Grower Summary

CP 118

Cucurbit Pollination: Mechanisms and Management to Improve Field Quality and Quantity

Annual *2016*

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Project title:	Cucurbit Pollination: Mechanisms and Management to Improve Field Quality and Quantity
Project number:	CP118
Project leader:	Professor Juliet Osborne, University of Exeter
Report:	Annual, December 2016
Previous report:	Not Applicable
Key staff:	PhD student: Jessica Knapp Professor Juliet Osborne; Dr Frank Van Veen
Location of project:	Cornwall, United Kingdom
Industry Representative:	Ellis Luckhurst, P.E. Simmons and Son, Gwinear Road, Cornwall
Date project commenced:	01/01/2015
Date project completed (or expected completion date):	[01/01/2018]

GROWER SUMMARY

Headlines

- All parthenocarpy-promoting techniques (genetic modification, hormone application and selective breeding) significantly increased fruit quantity and quality in 18 pollinator-dependent crop species (not including seed and nut crops as parthenocarpy causes seedlessness)' – findings from a meta-analysis desk study (Knapp et al., 2016 Journal of Applied Ecology).
- Pollinators contribute approximately £2.7 million to the value of UK courgette production - findings from 2015 and 2016 field seasons.

Background

The principal focus of this research project is to improve our understanding of the mechanisms which underpin fruit set in cucurbits. Generally, cucurbits require pollen to be transferred from male flowers to female flowers for successful pollination and fruit set (Delaplane et al. 2000).

Preliminary results from 2015 showed that whilst pollination increased the size, weight, and growth rate of courgettes, natural parthenocarpy (fruit set in the absence of pollination) meant that many fruits were able to reach marketable size without any pollination at all. This inspired a meta-analysis of studies across the world which had explored the effect of parthenocarpy promoting techniques (genetic modification, selective breeding, and hormone application) for increasing yield in different horticultural crops.

In the meantime, data on the effect of pollination on courgette yield were collected at additional sites in 2016. This was to calculate a more robust estimate of courgette dependence on pollinators and an economic estimate for the value of pollinators to UK courgette production.

Nonetheless, whilst pollination clearly affects cucurbit yield, there are many other environmental factors which contribute to fruit set such as soil quality, water availability and weather conditions (Boreux et al., 2013; Bos et al., 2007; Klein et al., 2014; Motzke et al., 2015). As a result, the productivity of insect pollinated crops are dependent on the presence of high functioning ecosystems that support pollinator populations, regulate disease, purify and cycle water, and nutrients (Figure 1). The spatial and temporal variation of pollinators, the resources which support their populations and other factors which influence fruit formation formed the basis of an observational experiment in 2016. During this field season I surveyed nine different courgette fields in three counties, three times in a season - the results of which are currently being analysed.

A simple breakdown of the progress of each data chapter (and its related funding objectives) follows:

Chapter	Title	Funding Objective	Progress
1	Re-evaluating strategies for pollinator-dependent crops: how useful is parthenocarpy?	In addition	*Accepted in Journal of Applied Ecology, September 2016*
2	Courgette production: pollination demand, supply, and value	2	*Submitted to Agriculture, Ecosystems and Environment, November 2016*
3	Influence of pollinators, floral resources, nutrients, and farm intensity for determining courgette yield	5 and 6 (updated)	In progress - specimens are currently being identified in the lab (estimated completion March 2017)
4	An intensively managed, mass flowering crop: a resource for pollinators?	3 and 4	Field work to take place in 2017
Report/ factsheet	Most effective wild pollinators of courgette in the South West	1	Data collected in 2015 and 2016. More field work will take place in 2017

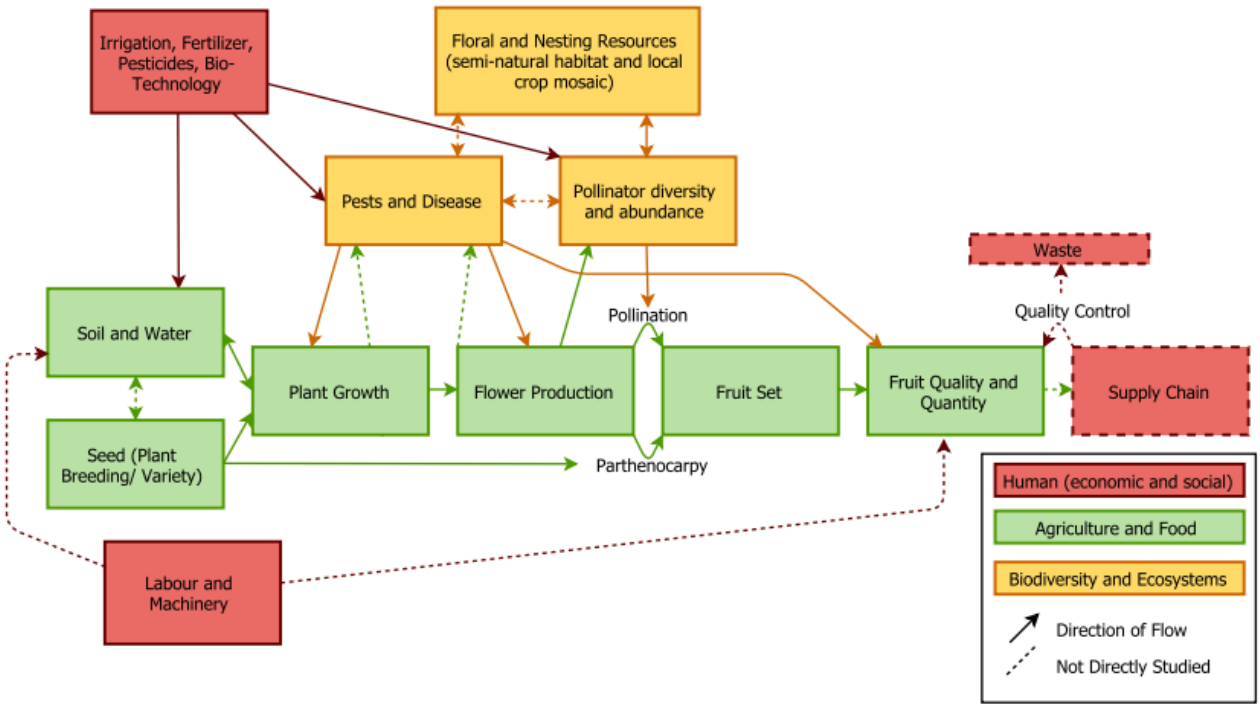

Figure 1. Conceptual framework of the human (economic and social), agricultural and food, and biodiversity and ecosystems which effect fruit set in pollinator dependent crops. Dashed and full lines distinguish between observed and experientially tested relationships during the course of this project.

All empirical work uses the popular courgette variety 'Tosca', a high yielding, compact variety, notably tolerant to powdery mildew which makes it a popular choice for commercial production.

Summary

- All parthenocarpy-promoting techniques (genetic modification, hormone application and selective breeding) significantly increased fruit quantity and quality in 18 pollinator-dependent crop species (not including seed and nut crops as parthenocarpy causes seedlessness).

Whilst most studies reviewing the reliance of global agriculture on insect pollination advocate increasing the 'supply' of pollinators (wild or managed) to improve crop yields, there has been little focus on altering a crop's 'demand' for pollinators. Parthenocarpy (fruit set in the absence of fertilisation) is a trait which can increase fruit quantity and quality from pollinator-dependent crops by removing the need for pollination.

I conducted a meta-analysis (Knapp et al., 2016) of studies examining the extent and effectiveness of parthenocarpy-promoting techniques (genetic modification, hormone application and selective breeding) currently being used commercially, or experimentally, on pollinator-dependent crops in different test environments (no pollination, hand pollination, open pollination).

All techniques significantly increased fruit quantity and quality in 18 pollinator-dependent crop species (not including seed and nut crops as parthenocarpy causes seedlessness). The degree to which plants experienced pollen limitation in the different test environments could not be ascertained, so the absolute effect of parthenocarpy relative to optimal pollination could not be determined.

Parthenocarpy has the potential to lower a crop's demand for pollinators, whilst extending current geographic and climatic ranges of production. Thus growers may wish to use parthenocarpic crop plants, in combination with other environmentally considerate practices, to improve food security and their economic prospects.

- Courgettes require pollination to improve fruit growth and weight, but natural parthenocarpy means that many can reach marketable length without pollination - findings from 2015 and 2016 field seasons

The importance of pollinators to courgettes is demonstrated through a significant reduction in fruit size and weight under **no pollination conditions**. Consequently, percentage fruit set, the size and weight, but not sugar content, of courgettes were significantly increased with pollination. As all sites experienced the same environmental conditions and pollination treatments, the observed reduction in fruit set (for non-pollinated and open pollinated flowers) was due to the absence of pollen. The relatively high fruit set of hand pollinated flowers (98%) suggests that resources (such as nutrient and water availability) were unlikely to be limiting courgette growth and fruit set in Cornwall, and demonstrates the quality and quantity of courgettes under optimal pollination conditions. Unfortunately it was impossible to identify any inter-variety differences in pollinator dependence within courgette as data from this study are only available for one courgette variety.

Nonetheless, it is of industrial and ecological interest that non-pollinated flowers were still able to reach marketable size and shape without any pollination at all. This is due to the natural parthenocarpic tendency of courgettes, previously observed in Tosca (Martínez et al., 2013) and other courgette varieties (Robinson and Reiners, 1999).

- In Cornwall, open pollination levels were high but this is likely to vary spatially and temporally in the landscape - findings from 2015 and 2016 field seasons

The level of open pollination at the study sites in Cornwall was very high, evidenced by no statistical difference in yield (length grown, circumference, and weight) of open- and hand-pollinated crops. Our experiments showed that different sites influenced pollinator abundance and yield, likely due to the spatial and temporal variation in the landscape surrounding each study site. However, yield (length grown, weight and °Brix) of open pollinated courgettes did not decrease with increasing distance into the crop. This is most likely because smaller (than

average) field sizes in Cornwall mean that yield measurements were taken at just 50m from the crop edge which might not be far enough from natural or semi-natural habitat (such as hedgerows) to detect differences in pollinators. Nonetheless, this may affect larger fields such as those in Cambridgeshire where the average distances to the centre of field is around 200m (average field size of 16.5 ± 3.1 ha).

High levels of open pollination observed at these study sites are attributed to a high abundance, but not diversity, of pollinators. This highlights that only a few abundant species, rather than high species richness (contrary to a previous study on pumpkins (Hoehn et al., 2008) and watermelons (Kremen et al., 2002)), are able to deliver the pollination requirements for a whole crop (Kleijn et al., 2015; Winfree et al., 2015). Fortunately, these species are generally widespread, resilient to agricultural expansion and can be encouraged through simple conservation measures (Kleijn et al., 2015). These pollinator observations and fruit set experiments also show that *B. terrestris/ B. lucorum* and *A. mellifera* are able to fulfil the pollination requirements of courgette, without squash and gourd bees (belonging to the genera *Peponapis* and *Xenoglossa*) which have previously been regarded as the most important pollinators of Cucurbita crops in North America (Hurd et al., 1974).

- Pollinators contribute approximately £2.7 million to the value of UK courgette production - Calculated from dependency estimates from 2015 and 2016 field seasons

Pollination experiments demonstrate that 41% of courgette fruit set is dependent on natural pollination. Based on one hectare of courgettes being worth over £8,000 to the grower in market value and around 808ha grown, we estimate that pollinators contribute approximately £2.7 million to the total economic value of courgettes in the UK.

Financial Benefits

Based on economic calculations, growers could receive an additional £166 per ha by maximising pollination.

Action Points

- Analyses are still underway so no action points confirmed yet