Climate Change and UK Horticulture: What is to come and how to build resilience?

Prof Rosemary Collier, Warwick Crop Centre, University of Warwick
Joe Rolfe, RB Organics

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- Very general predictions of effects on UK climate expected. wetter winters e.c.t.
- A general introduction to the effects of temperature, co2 and ozone on veg and perennial fruit production, yields, seasons, quality,
- A general introductions into effects on hydrological cycles. covering effects of extremes of both wet and dry and the effects on soil biology and SOM.
- Detail on the effect of climate change change on invertebrate pests, perhaps carrot root fly to tie in with Joe (please do another if more appropriate) . phenology, abundance, behaviours, survival would, monitor and adaption e.c.t. Can you liaise with Joe on how to best integrate as he may be giving detail on IPM as to not over lap too much. Would be good to hear the theory behind the practice though!
- Finishing points would be to hear what the major challenges you see for organic production and what systems or practices we could use that are not currently common place.

University of Warwick, School of Life Sciences

- Research on crops – especially vegetables – Warwick Crop Centre
- Previously National Vegetable Research Station and then HRI
- Just celebrated 70 years of research at the Wellesbourne Campus
- Focus on reducing inputs in crop production
- Home of the UK Vegetable Gene Bank (funded by Defra)
- Cross-University them on 'Food'

Climate change is happening…

Climate Change Is Starving Out Reindeer in Sweden's Arctic

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UK climate – the recent past

- The average temperature over the most recent decade (2009-2018) has been on average 0.3°C warmer than the 1981-2010 average and 0.9°C warmer than the 1961-1990 average.

- Winters in the UK, for the most recent decade (2009-2018), have been on average 5% wetter than 1981-2010 and 12% wetter than 1961-1990.

- Summers in the UK have also been wetter, by 11% and 13% respectively.

UK climate projections – UKCP18

- By the end of the 21st century, all areas of the UK are projected to be warmer, more so in summer than in winter.

- Hot summers are expected to become more common. The temperature of hot summer days, by the 2070s, show increases of 3.7 °C to 6.8 °C, under a high emissions scenario, along with an increase in the frequency of hot spells.

- Hot spells (maximum daytime temperatures exceeding 30 °C for 2+ consecutive days) are largely confined to the south-east currently. In the future (by 2070s), under a high emissions scenario, the frequency of hot spells increases.

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Effects of temperature on perennial fruit production

- In the absence of effective chilling, floral bud development is hampered and anthesis may be protracted and un-synchronised with the life cycles of pollinators. Often, floral structures are of 'poor quality' and fail to attract pollinators or produce viable ovules and/or pollen.

Jerzy Opioła

- Although lack of winter chilling will have serious repercussions for UK perennial fruit crops, this may be partially compensated for by gains caused by less frequent frosts.

Fir0002/Flagstaffotos

- Selective breeding of new varieties is one way to address this.

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Effects of temperature on vegetable and salad production

Crop	Winter Temperature	Summer Temperature
Potato	No impact on growth and yield but higher winter temperatures may cause loss of quality in ambient stores.	Warmer summers in high latitudes are associated with higher yields.
Salads / leafy vegetables	Winter salads sourced from overseas.	Crops develop more quickly at higher temperatures and mature earlier. Yield increases for early season plantings but decreases for late summer plantings. Premature bolting can impair quality.
Brassica	Warm winters can delay curd initiation and affect scheduling.	High temperatures have negative impact on yield and quality e.g. blindness and buttoning. Seed production impaired at high temperatures.
Carrot	Unlikely to have an impact.	Increased temperature has a positive impact on growth and yield which is enhanced at elevated CO_2
Onion	Onions are in storage over winter.	Increased temperature accelerates development and reduces yield, offset by elevated CO_2

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UK climate projections – UKCP18

- Despite overall drying trends in the summer in future, new data suggests future increases in the intensity of heavy summer rainfall events.

- UKCP projects an extension of the convective season from summer into autumn, with significant increases in heavy hourly rainfall intensity in the autumn.

- UKCP suggests significant increases in hourly precipitation extremes in the future. For example, rainfall associated with an event that occurs typically once every 2 years increases by 25% (central estimate).

Water – too much, too little

- Land preparation
- Sowing or planting
- Harvesting
- Water-logging – effects on annual and perennial crops
- Disruption to scheduling/continuity of supply

26 July 2006 – very dry. This was the week they stopped planting brassicas in Lincolnshire

Effects of elevated CO2

- The main predicted effects of elevated CO_2 that might occur up to 2050 are to
  - increase photosynthesis
  - improve the efficiency of water use
- with the potential to increase crop yield, provided that other essential resources such as soil water and nutrient availability are not limiting.

Effects of elevated CO_2

- The ability of crops to benefit also depends on crop genotype (cultivar) and management.
- Plants grown at elevated CO_2 can have significant compositional differences (higher carbohydrates and lower nitrogen) with consequences for product quality and, for example, fertiliser management programmes may need to be adjusted to avoid nutrient imbalances.

Brassica diversity set
University of Warwick

Effects of elevated ozone

- Any increase in ozone levels in the UK is predicted to be small, so the impact will be limited.
- Lettuce - described as an ozone sensitive crop. Ozone causes loss of yield and visible quality.
- Potato - foliar injury but comparatively less reduction in yield. Quality effects are small and variable.
- Carrot - causes chlorosis of the leaves and some loss of yield.

Effects of climate change on soil biology

- Increased productivity leads to more crop residues, greater total root mass and root exudation, increased mycorrhizal colonization and activity of other rhizosphere or soil micro-organisms, including symbiotic and root-zone N fixers - with a positive effect on N supply to crops

- Increased microbial and root activity in the soil would lead to increased rates of plant nutrient release from soil minerals

- Increased mycorrhizal activity would lead to better phosphate uptake.

- These effects would be in synergy with better nutrient uptake due to higher atmospheric CO_2 concentration

Effects of climate change on soil quality

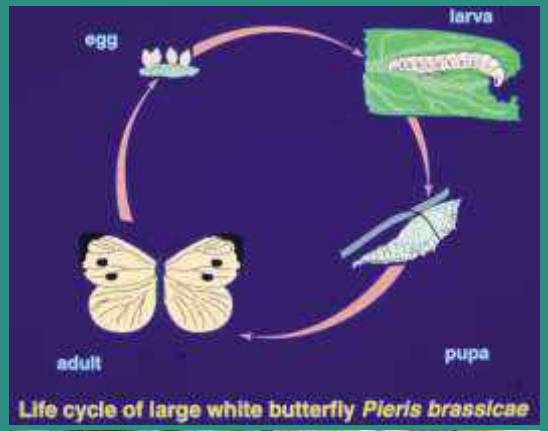
- Increased production of root material tends to raise soil organic matter

- Higher C/N ratios in residues would entail slower decomposition and slower remobilization of plant nutrients and uptake by roots - providing more time for incorporation into the soil by earthworms etc. Higher soil temperatures would counteract increases in 'stable' soil organic matter content but would further stimulate microbial activity

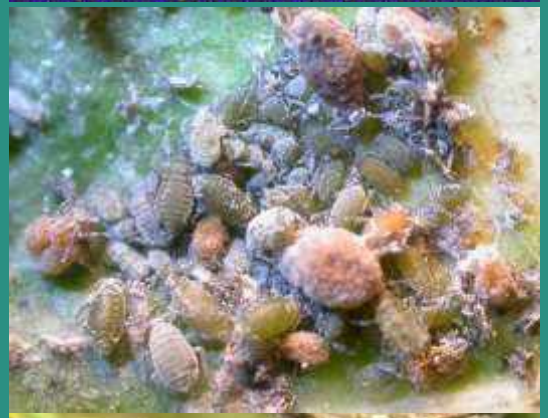
- The increased productivity and water-use efficiency of crops and vegetation, and the generally similar or somewhat higher rainfall indicated by several global circulation models, not fully counteracted by higher evapotranspiration, would be expected to lead to widespread increases in ground cover, and consequently better protection against runoff and erosion. However, extreme events (wet and dry) are still likely to have adverse effects

What drives insect biology?

- Cold-blooded animals - so rate of development is dependent on ambient temperature. The hotter it is the faster they develop – within certain limits.
- Survival can be affected by being too wet or too dry.
- Some species have special adaptations to survive extreme conditions.
- Natural enemies include mammals, birds, other insects, pathogens (fungi, bacteria, viruses).
- Climate change will also affect these and in some cases the synchrony between them and their prey.



Life cycle of large white butterfly *Pieris brassicae*



Three pests of carrot!

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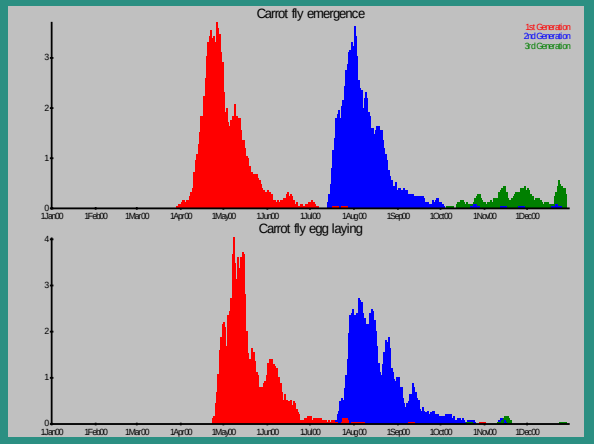
Carrot fly and climate change

- Complicated!
- 1st (spring) generation may be earlier
- 2nd (summer) generation may ‘disappear’ – aestivation
- 3rd (autumn) generation may become more significant
- Southern France and Switzerland are good examples
- Carrot fly does not do well in hot places



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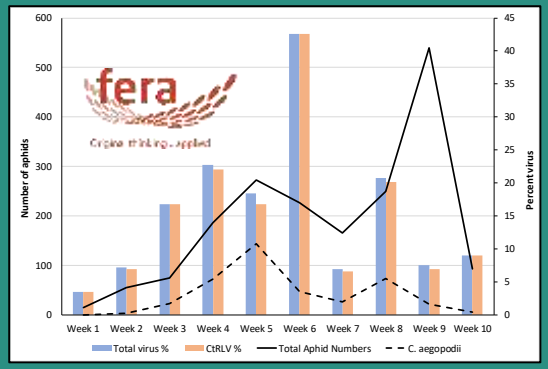
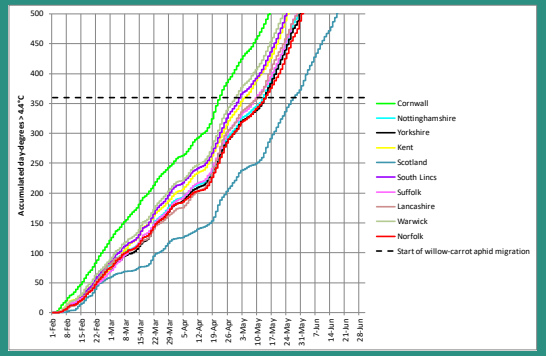
Aphids

- Virus transmission is an issue – loss of yield and quality
- Probably due to willow-carrot aphid but could be other species too (current AHDB project)
- Overwintering biology may change – from cold-resistant egg on willow to active stages on herbaceous hosts (overwintered carrots?)
- Could migrate earlier in spring
- Other impacts not clear





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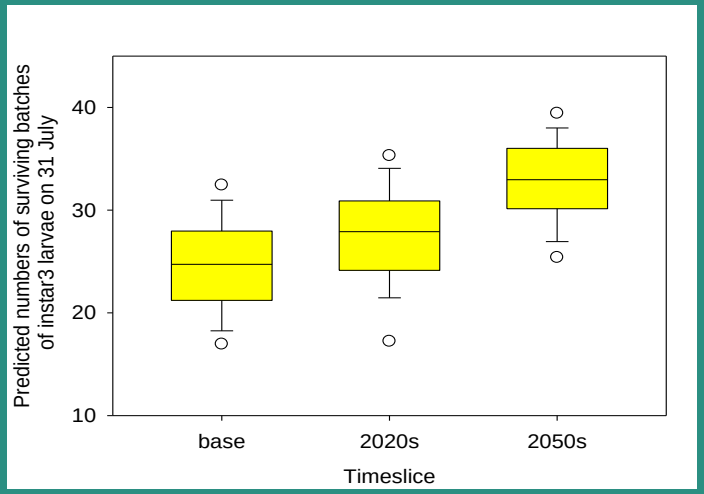
Turnip moth

- Sporadic pest – thrives when weather is hot and dry
- Small caterpillars very sensitive to rainfall – basis of cutworm forecast
- Earlier work on UKCP09 projections suggested that incidence of damage likely to get worse
- However, heavy rainfall would cause mortality of sensitive stages



The impacts – personal view

- Extreme weather events (drought and excess rainfall) will cause the most disruption to horticultural production (continuity of supply, yield and quality)
- Infestations by some pests are likely to become more frequent but others may become less common
- Impacts on effectiveness of natural enemies of pests are hard to predict
- The UK may become more vulnerable to invasive pests and pathogens

Scott Bauer, USDA ARS

Acknowledgements

- Thank you to;
- My colleagues at the University of Warwick and previously at Warwick HRI
- Defra for funding two projects on the impact of climate change on horticulture/agriculture (AC0301; AC0310)
- Publications:
  - Collier, R.H. & Else, M. (2014). UK Fruit and Vegetable Production – impacts of climate change and opportunities for adaptation. In: Climate Change Impact and Adaptation in Agricultural Systems. J. Fuhrer & P.J. Gregory (Eds). CABI Publishing, p 88-109.
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  - Collier, R., Fellows, J., Adams, S., Semenov, M. and Thomas, B. (2008). Vulnerability of horticultural crop production to extreme weather events. Aspects of Applied Biology 88, 3 – 14.

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RBOrganic Farm

Joe Rolfe

- 100% Organic vegetable growing business formed in 2004
- Based at Houghton Hall (Norfolk)
- Long term land agreement with available water (key resource)
- Additional tenancies in Norfolk with water
- Certified by Soil Association Certification

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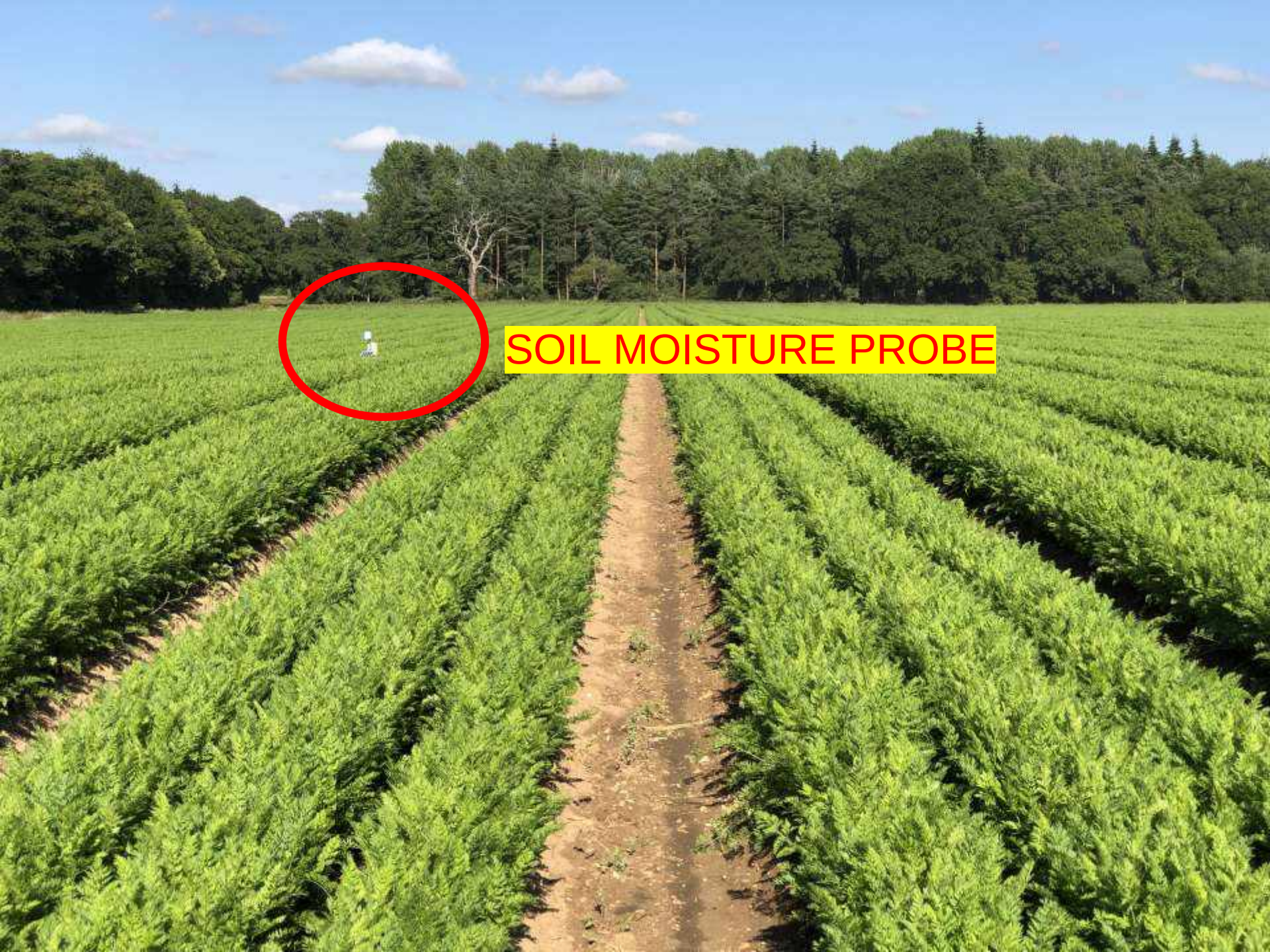
What do we grow?

- Carrots 6000t, Potatoes 2500t (1500t Whites, 1000t Salads) , Onions 1000t, JV on Leeks
- 99% sold in retail/export
- New varieties – trials & commercial
- Hand weeding (100+ seasonal staff)
- 5 full-time staff and contractors for specific tasks

Soil Management

- *Why is soil management important?* Resilience is key as the climate changes…

- Converting to Organic
- Rotation is critical in reducing weed burden.
- Building SOM %
- Use of FYM as fertility and soil conditioner (healthy living soils)
- Winter cover crops (Oil Radish)
- Breaking pest pressure/cycles
- Livestock make up a key part of the rotation
- Understanding true crop requirement (Soil Sampling)
- Carbon Sequestration
- Water management (soil moisture probes)


SOIL MOISTURE PROBE

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	2019	2018	2017	2016	2015	2014	2013	2012
	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)	Rain (SUM mm)
January	18.8	32.2	31.8	65.6	45	99	27.6	36.4
February	25	35.2	48.2	25	53	52.2	30.8	9.4
March	44.2	61	46.2	70.6	27	25	45	42.6
April	8.2	68.2	22.4	58.6	18.6	19	12.4	43.2
May	35.4	48.6	59	42.2	44.4	97.6	51	7.8
June	129	16.8	100	93.6	22	49.8	20.6	105.2
6 month total	**260.6**	**262**	**307.6**	**355.6**	**210**	**342.6**	**187.4**	**244.6**
July	32.8	36.8	82.6	41.6	115.6	27	25.8	115.8
August	41.4	49.2	33.4	53.4	95.4	98.8	59.2	79.4
September	73.4	26.6	68	55.4	41	17	45.2	35.6
October	70.2	48.8	28.4	51.2	54	69.8	116.8	75.4
November	85.6	40.6	58.6	61.4	74.6	64	63.2	104.2
December	60	53.6	85.8	22.4	60.4	46.4	34.8	78.6
6 month total	**363.4**	**255.6**	**356.8**	**285.4**	**441**	**323**	**345**	**489**
12 month total	**624**	**517.6**	**664.4**	**641**	**651**	**665.6**	**532.4**	**733.6**

Production systems to buffer pests and diseases

- Carrot Fly
- Learning about pest life cycles and habitats key
- Carrot Willow Aphid

- Creating habitats that beneficial insects can flourish in
- Integrating this approach in to commercial scale farming

Production systems to buffer pests and diseases

- **Life-cycle**
- First generation adult flies are often on the wing when cow parsley is in full flower at the end of April. They migrate into crops from nearby sheltered areas such as hedgerows. The adults are very weak fliers and rarely rise above a height of 50 cm. Eggs are laid into soil crevices around the base of host plants. Depending on temperature the larvae usually hatch in about one week and feed on the plant roots. Further damage can be caused by the larvae moving from plant to plant. After completing three growth stages (moults) the larvae pupate in the soil. The transition from egg to adult can be completed in 3 months. Carrot flies can survive the winter in a variety of different ways. The adults can survive by sheltering in warm protected environments, the pupae can overwinter in the soil or the larvae can survive in the roots of host plants, especially in crops which have been covered with straw for protection from cold weather. There are usually two generations per year but a third generation is possible especially if temperatures remain high into the autumn. The first generation arises in late April/early May and the second is on the wing in late July. It is the first two generations which are responsible for economic crop damage

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Production systems to buffer pests and diseases

Critique of Organic Farming systems

- Higher cost of production
- Reliance on labour (cost, availability, reliability, skills).
- Perception of lower yields, but high quality
- Robotics may be the answer to some of the efficiency challenges, but it needs to get here quickly
- Ploughing/Cultivations is controversial but important

Thank You for listening!

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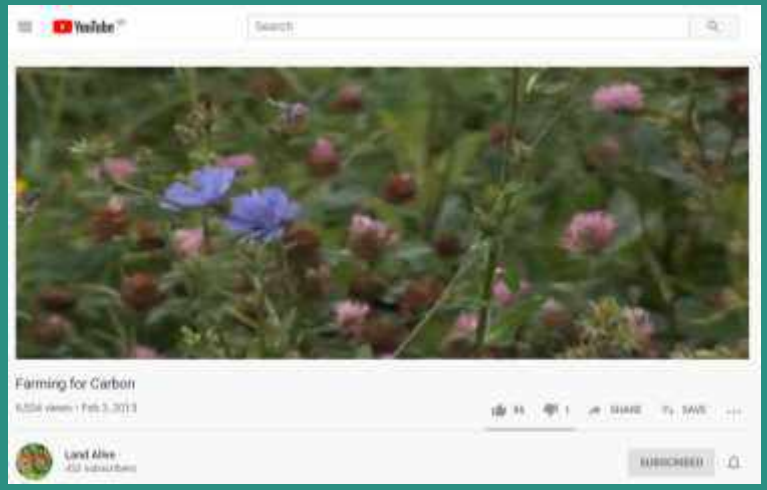

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