Improving the performance of the native bumblebee, *Bombus terrestris audax*

(AHDB Projects PE 031 & PE 031a)

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The non-native bumblebees, *Bombus terrestris terrestris* (Btt) and *B. terrestris dalmatinus* (Btd), provided UK tomato growers with over 27 years of reliable and maintenance-free fruit set. The economics of tomato production changed considerably during that time and growers became dependent upon the benefits that were obtained from using biological pollination. However, at the end of 2014, Natural England withdrew the licence to release non-native bumblebees in unscreened glasshouses in the UK. The native sub-species, *B. terrestris audax* (Bta) could still be used and the bumblebee producers acted quickly to step up production of Bta so that growers would still have the option of biological pollination.

However, it was known that Bta was inferior to Btt/Btd for tomato crop pollination because it had been tested and rejected during the 1980s. So it was no surprise when it proved to be far from the reliable experience to which growers had become accustomed. One grower estimated that poor fruit set cost him £50,000 per hectare in 2015 and several others resorted to labour intensive manual pollination which had not been used since bumblebees were first introduced.

In 2017, the Tomato Growers' Association (TGA) organised an industry-wide survey to gather more information about the problem (AHDB Project PE 031). Growers representing 98% of UK production participated and their clearest message was that Bta were less 'vigorous' than Btt/Btd and more likely to fail to provide adequate pollination if anything was sub-optimal. Small fruiting cultivars, such as Piccolo, were most susceptible.

The TGA initiated further studies in 2018 (AHDB Project PE 031a) to investigate issues raised by growers in the survey. The work fell into three categories with the first examining Bta colony life in tomato crops. Twelve tomato growers participated in this study, providing a spread of locations as well as different bumblebee suppliers and types of tomatoes. The growers followed an agreed protocol to collectively monitor 161 hives with 777 individual colony assessments between mid-June and the end of September. The Bta hives generally contained good active colonies upon delivery but 62% went into decline within 2 weeks of being placed in a crop and this increased to 90% within 4 weeks. This rapid decline was in complete contrast to our expectations with no consistent differences between bumblebee supplier, location or tomato type. In fact, the only two common factors appeared to be 'Bta bumblebees' and 'tomato crops'; suggesting that Bta either do not like the growing environment or the plants do not provide adequate food.

The second series of studies investigated Bta flight behaviour at three sites: a crop of Piccolo at Warwick Crop Centre (WCC), a commercial tomato crop and an outside orchard. 'Bee traffic' was recorded by manually counting bees entering and exiting the hive from sunrise to sunset. Activity followed a similar pattern regardless of hive location or temperature, with the first activity just after sunrise, rising to a peak between 11:00h and 14:00h. Flights within one hour of sunset were rare. One notable feature was that activity in colonies in tomato crops

was considerably lower than outdoors. As part of this investigation, the team worked with 'Arnia Hive Monitors' to adapt their honeybee remote monitoring system (RMS) to work with the much smaller bumblebee colonies. The RMS not only provided continual and more detailed information on Bta activity than labour intensive manual counts but also provided information on the hive environment / health. This system will provide a valuable tool for future studies.

The third series of studies looked at flower development in small fruiting tomato cultivars. A scale representing stages in the development of Piccolo flowers was devised and used to record development of flowers from dawn until dusk. Observations were confirmed using continuous time-lapse photography and validated in the commercial crop. Pollen flow was assessed on the same flowers using established methods as well as a purpose built 'electric bee'. Each flower was found to open on two successive days releasing most pollen on the first day between 12:30h and 13:30h. This was reasonably well matched to Bta flights although some flowers peaked much earlier or later. The anthers of each flower had the potential to produce many more pollen grains than required to fertilise all the ovules in the ovary; *eg* 20,000 pollen grains but fewer than 120 seeds! However, pollen was more difficult to extricate manually than from flowers of larger fruiting cultivars and we don't yet know how efficiently this is done by Bta. Observations suggested that pollen production and release were inhibited by high temperatures which has previously been reported in published literature. High temperatures may have contributed to variability in pollen production by different flowers, which was more noticeable in August than September, and this may also have affected pollen viability. Further studies are required to investigate pollen release, pollen transfer to the stigma and successful germination of pollen grains.

Footnote:
Studies have continued into 2019 / 2020 (AHDB Project PE031b) and the results will be reported here in due course.