Is it worth supplementing pumpkin fields with bees?

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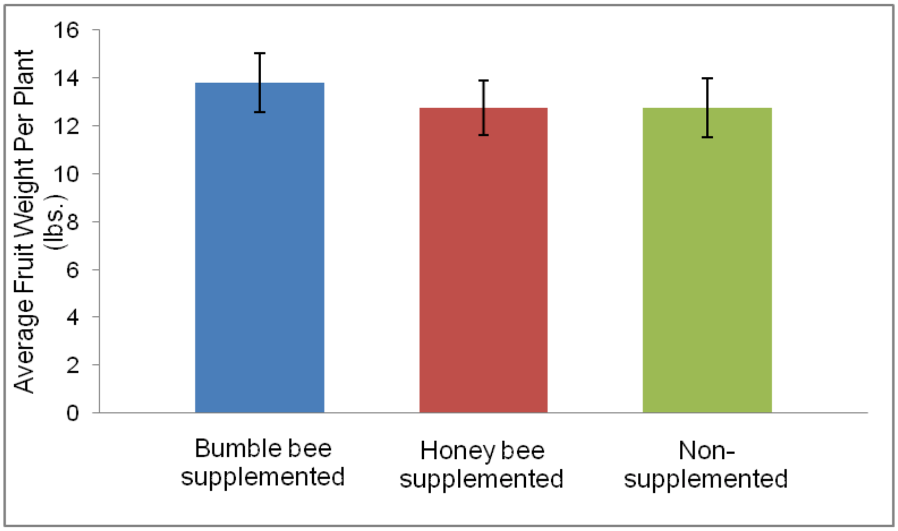
Vine crops such as pumpkin, squash, cucumber and watermelon are some of New York State's most valuable vegetable crops. These crops require pollination by bees, the most well-known of which is the honey bee, *Apis mellifera*. Honey bee hives are placed in vine crops during the time they need to be pollinated. Unfortunately, Colony Collapse Disorder (CCD), parasitic mites, viruses and other pathogens continue to cause significant losses in populations of honey bees throughout the US. Fewer honey bee hives are now available for vine crop growers and the cost of renting hives has increased from approximately \$30 per hive to ≥\$75 per hive. With no relief in sight, growers will continue to pay more for renting hives, unless alternative pollinators are identified to service their vine crops. Previous research has shown that on an individual basis, the common eastern bumble bee, *Bombus impatiens* **(Fig. 1)**, was the most efficient pollinator of pumpkin compared with other common species including the honey bee and squash bee, *Peponapis pruinosa*. Not only are bumble bees efficient pollinators, but they are also naturally abundant and available commercially making it a perfect candidate as an alternative pollinator to honey bees in pumpkin fields.

Fig. 1. Common eastern bumble bee covered in pumpkin pollen.

Will Fruit Yield Increase if Bumble Bee Colonies are Placed in Fields? In the Finger Lakes Region of New York in 2011 and 2012, we explored the potential of increasing pumpkin yield by supplementing fields with commercially produced common eastern bumble bees, compared with the yield resulting from fields supplemented with locally rented honey bees. A total of 12, 17 and 14 commercial pumpkin fields were supplemented with bumble bees, honey bees or no bees, respectively. Fields ranged in size from 1 to 25 acres; fields of similar size were grouped and randomly assigned one of the three supplementation treatments (i.e., bumble bees, honey bees or no bees). Numbers of bumble bee colonies and hives placed in each field depended on its size. For bumble bees, one QUAD (= four colonies in a box) was placed for every 2 acres and 1 honey bee hive placed for every 3 acres. All fields were separated from each other, and other fields that had honey bee hives, by at least 1 mile.

The jack-o-lantern variety, 'Gladiator', was planted in all commercial fields. Ten seedlings were transplanted into each of three locations in the field (=30 plants per field). In September, when the crop was mature, all marketable fruit were counted and weighed. Data were analyzed using an ANOVA and treatment means were then compared using a t-test at $P<0.05$. The average fruit weight per pumpkin plant in fields supplemented with commercial bumble bees did not differ significantly from fruit weight in fields supplemented with honey bees or those that were not supplemented (**Fig. 2**).

Fig. 2. Mean (± SEM) pumpkin, *Cucurbita pepo*, var. 'Gladiator', fruit yield from fields supplemented with commercial bumble bee colonies ($n = 12$), honey bee hives (n= 17) or were not supplemented ($n = 14$) in New York in 2011 and 2012.



Do bumble bees and honey bees visit more pumpkin flowers in fields in which they are supplemented? Bees visiting pumpkin flowers were recorded at three locations in each field and three times during the blooming period in both 2011 and 2012. Bee visits to pumpkin flowers in bumble bee-supplemented, honey bee-supplemented and non-supplemented fields were analyzed using an ANOVA and treatment means were compared using a t-test at $P<0.05$. Contrary to our expectations, there were no more visits to flowers by bumble bees in fields supplemented with bumble bees than in fields that were not supplemented (**Fig. 3**). Likewise, there were no more honey bee visits to flowers in fields supplemented with honey bees than in fields that were not supplemented.

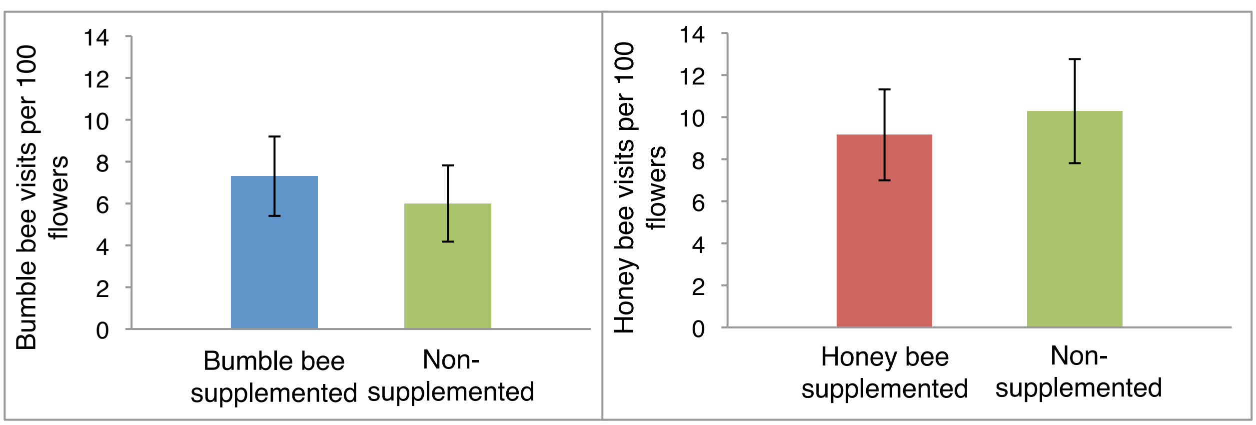


Fig 3. Bumble bee and honey bee visits to pumpkin flowers in bumble bee supplemented, honey bee supplemented and non-supplemented fields in 2011 and 2012.

What are the bees foraging on if not pumpkin? Pollen on the legs of bees returning to their hives in bee-supplemented pumpkin fields was identified to determine where the bees were foraging. Bumble bees were sampled from 6 bumble bee-supplemented fields (*n*=152 bees) and honey bees were sampled from 4 honey bee-supplemented fields (*n*=146 bees) three times during bloom. A random sample of 100 pollen grains from each bee was counted and identified to the lowest taxonomic rank feasible. For each bee species, the pollen data were pooled across all collection sites and collection times and represent the percentage of pollen collected from each plant species. Surprisingly, very few bees foraged for pumpkin pollen (**Fig. 4**). Pumpkin pollen only consisted of 2.5% and 0.2% of the total pollen collected from honey bees and bumble bees, respectively (**Fig. 4**). Both bee species foraged on pollen from many different weed species including ground cherry (Solanaceae), clover (Fabaceae), Queen Anne's lace (Asteraceae), dandelion (Asteraceae), goldenrod (Asteraceae), English plantain (*Plantago*), and pokeweed (Phytolacca) (**Fig. 4**). Most surprising was that 30% of the pollen collected by honey bees was from corn (*Zea mays*) and nearly 50% of the pollen collected by bumble bees was from solanaceous plants, which may have included crops such as tomato, peppers and potato.

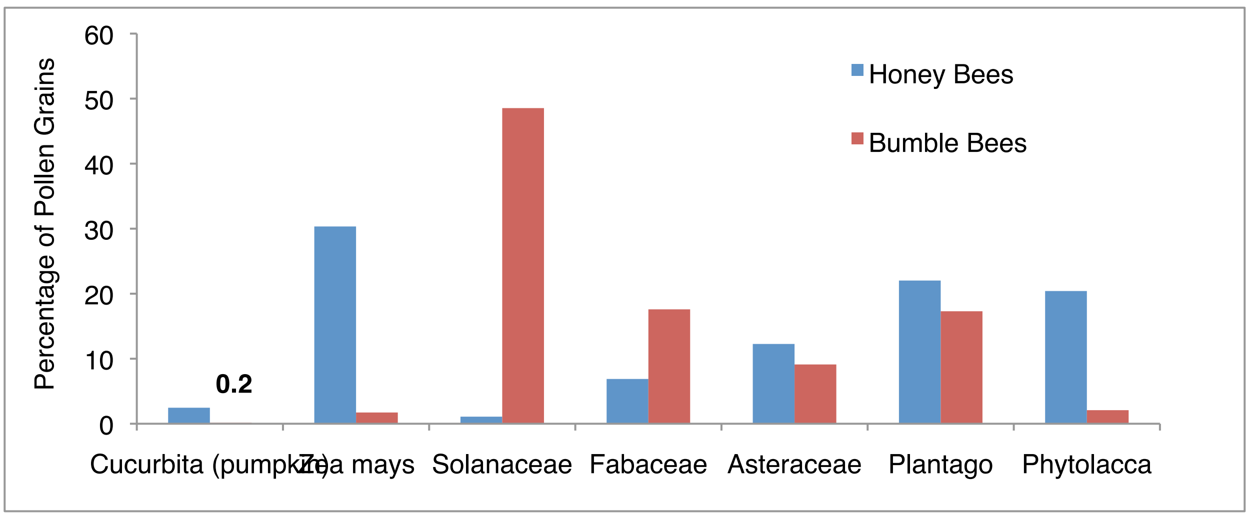


Fig. 4. Overall percentage of pollen grains returned to honey bee hives (*n*=146 bees) and bumble bee colonies (*n*=152 bees).

Later in the season, around August 1st, we began observing bees returning to their hives with pollen covering their bodies (**Fig. 1**). We sampled these bees (*n*=28 honey bees, *n*=61 bumble bees) and confirmed that 100% were covered with pumpkin pollen. After August 1st, 33% of bumble bees and 13% of the honey bees returning to their hives were covered in pumpkin pollen. These results indicate that honey bees and bumble bees were likely foraging for nectar in male flowers and accidentally contacted pollen. This foraging activity likely contributed to pollination of pumpkin fruit. We continued to observe pollen-coated bees long after the majority of fruit in the field was set, suggesting that most of these bees were not playing an important role in pollination.

Among the most common bee species that pollinate pumpkin, which ones have the greatest impact on pumpkin yield? The relationship between bee visits to pumpkin flowers and fruit yield was described for each of the most commonly encountered species in pumpkin fields (i.e., common eastern bumble bee, honey bee and squash bee). Bee visit data and pumpkin yield from the 2011 and 2012 studies were combined (*n*=43 fields) and used in the regression analysis ($P<0.05$). Results indicated that the number of bumble bee visits to pumpkin flowers had a significant impact on fruit yield; yield increased as the number of flower visits in a field increased (**Fig. 5**). In contrast, the frequency of honey bee and squash bee visits to pumpkin flowers was not correlated with yield. Although supplementing pumpkin fields with bees did not increase bee visits to flowers, more bumble bee visits to flowers in certain fields resulted in greater yield. These results support previous research suggesting that bumble bees are efficient pollinators of pumpkin. Additionally, some landscapes near pumpkin fields may support larger bumble bee populations than others. Results of our landscape study from 2011 indicated that greater levels of semi-natural grassland (e.g., weedy ditches, fallow fields, etc.) in the landscape supported more bumble bee visits to pumpkins.

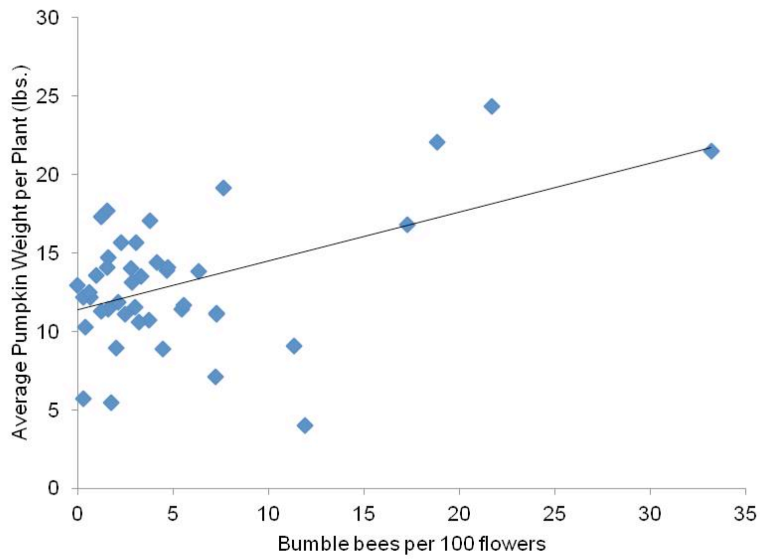


Fig. 5. Bumble bee flower visitation frequency is significantly positively correlated with pumpkin yield ($P=0.002$; $n=43$).

Conclusions. Bumble bees are important pollinators of pumpkin and fruit yield will increase when visited more by bumble bees. Yet, supplementing pumpkin fields with bumble bee colonies will not necessarily increase pumpkin yield. These seemingly contrasting results may be explained by differences in the local abundance of native common eastern bumble bee populations near pumpkin fields. For example, a pumpkin field near a locally abundant bumble bee population would not need to be supplemented because the native population would provide sufficient pollination of the crop. Conversely, a pumpkin field that is near a low population of bumble bees may benefit from supplementing with commercial bumble bees to increase pollination and therefore fruit yield. To address this point, we intend to identify landscape features near pumpkin fields that were positively associated with bumble bees visiting pumpkin flowers. This information will be used to develop a Decision-Making Guide for use in deciding whether supplementing fields with commercial bumble bees could be economically advantageous or that the native bee population will likely be large enough to provide maximum pollination and high fruit yields.