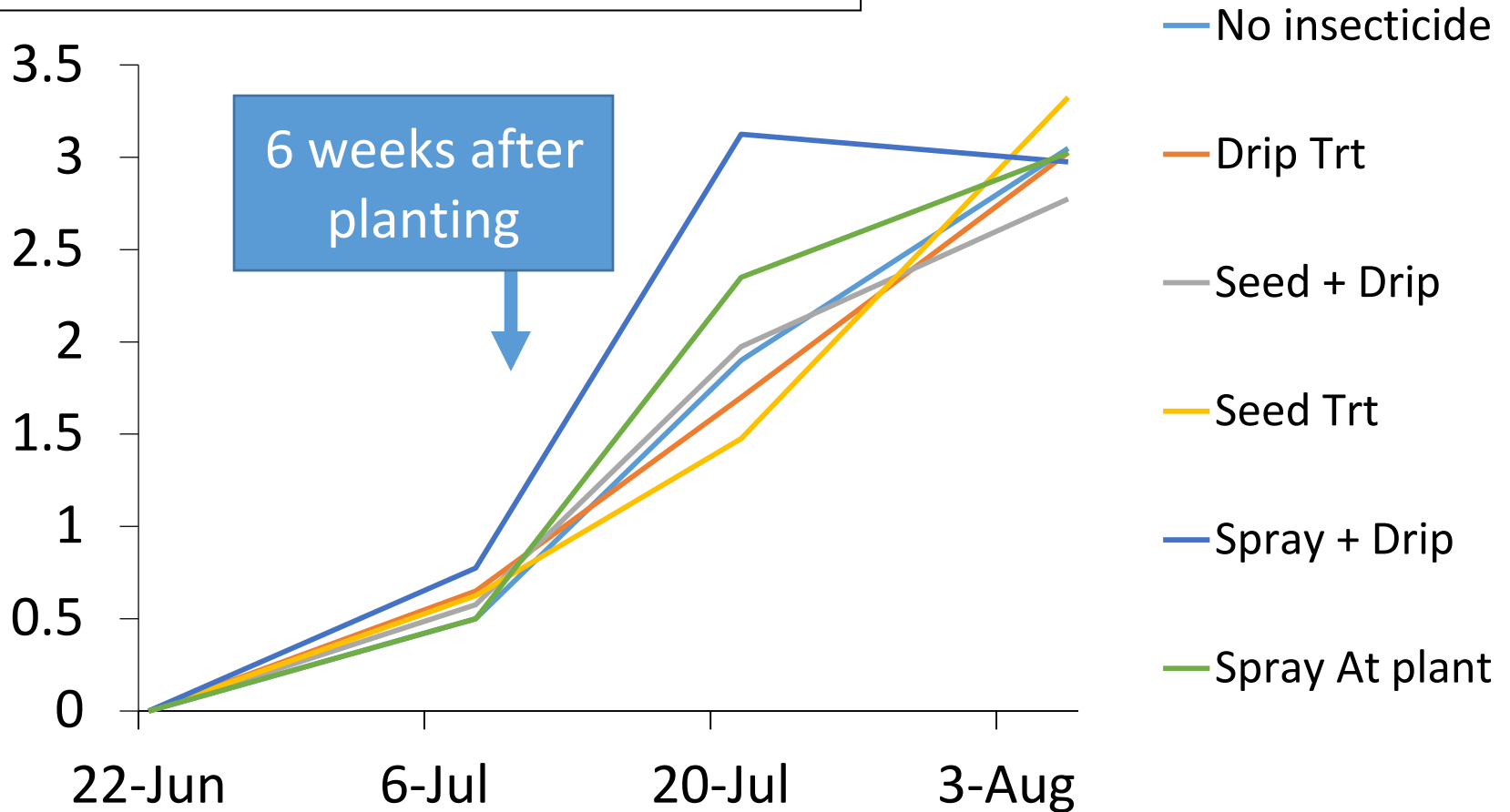
Experiment 1 –larvae

Number of cabbage maggot larvae per 10 plants



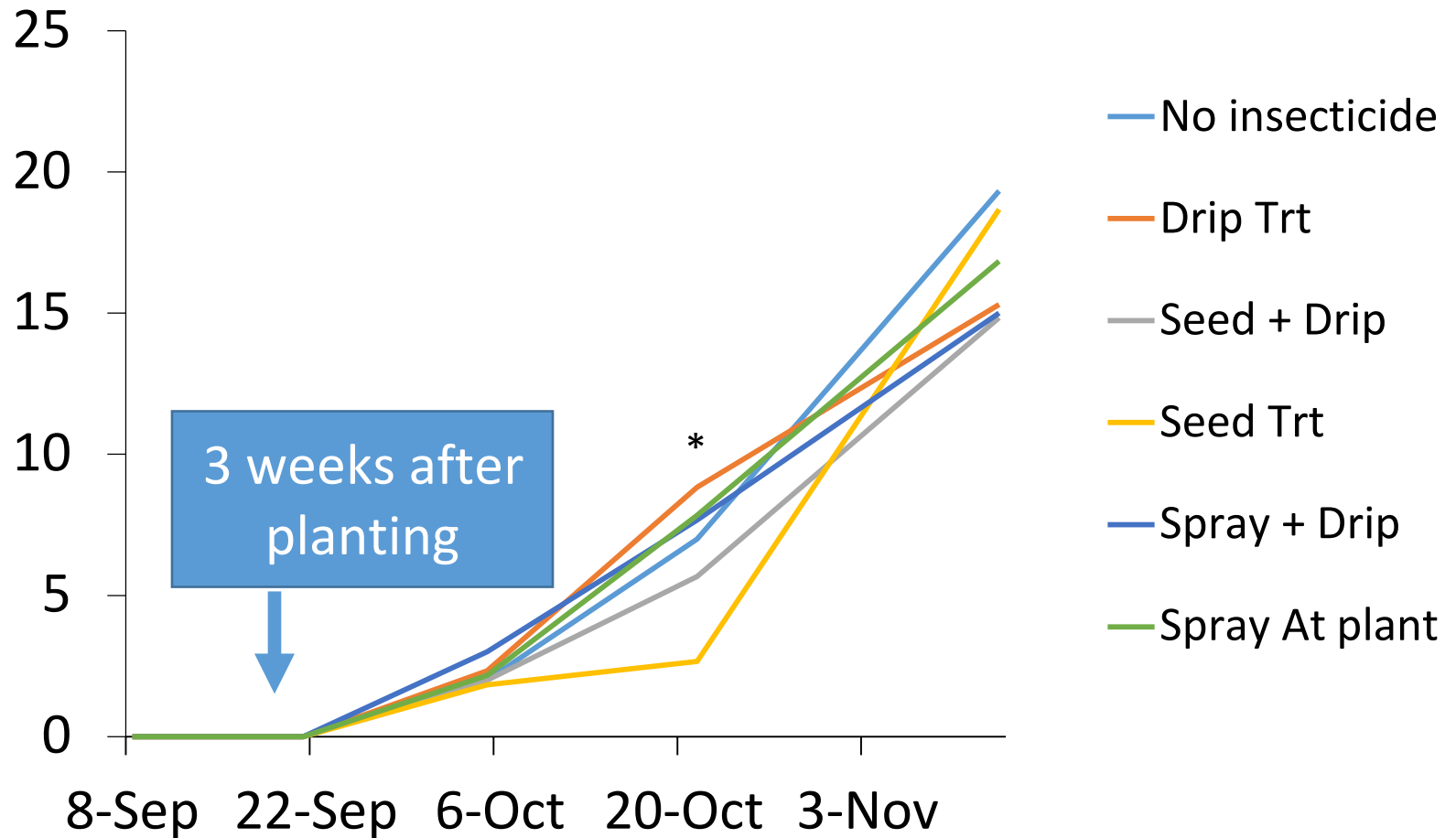
Experiment 1 - Severity

Mean Severity of 60 root samples



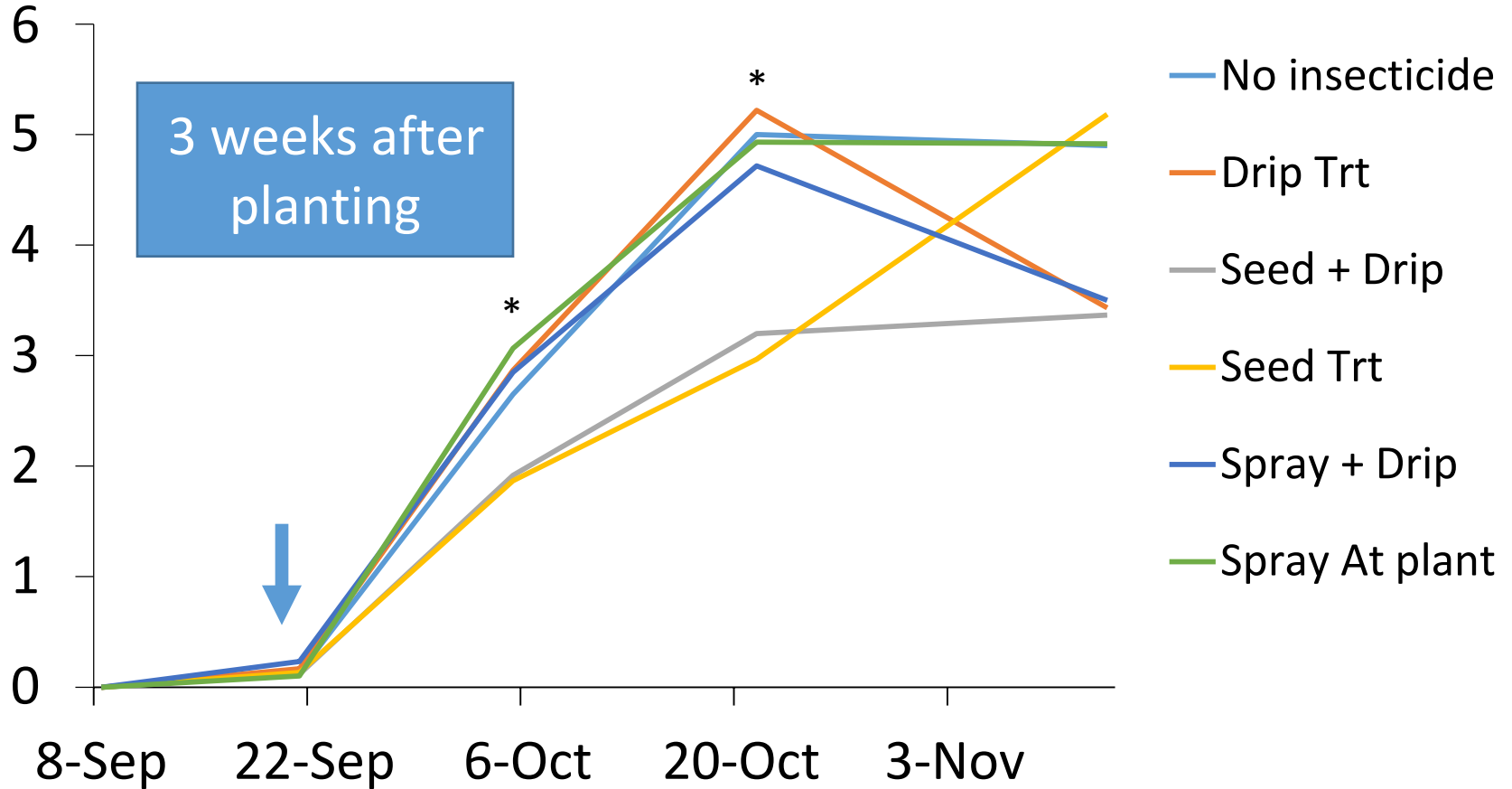
Experiment 2 – larvae

Number of maggots/ 10 roots



Experiment 2 – Severity

Severity of Injury per 10 plants



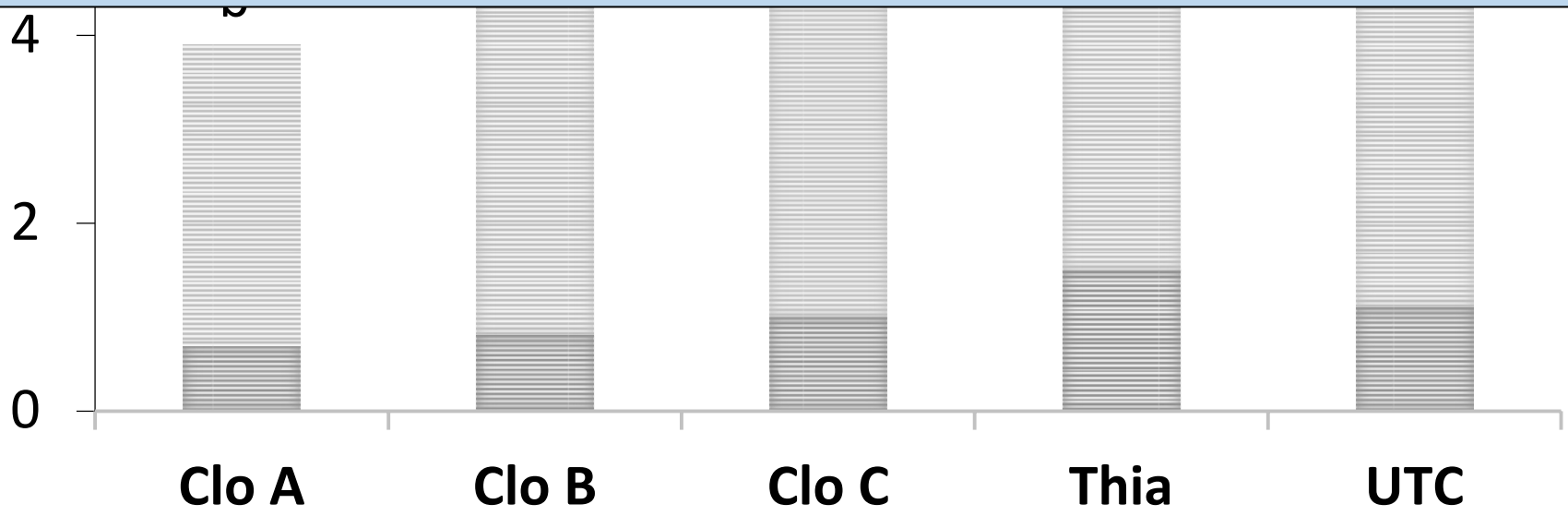
Seed treatment

Active ingredient	Appli. rate / seed
Clothianidin A	0.750 mg
Clothianidin B	1.170 mg
Clothianidin C	1.680 mg
Thiamethoxam	1.160 mg
UTC	

Seed treatment

Severity of cabbage maggot infestation

- Seed treatment suppressed cabbage maggot infestation on broccoli
- More research is needed to validate the utility of chemigation through drip irrigation for cabbage maggot control



Overarching results

- Trap cropping with turnip (especially in perimeter planting) could reduce CM injury severity on main crop
- Early phase of broccoli is more vulnerable to CM injury than later stages
- Commercial broccoli and cauliflower varieties did not show any evidence of resistance or susceptibility
- Extended fallow period between crops reduced CM injury on broccoli
- Among insecticides, clothianidin was the most effective insecticide compared with other insecticides
- Seed treatment of clothianidin suppressed CM infestation on broccoli



Acknowledgements

- Growers, Pest Control Advisers, students
- Grant managers: Patricia Matteson, Basil Ibewiro, Matt Fossen
- Christine Uhrik
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 - California Department of Pesticide Regulation

