Fruit set response of lowbush blueberry (*V. angustifolium*) in different introduced pollinator environments

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Introduction

Commercial lowbush blueberry fields in New Brunswick are grown and maintained by promoting the growth of wild *Vaccinium angustifolium* in early successional stage forests. Lowbush blueberries exhibit some self-incompatibility and/or inbreeding depression. Fruit yield differs both between and within fields. A host of native pollinators (*Andrena, Bombus, Halictus, Agapostomon, Augochlora, Augochlorella* and *Lasioglossum*) are well adapted to the floral biology of *V. angustifolium*. However, increases in production intensity combined with anthropogenic disturbances surrounding production areas is believed to render native pollinator services insufficient for full fruit production.

The use of managed pollinators in lowbush blueberry fields is now widespread throughout New Brunswick. The three species commonly used are the honeybee (*Apis mellifera*), the bumblebee (*Bombus spp.*) and leafcutter bee (*Megachile rotundata*). These three species have been shown to differ significantly in their pollination effectiveness in blueberries (Javorek, 2002). To determine whether pollination services of indigenous pollinator communities can be replaced with those of introduced pollinators, we measured fruit set responses to different introduced pollinator combinations. Data on pollinator behavioural characteristics were also collected to determine if specific pollinator attributes influenced fruit set.

Methods

Our research fields were located around Neguac, NB, a coastal community on the North Shore of Miramichi Bay. Twenty-four fields were selected and divided into 8 pollinator treatment groups consisting of **control** (no introduced pollinators) fields, **fields with a single introduced pollinator species (honeybee, bumblebee, or leafcutter bee)**, fields with a combination of **two introduced pollinators**, and fields with **all three introduced pollinators**.

In each field twelve blueberry clones were selected along a 60 meter transect originating from the field edge and progressing towards the middle of the field. Each clone consisted of an **open-pollinated inflorescence** (i.e., pollinated by pollinators present in the field), a bagged **self-pollinated inflorescence**, and an **inflorescence selected for supplemental pollination** (using pollen transferred from another clone). Flower counts and supplemental pollination were conducted a minimum of three times throughout the flowering period.

Pollinator foraging behaviour was observed in areas surrounding the transects. The foraging information consisted of the number of flowers visited, time spent foraging on flowers, the number of inflorescences visited, flight distance between inflorescences and the approximate number of clones visited during the bee chase.

Upon fruit set, berries were counted and collected for seed. **Fruit set (proportion of flowers setting fruit)** was then calculated.
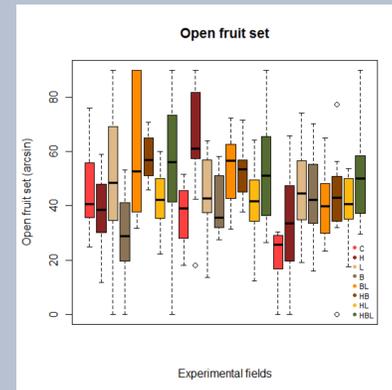
Results

Figure 1. Open fruit set (arcsin transformed) in 24 experimental fields. Each colour represents a specific pollinator treatment (see key in figure)
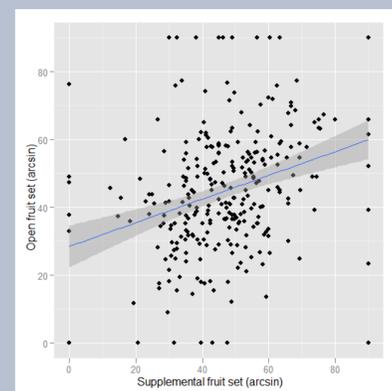
B=bumblebee,
H=honeybee,
L=leafcutter.

Figure 2. Open fruit (arcsin transformed) in 8 pollinator treatments, B=bumblebee, H=honeybee, L=leafcutter.

Figure 3. Linear regression between supplement fruit set and open fruit set ($r^2=0.09$, $P<0.001$).

Apis mellifera

Megachile rotundata
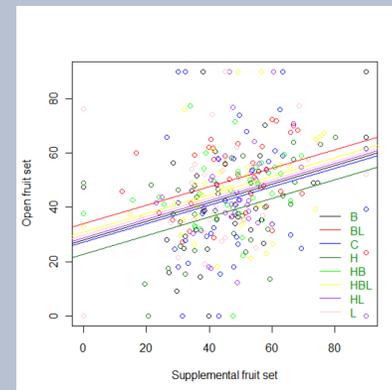
Bombus impatiens

Figure 4. Open fruit set as a function of supplemental fruit in 8 pollinator treatments. Each line represents the ANCOVA regression for a particular pollinator treatment.
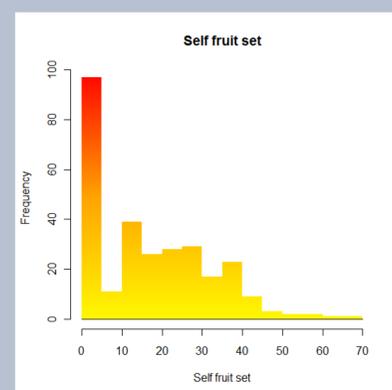
Table 1. Tukey's (HSD) analysis of differences between groups with a confidence range of 95.00%

Treatment comparison	Standardized difference	Critical value	P value
BL ~ H	3.062	3.054	0.049

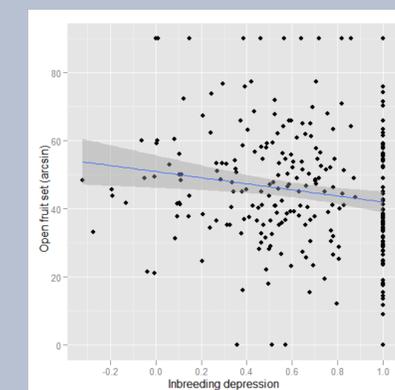**Figure 5.** Frequency of self fruit set (arcsin) from 288 blueberry plants in 24 fields.

Figure 6. Open fruit set as a function of inbreeding depression [$1-w_s/w_o$], where w_s=self fruit set and w_o=supplemental fruit set ($r^2=0.02$, $P<0.01$).

Results and Discussion

Daily temperature patterns during the flowering period were not significantly different between regions around Neguac where the fields occur (not shown) and thus are not likely to have contributed to differences in bee foraging behaviour or plant microenvironment. None of the pollinator behaviour metrics evaluated were significantly correlated with fruit set measurements (data not shown).

Open pollinated fruit set between fields (Fig. 1), differed significantly but no single pollinator treatment (Fig. 2) consistently accounted for the highest fruit set (F=1.32 , P=0.24). The correlation (Fig. 3) between open fruit set and supplemental fruit set is statistically significant (F=30.8, P<0.001), suggesting that there may be underlying characteristics unique to clones that contribute to variation in individual levels of fruit set.

Increasing either pollinator abundance or diversity of the introduced pollinator community did not systematically increase fruit set across our experimental populations (data not shown). There is weak evidence that suggests the combination of bumblebee and leafcutter bee may be more effective at increasing fruit yield than honeybee alone (Fig. 4).

Within the 24 fields evidence for self-incompatibility and/or inbreeding depression was found (Fig. 5), with no significant differences in self fruit set seen between fields (F=0.76, P=0.78). Inbreeding depression estimates derived from fruit set values (1.0-[self/supplemental]) suggest that inbreeding depression is prominent (Fig. 6) and may be an important factor in determining fruit set levels in the presence of pollinators. The differences in fruit set seen in the populations may be due to simple environmental factors (soil conditions, water status) or, as our results suggest, intrinsic factors of the blueberry clones themselves (clonal growth, varying degrees of self-sterility).

Future directions

The clonal growth habit of *V. angustifolium* coupled with the self-incompatibility and inbreeding depression may account for much of the variability seen in fruit set. Bell (2010) suggests a clone's fruit yield is an inherent function of its maternal genetic makeup and influenced by the pollen environment in which it is found. In lowbush blueberry clonal size can vary significantly ($\approx$ 6-23 m^2), with size generally related to age of the clone.

Future studies should focus on the potential effects of large clone size on intraclonal movement of pollinators and pollen (i.e. self-fertilization). Larger long-lived perennial plants are also liable to accumulate deleterious mutations (Scofield & Schultz 2006); determining the role of somatic mutations and pollen environment in clones of various size is necessary to the pollination ecology of *V. angustifolium* and can further optimize fruit production.

References

Bell, D.J., Rowland, L.J., Stommel, J., & Drummond, F.A. 2010. Yield Variation among Clones of Lowbush Blueberry as a Function of Genetic Similarity and Self-compatibility. *Journal of the American Society for Horticultural Science*, 135, (3) 259-270

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