The Biology & Integrated Management of the Bean Seed Fly

Update Meeting: 08/12/2021

Becca McGowan & Rosemary Collier

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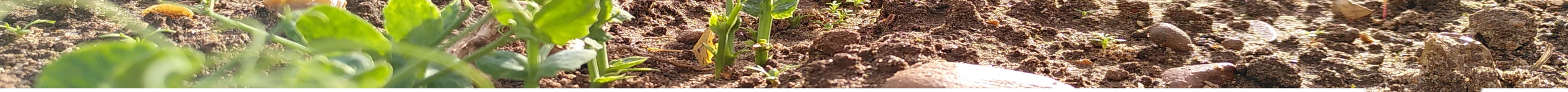

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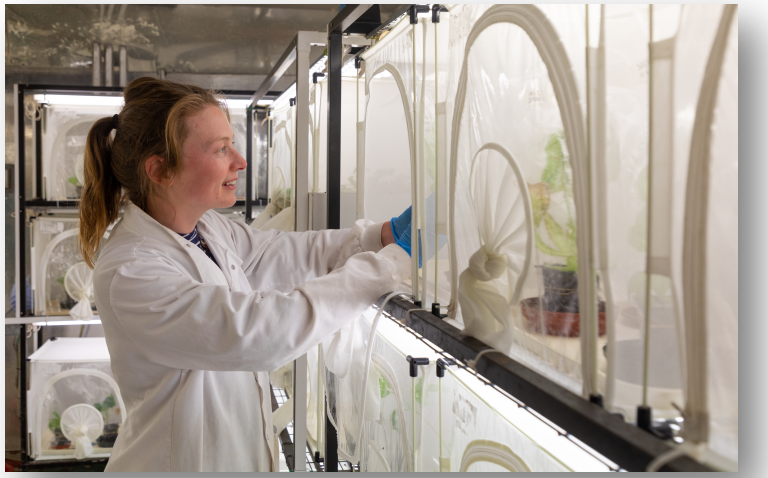

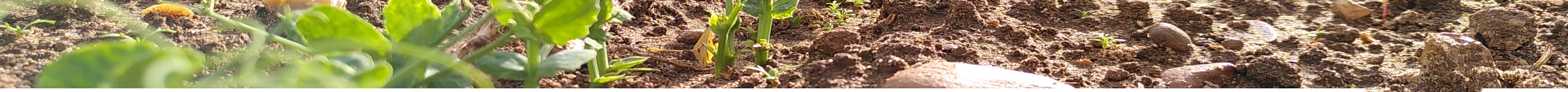

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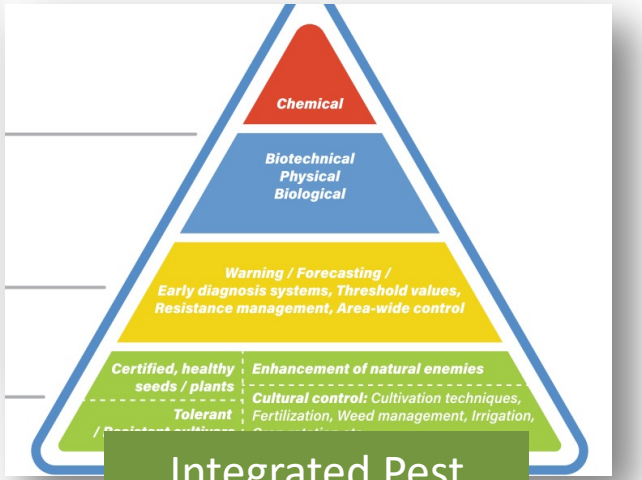
Introduction

- Bean Seed Fly (BSF): Complex of two species
- Root maggot: Feeding on the seed and stem of a wide range of crops
- The problem: Lack of effective insecticides (especially seed treatments)

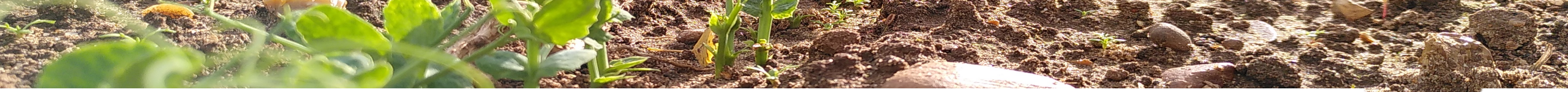
Delia platura[1]

Delia florilega[1]

Symptoms of BSF damage[2,3]



Integrated Pest Management Pyramid[4]



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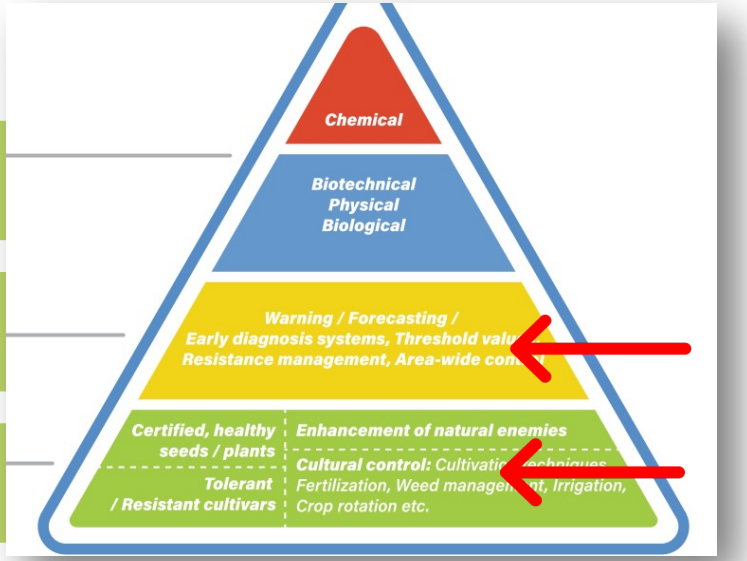
Project Aim:

Contribute towards an integrated pest management strategy to reduce crop and economic losses caused by the BSF

Objectives:

1. Overwintering biology
2. Monitoring
3. Forecasting
4. Cultural & interference strategies



Objective One

Overwintering biology

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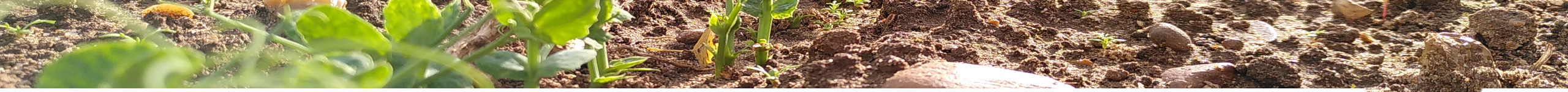

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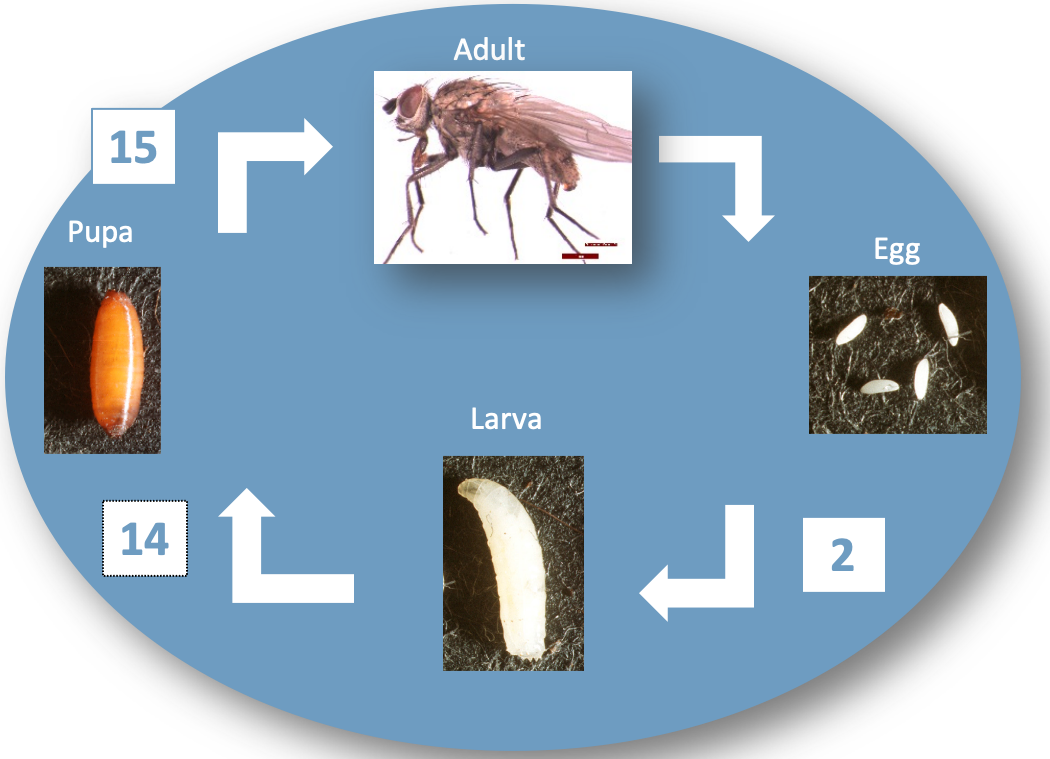
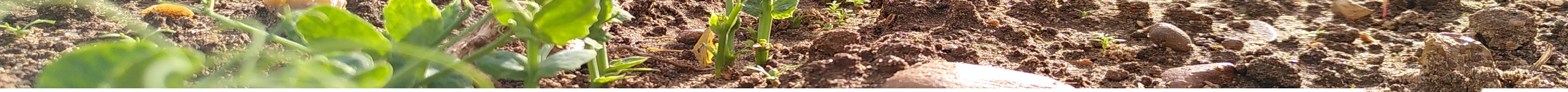
Pattern of activity

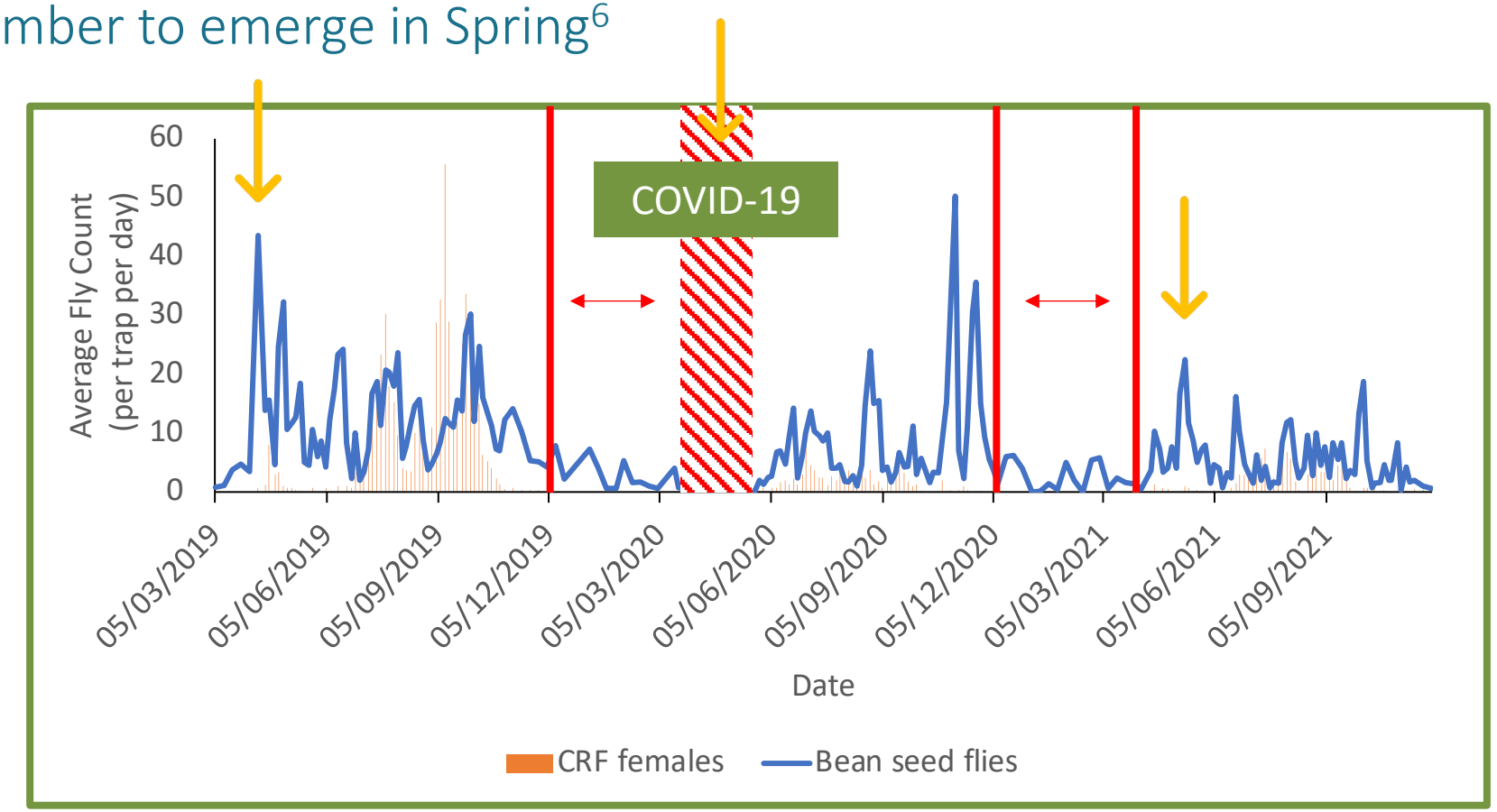
- Life cycle[5]: Eggs – Larvae – Pupae – Adult
- Environmental drivers: Temperature, daylength…

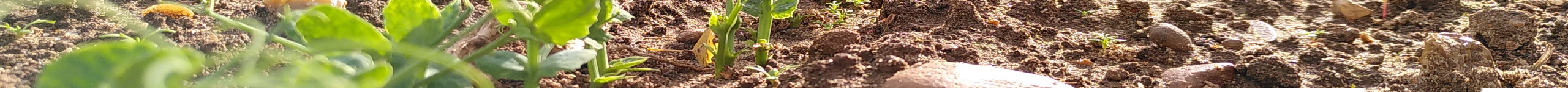




Pattern of activity

- Reduced activity during winter – Are they in diapause (similar to hibernation)?
- Large number to emerge in Spring[6]





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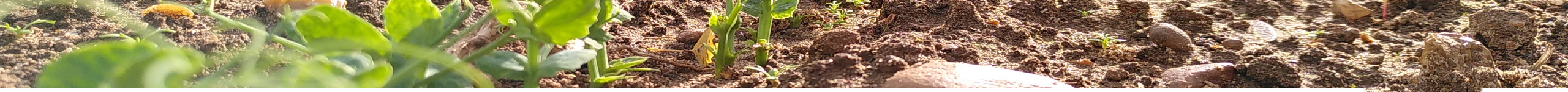
Research Questions

1. Do wild BSF enter diapause?
2. If wild BSF enter diapause, when do they complete diapause?
3. How long do BSF pupae spend in diapause?

WHY?

Aid predictions of spring emergence



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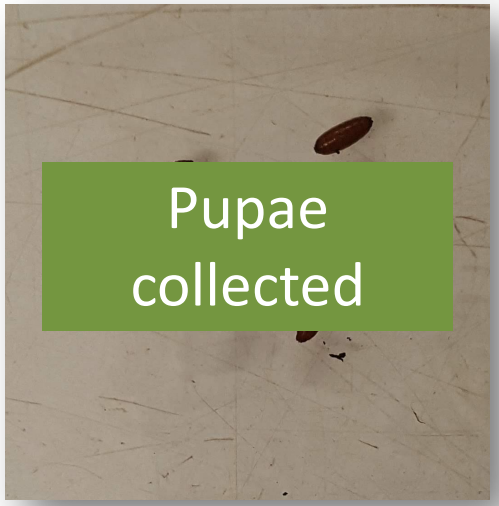
General Methods



Emergence recorded at 20°C

Placed at 0°C for different durations

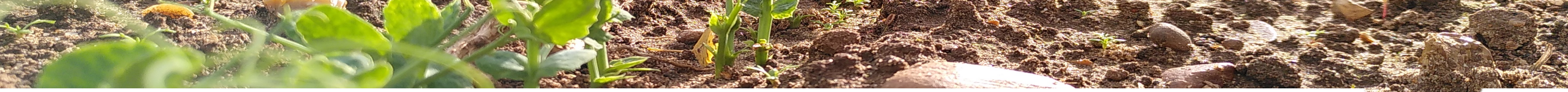
Did adult flies emerge in 15 days at 20°C?

YES

Not in diapause

No

In diapause



1 Do wild BSF enter diapause?

YES
Only those laid towards late September

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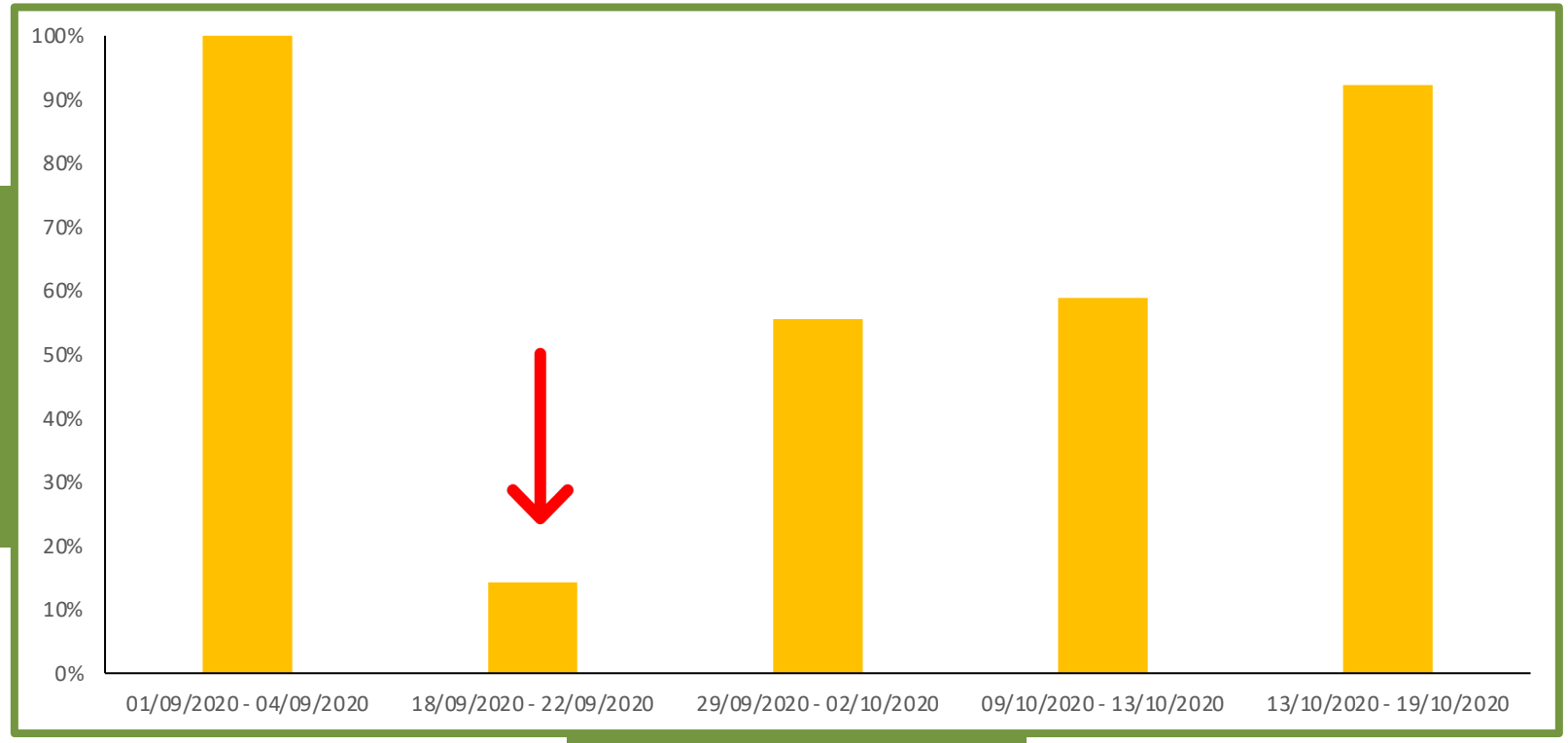
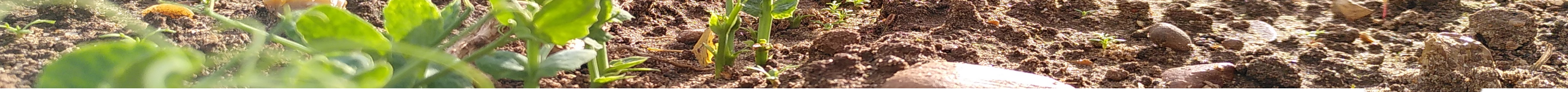
Proportion to emerge by day 15 at 20°C



Egg laying date



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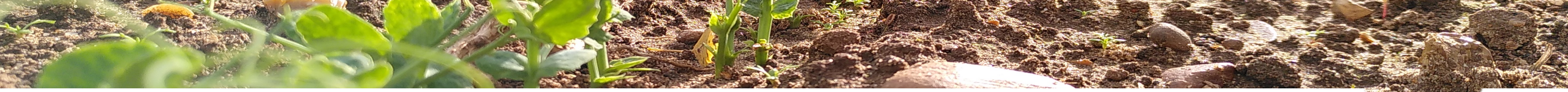
2 If wild BSF enter diapause, when do they complete diapause?

BY THE MIDDLE OF AUTUMN?

Egg laying date: 18/09 – 22/09

Proportion to emerge by day 15 at 20°C

Sub-Sample Date



3 How long do BSF pupae spend in diapause?

BETWEEN 0 – 50 DAYS

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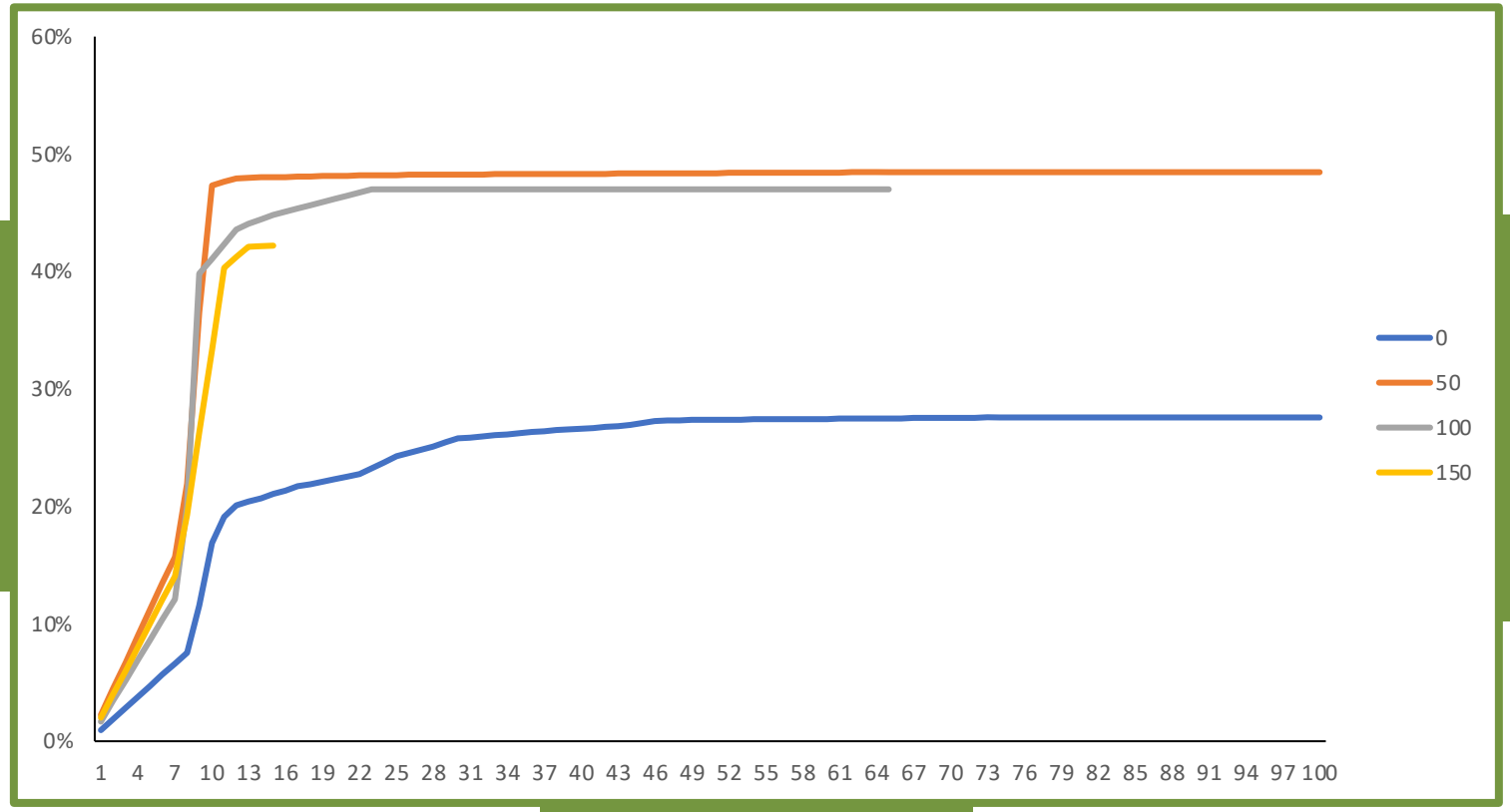
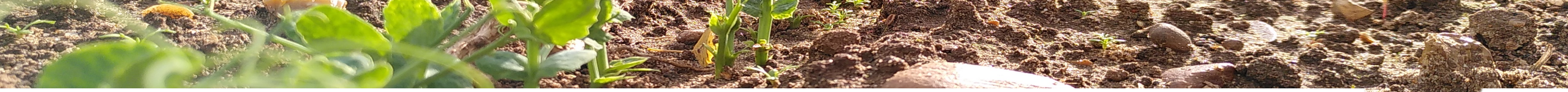
Average proportion of adult flies to emerge



Days spent at 0°C before being placed at 20°C

Days at 20°C



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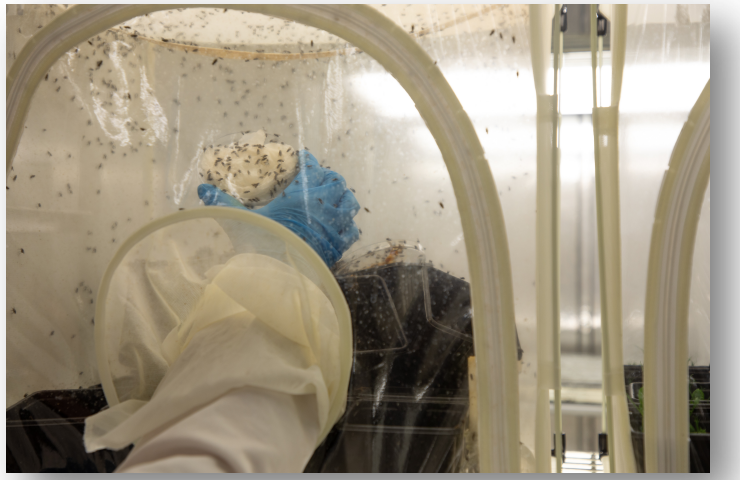
Current Conclusions

- The overwintering biology of BSF is not as expected
- A small proportion of wild BSF enter diapause in early Autumn
- Their diapause is relatively short (compared to Cabbage Root Fly & Onion Fly)

Future Work

- Further repeats of original experiments
- What conditions initiate, maintain and end diapause?

Aid predictions of spring emergence



Objective Two

Monitoring the Bean Seed Fly

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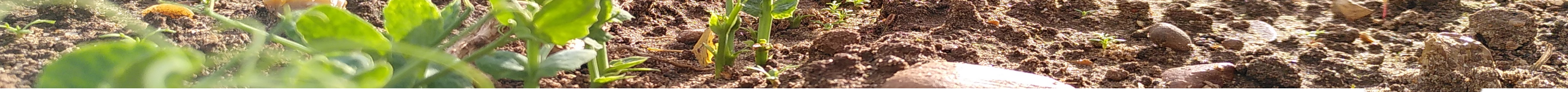
Blue Sticky Traps

- BSF can be easily confused with similar species
- Sticky traps catch more BSF than yellow water traps[7]
- Blue sticky traps catch larger ratios of BSF to Cabbage Root Fly[8]
- Sticky traps containing baits which attract BSF are marketed to catch more BSF than traps not containing a bait



Research Question

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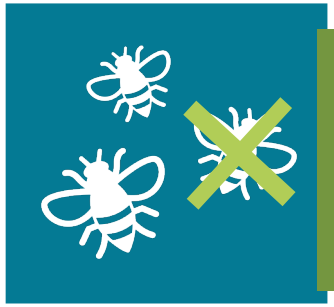
1 Do blue sticky traps with a bait attached catch more BSF than blue sticky traps not containing a bait?

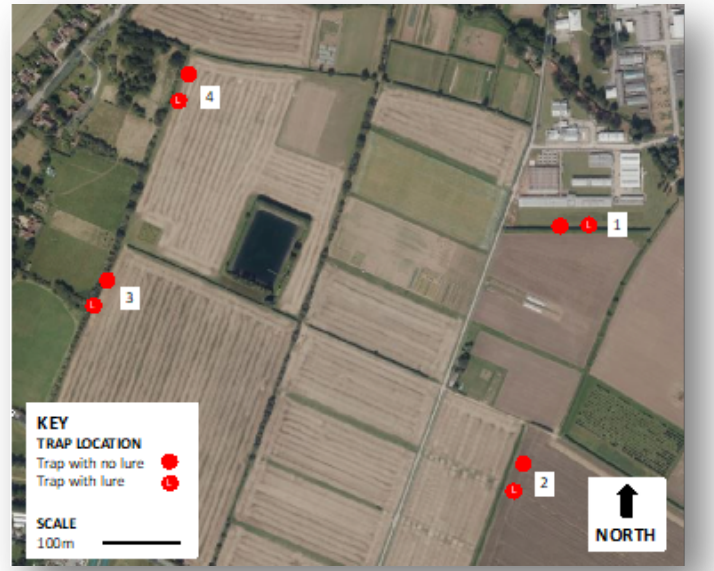
WHY? →

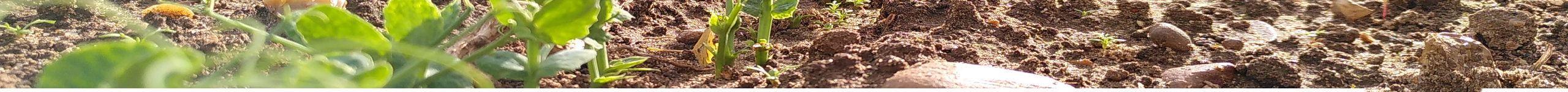


Traps that catch more BSF than similar species

Methods

- BSF counts compared on blue sticky traps with baits and no baits attached:
  - In 4 different locations at Warwick Crop Centre
  - Over 4 weeks





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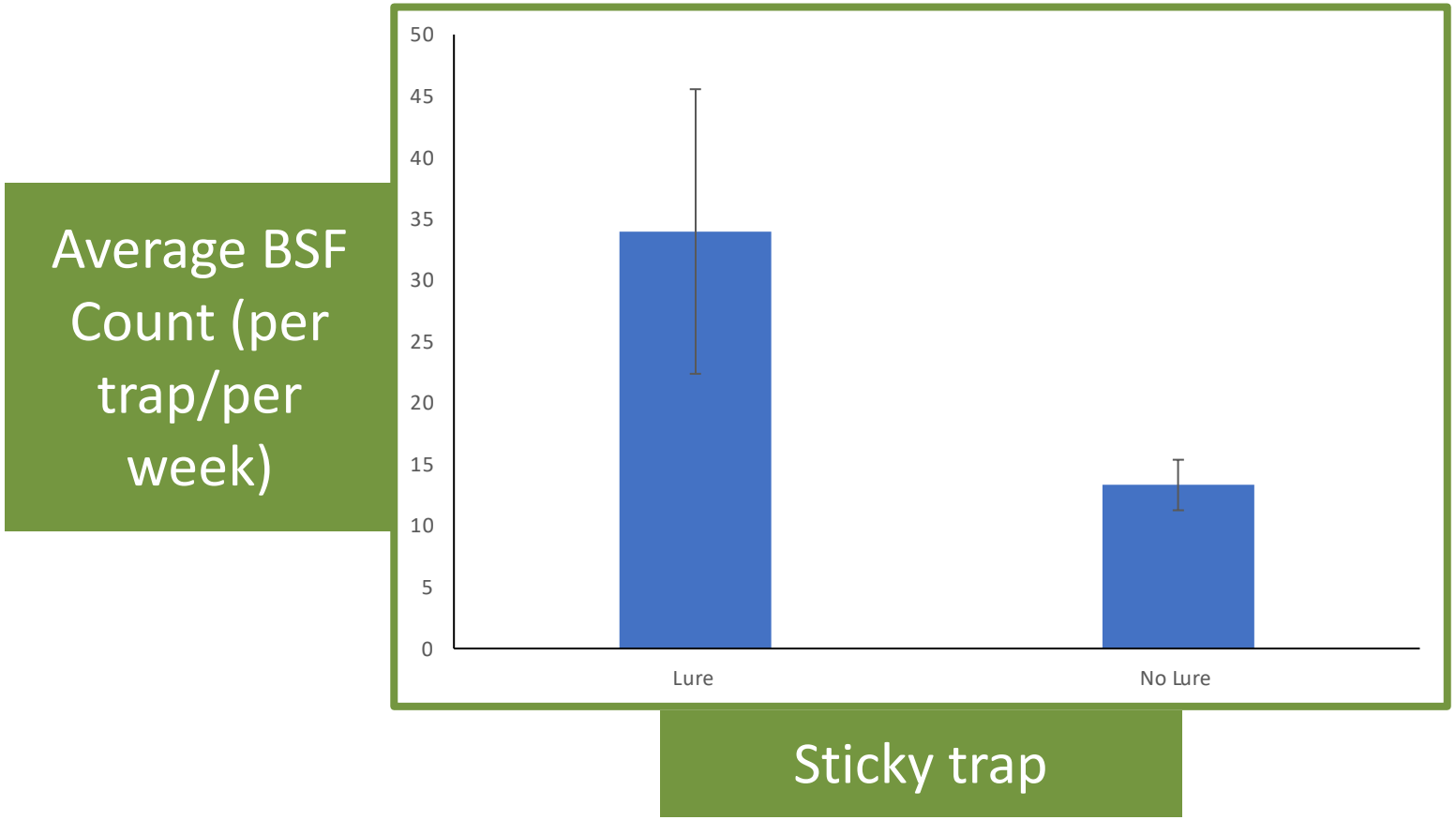
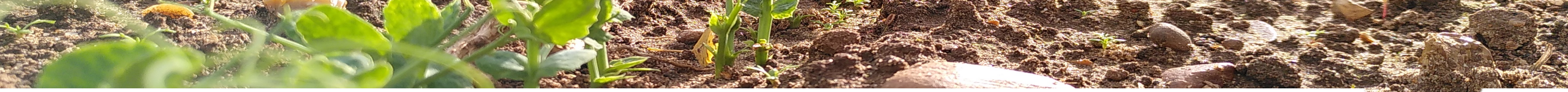
Results

- Significantly more BSF were caught on traps containing a bait than those not containing a bait (P = 0.01, W = 183.5)





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Current Conclusions

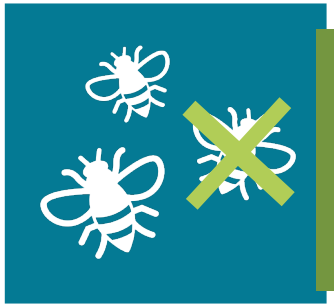
1

Do blue sticky traps with a bait attached catch more BSF than blue sticky traps not containing a bait?

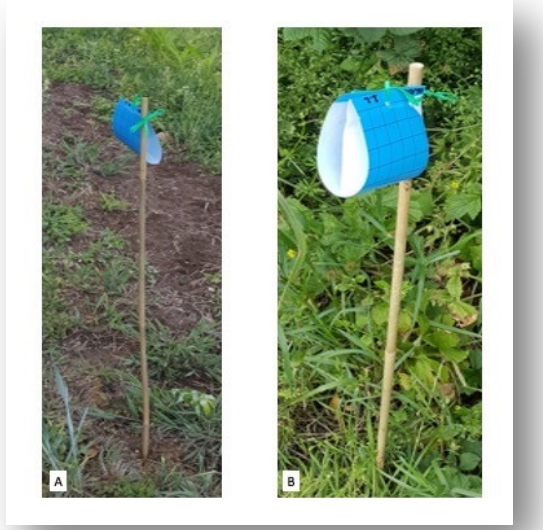
YES

Future Work

- Which trap set up catches a higher ratio of BSF to similar species?
- Is there a difference in BSF counts on traps placed at different heights?



Traps that catch more BSF than similar species



Objective Three

Forecasting the BSF

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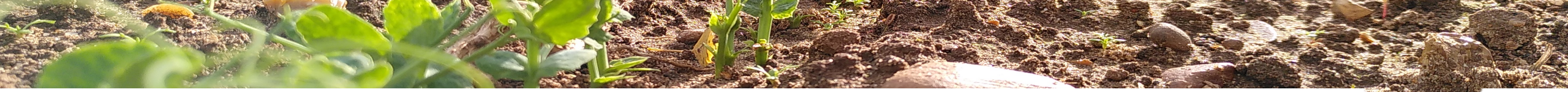
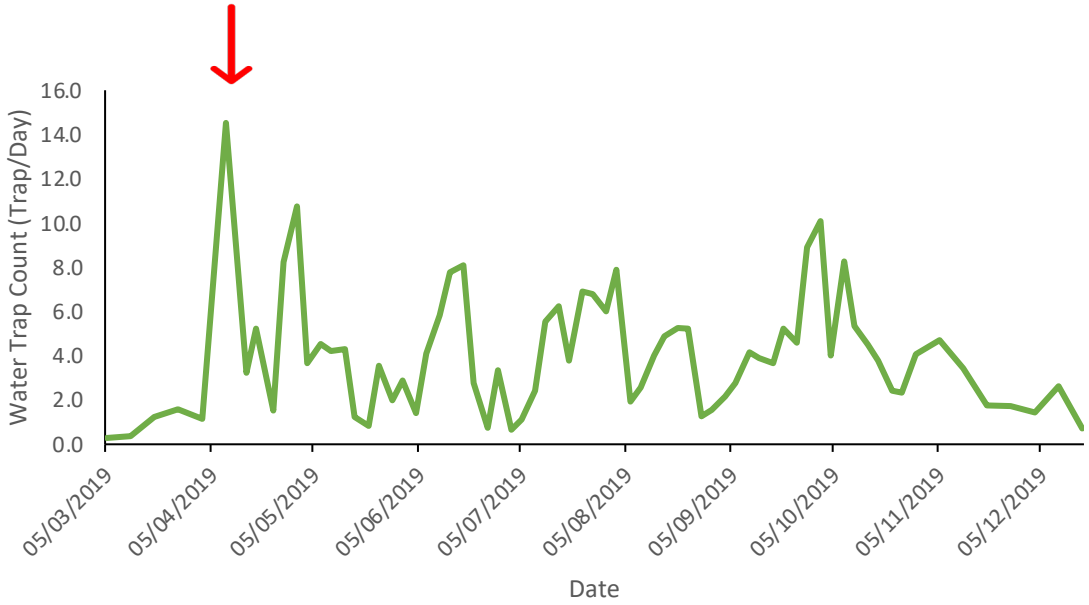


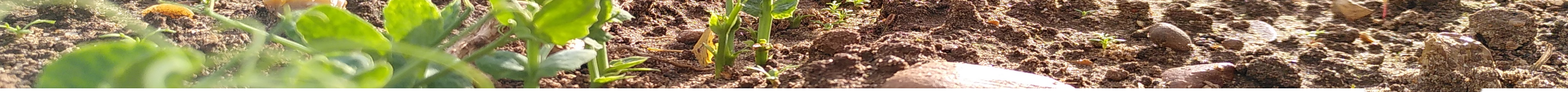
Insect Forecasts

- It would be beneficial to predict the spring emergence of the BSF
- Insect forecasts predict insect activity based on environmental factors such as temperature[9]
- Many models use the accumulation of **day–degrees** to predict insect activity[6,10]



$$Degree\ hours = \sum (Mean\ hourly\ soil\ temperature) - base\ temperature$$

$$Degree\ days = \frac{Degree\ hours}{24}$$



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Research Question

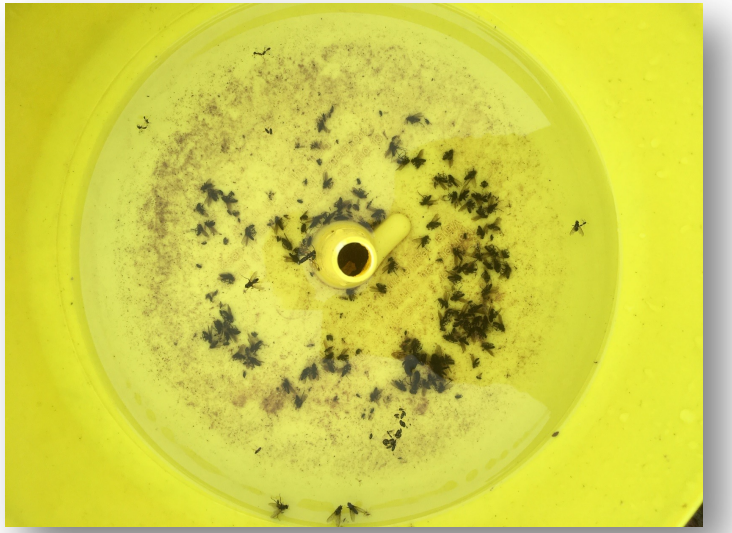
1 Can the accumulation of day-degrees be used to predict the spring emergence of BSF?

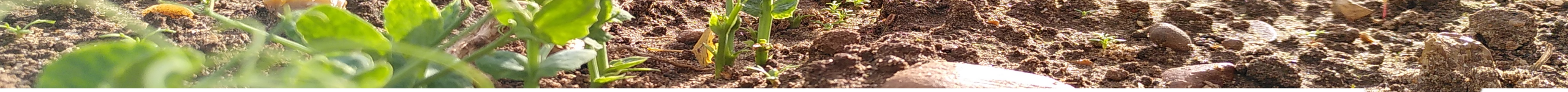
WHY? →

Aid decision making (e.g. sowing timing)

Methods

- 5 years of BSF activity data (2014, 2016, 2017, 2018, 2019)
- BSF activity data: 3 water traps & BSF counted 2 x weekly
- Day degrees:
  - Soil temperature
  - Base temperature: 3.9°C[6]
  - Day degrees accumulated from 1st January





Results

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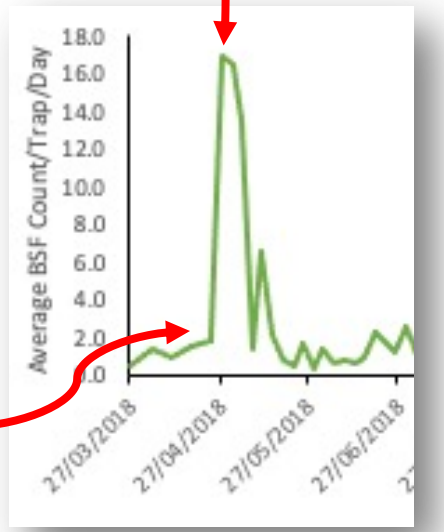
Estimating the peak

- Average accumulated day-degrees for the estimated start and peak of the emerging generation of BSF

PEAK: 275±72

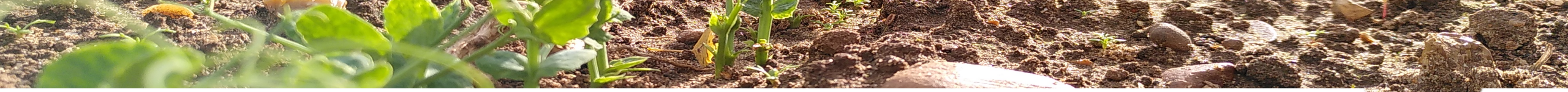
START: 207±58



Statistical Analysis

- An equation to estimate the pattern of the spring emergence of BSF
- A significant relationship between the accumulation of day-degrees and the proportion of BSF caught for the emerging generation of BSF ($P<0.0001$)

Percentage flies caught	Accumulated Day-Degrees
10	178
25	241
50	313
75	384
90	442
100	523



Comparing predictions to observations

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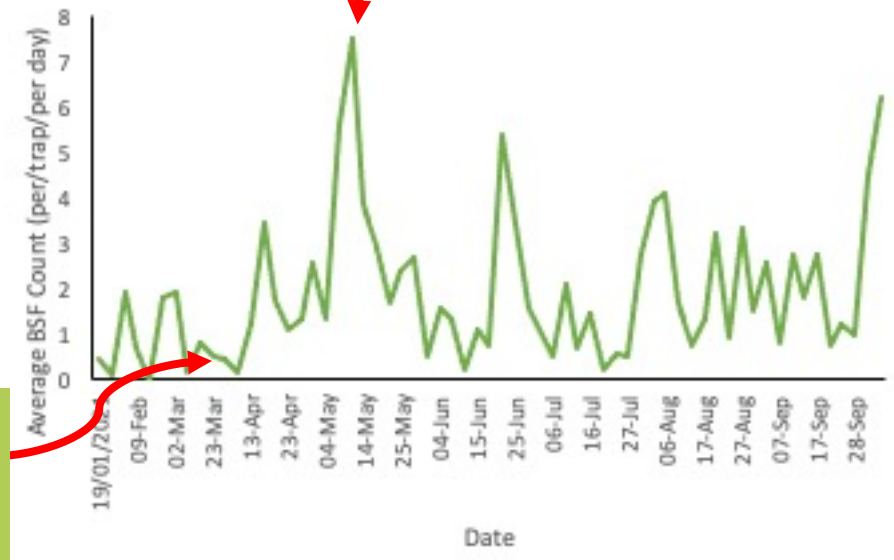
Estimating the peak

- Observed BSF counts for 2021
- Observed day-degrees for the start & peak of emergence

PEAK: 389 (275)

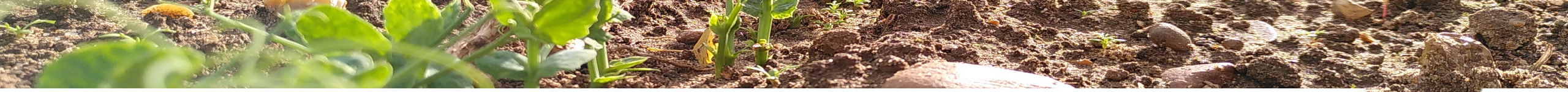
START: 178 (207)



Estimating the proportion of BSF to emerge

- Proportion of BSF to emerge from the emerging generation of BSF for 2021
- Date difference: (Observed - Predicted)

Percentage flies caught	Observed Date	Predicted Date	Difference
10	15/04	05/04	10
25	29/04	21/04	8
50	09/05	30/04	9
75	16/05	11/05	5
90	27/05	18/05	9
100	08/06	28/05	11



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Current Conclusions

1

Can the accumulation of day-degrees be used to predict the spring emergence of BSF?

YES (A statistically significant relationship)

Future Work

- Further development of the model combining new knowledge gained about BSF overwintering biology
- Test the accuracy of the model in different regions of the UK

Aid decision making (e.g. sowing timing)

Objective Four

Cultural & Interference Strategies

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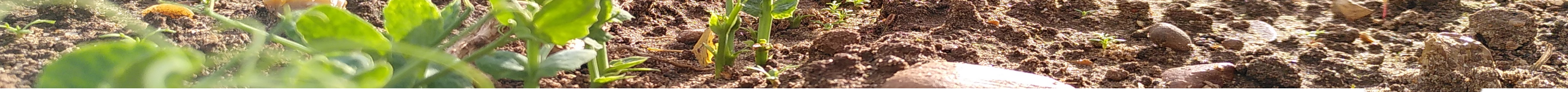

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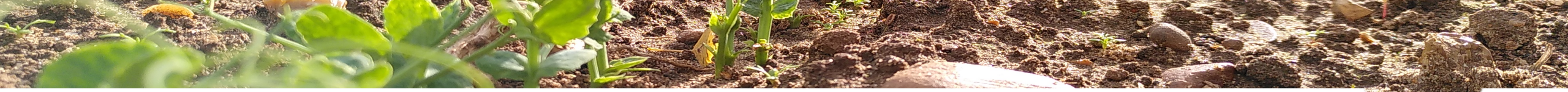
Cultivation & Covering a Crop

- BSF are stimulated to lay eggs in areas of organic matter such as recently cultivated soils[11]
- Delaying the time between cultivating the soil and sowing the crop may reduce damage caused by BSF
- Row covers may prevent BSF from reaching the soil to lay eggs[12,13]
- If cultivation occurs close in time to sowing the crop, covering the crop with a mesh may reduce damage caused by BSF

Row cover, picture source: https://en.wikipedia.org/wiki/Row_cover



Research Question

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1

Can the timing of cultivation and covering of the crop in relation to sowing the crop reduce damage caused by BSF?

WHY?

Reduce crop damage caused by the BSF

Methods

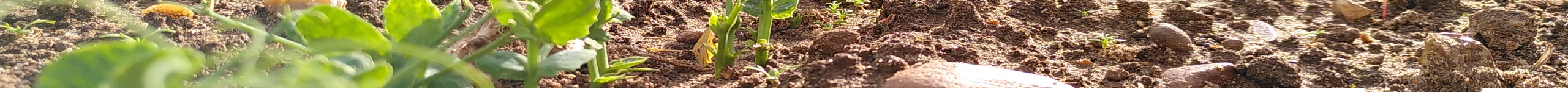
- Replicated field trial
- Vining peas: 46 seeds per m per row & 3 – 7 cm depth
- Power harrow & polyester row cover
- Assessments: Emerged plants per bed, BSF tunnelling in seed, number of seeds containing larvae
- Repeated 3 times in 2021

Cultivation (days before sowing)	Crop Covering Timing
21	No covering
14	Day of sowing
7	Day after sowing
3	
1	
0	

Results

- Very low numbers of BSF at Warwick Crop Centre in 2021

Year	Date of Spring Emergence Peak	Flies/trap/day
2021	11 May	8
2019	9 April	14
2018	27 April	17
2017	13 April	21
2016	3 May	36
2015	17 April	39
2014	9 May	35
2013	13 May	33
2012	23 April	49
2011	15 April	19



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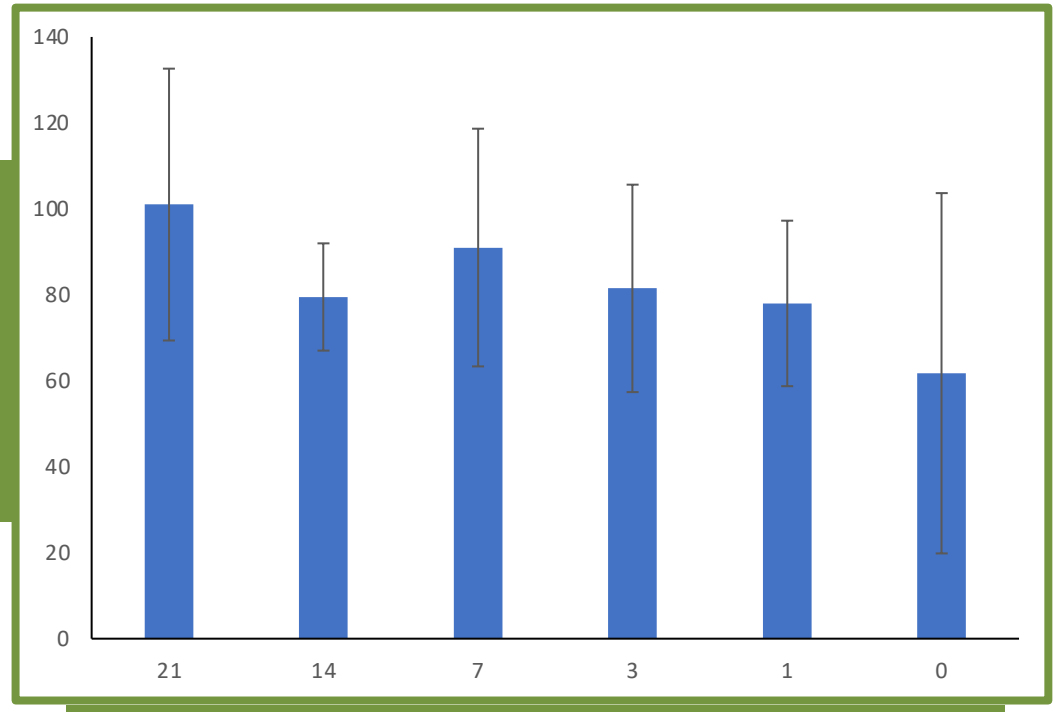
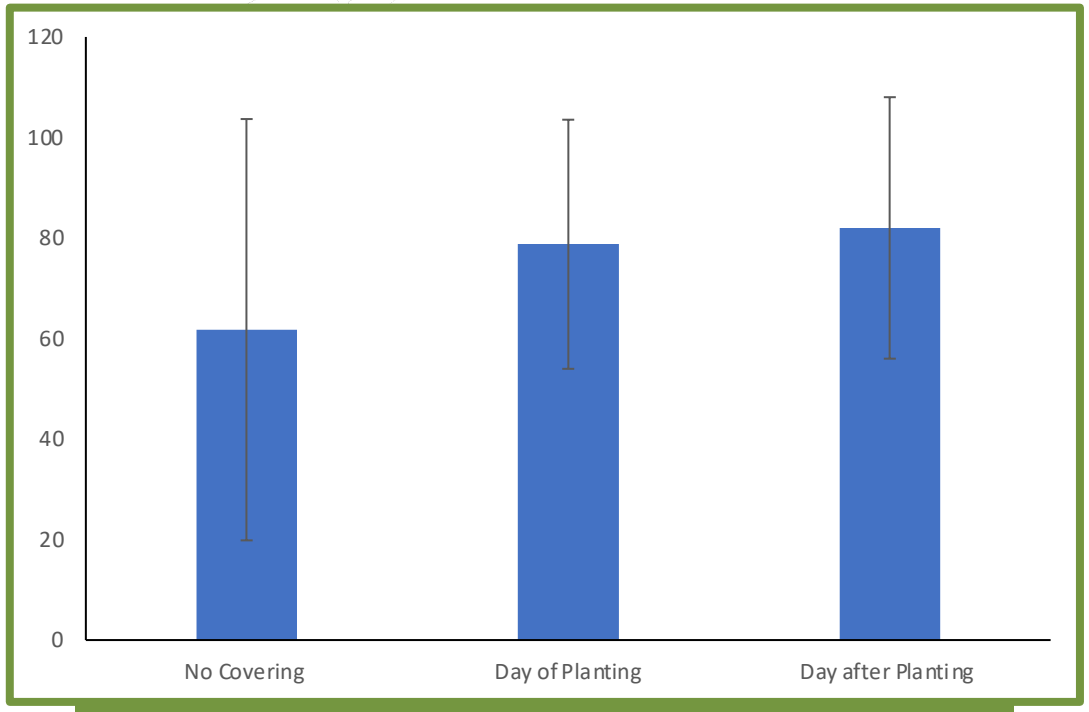
Results

- Repeat One & Two: No significant findings
- Repeat Three: Trends

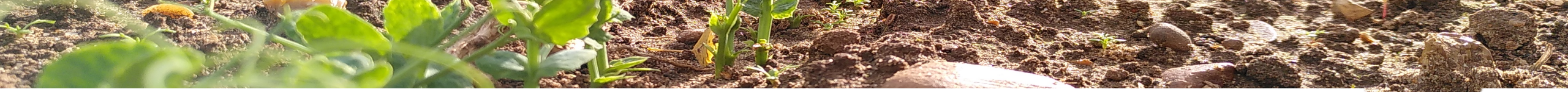
Average Emerged Plants (per middle 2m per plot)



Day of Cultivation (Days before sowing)



Day of Covering (Cultivation = day of sowing)



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Current Conclusions

1

Can the timing of cultivation and covering of the crop in relation to sowing the crop reduce damage caused by BSF?

??? – Becky's data shows more of an effect

Future Work

- Repeat the whole experiment next year with addition of organic matter

Reduce crop damage caused by the BSF

Conclusions (So far…)

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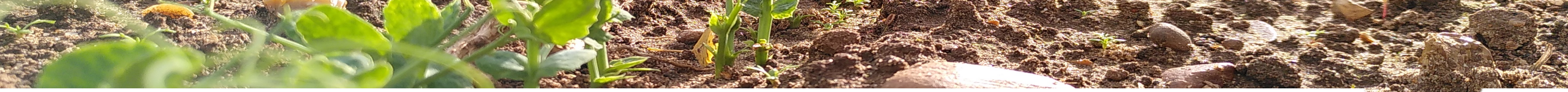

Conclusions

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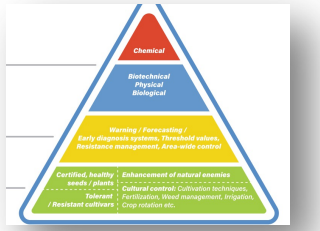
1	• Overwintering biology	A proportion of BSF enter diapause in early Autumn and it is relatively short
2	• Monitoring	Blue sticky traps with a bait attached catch more BSF than blue sticky traps with no bait attached
3	• Forecasting	The spring emergence of BSF can be predicted using accumulated day-degrees
4	• Cultural & interference strategies	Delaying the time between cultivation & sowing or covering the crop show potential but further research required



Many thanks for listening!

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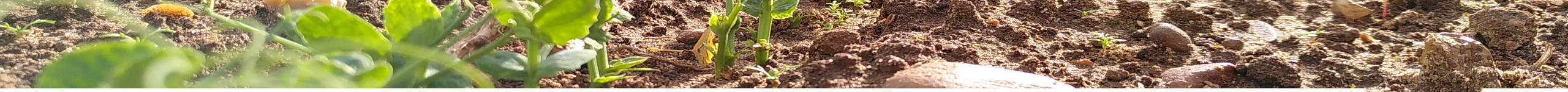

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References

1. Savage, J., Fortier, A., Fournier, F. & Bellavance, V. Identification of Delia pest species (Diptera: Anthomyiidae) in cultivated crucifers and other vegetable crops in Canada. *Can. J. Arthropod Identif.* **29**, 1–40 (2016).
2. Collier, R. H. Factsheet: Bean Seed Fly. 1–4 (2012).
3. Vea, E. V, Webb, D. R. & Eckenrode, C. J. *Seedcorn Maggot Injury*. (1975).
4. Karuppuchamy, P. & Venugopal, S. *Integrated Pest Management of major pests and diseases in eastern Europe and the Caucasus*. *Breeding Oilseed Crops for Sustainable Production: Opportunities and Constraints* (2017). doi:10.1016/B978-0-12-801309-0.00020-3
5. Throne, J. E. & Eckenrode, C. J. Development Rates for the Seed Maggots Delia platura and D. florilega (Diptera: Anthomyiidae). *Environ. Entomol.* **15**, 1022–1027 (1986).
6. Broatch, J. S., Dosdall, L. M., Clayton, G. W., Harker, K. N. & Yang, R.-C. Using Degree-Day and Logistic Models to Predict Emergence Patterns and Seasonal Flights of the Cabbage Maggot and Seed Corn Maggot (Diptera: Anthomyiidae) in Canola. *Environ. Entomol.* **35**, 1166–1177 (2006).
7. Broatch, J. S. & Vernon, R. S. COMPARISON OF WATER PAN TRAPS AND STICKY TRAPS FOR MONITORING DELIA SPP. (DIPTERA: ANTHOMYIIDAE) IN CANOLA. *Can. Entomol.* **129**, 979–984 (1997).
8. Finch, S. & Collier, R. H. Effects of the angle of inclination of traps on the numbers of large Diptera caught on sticky boards in certain vegetable crops. *Entomol. exp. appl* **52**, 23–27 (1989).
9. Olatinwo, R. & Hoogenboom, G. Weather-based Pest Forecasting for Efficient Crop Protection. *Integr. Pest Manag. Curr. Concepts Ecol. Perspect.* 59–78 (2013). doi:10.1016/B978-0-12-398529-3.00005-1
10. Funderburk, J. E., Higley, L. G. & Pedigo, L. P. Seedcorn Maggot (Diptera: Anthomyiidae) Phenology in Central Iowa and Examination of a Thermal-Unit System to Predict Development Under Field Conditions. *Environ. Entomol.* **13**, 105–109 (1984).
11. Hammond, R. B. Influence of Cover Crops and Tillage on Seedcorn Maggot (Diptera: Anthomyiidae) Populations in Soybeans. *Environ. Entomol.* **19**, 510–514 (1990).
12. Matthews-Gehringer' And, D. & Hough-Goldstein, J. *Physical Barriers and Cultural Practices in Cabbage Maggot (Diptera: Anthomyiidae) Management on Broccoli and Chinese Cabbage*. *J. Econ. Entomol* **81**, (1988).
13. Hough-Goldstein, J. A. Tests of a Spun Polyester Row Cover as a Barrier Against Seedcorn Maggot (Diptera: Anthomyiidae) and Cabbage Pest Infestations. *J. Econ. Entomol.* **80**, 768–772 (1987).