A SURVEY OF FIELD ACTIVITY AND INFLUENCES OF COMMERCIALLY REARED BUMBLEBEE *(BOMBUS* SP.) ON POLLINATION, FRUIT SET AND PRODUCTIVITY IN CRANBERRY.

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INTRODUCTION

Cranberry fruit set under field conditions typically ranges from 25 to 40% of potential. Up to 28% of fruit failing to set and develop in 'Searles' cranberry is a result of lack of pollination by honey bees and other native pollinators (Birren-kott and Stang, 1989). Several species of bumblebees (Bombus) are recognized as highly effective in pollinating cranberries.

The ability to effectively rear bumblebees under laboratory and commercial conditions is a recent and promising development. Commercially reared bumble-bees have been demonstrated to be highly effective in providing pollination for various greenhouse crops including cucumbers and tomatoes. Our objectives in this study were to assess reared bumblebee activity and potential effects on cranberry fruit set and productivity in the field.

Eighteen colonies of bumblebees including three separate species, *Bombus impatiens*, ***B.*** *terricola* and *B. ternarius* commercially reared by Bees Under Glass Pollination Services, Inc. were obtained in mid June, 1991. These species are native to Wisconsin with *B. impatiens* more common in southern areas of the state. Reared colonies consisted of a queen and variable numbers of workers estimated at 10 to 30 per nest. Individual colonies were maintained in specially constructed individual nest boxes. Bee populations were much lower than normally would be expected as a result of some delay in funding commitments for the study and unusual earliness of the blossoming season in 1991. Reared colonies at full strength would contain 200 to 300 worker bees. In 1991 blossoming occurred up to ten days earlier. Hence a major portion of the research was done in northern Wisconsin cranberry marshes to coincide with the blossoming period.

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Experiment I

Two separate insect cages (2 x 2 x 6 meter) were placed over established 'Searles' cranberry beds at Cranberry Lake Corporation, Phillips, WI on 24 June, 1991 at 5 percent blossoming stage. Within each cage, 5 screened frames were placed over plants to control bee access to flowers during the experiment. Individual active, larger colonies of *B. impatiens* and *B. terricola* were placed in the separate cages on 25 June. Rapid blossoming occurred with full bloom on 28 June. For 3 to 6 hours each day on 25, 26, 27, 29 June and 1 July, the small frames inside the cages were removed and individual flower visits by bees were monitored. Single flowers visited once, twice or three times by bees were labeled. The experiment was terminated 3 July. On 21 September, all labeled upright shoots and fruit were harvested from the caged plots. For comparison, upright shoots with fruit were randomly harvested from the uncaged plot in the same bed and from plants within the cage not covered by screens. Individual berry length, diameter, and weight were recorded. Each berry was cut and seeds were removed, separated into large (fertilized, presumably viable) and small (unfertilized, nonviable) groups and counted.

Experiment II

To examine unrestricted field behavior of reared bumble bees, single bumble bee colonies (queen plus 20 to 30 workers) were placed in the center of producing 'Searles' cranberry beds at four locations in Wisconsin. Locations included R.S. Brazeau, Inc. and Gottschalk Cranberries, Inc., Wisconsin Rapids, Alder Lake Cranberries, Inc. and Koller Cranberries, Inc., Manitowish Waters. At Cranberry Lake Corporation, ten remaining small colonies of *B. impatiens,* two *B. ternarius* and one colony of *B. terricola* were placed next to each other in 'Searles' . At Alder Lake (A), Koller (B) and Cranberry Lake (C) paired comparisons between beds containing reared bees and not containing bees (control) were established.

Plant sampling locations within paired beds were established from the centrally located bee colony or bed center of the control. Five concentric circles beginning 3 meters from the bee colony or center point and 3 meters apart were marked. On each circle a total of sixteen points were located, starting from the cardinal direction points. Ten flowering uprights were selected for each sample and labeled to identify the radial location and direction. The number of flowers, number of fruit and fruit weight for each upright were recorded for determination of percent fruit set and mean fruit weight.

Observations: Reared bumblebee behavior

Reared bumblebee colonies were observed from dawn to dusk and at shorter intervals on separate days for numbers of flights and approximate duration of flights. Similarly, numbers of flowers visited per unit time were recorded.

RESULTS

Experiment I

In the caged study, *B. terricola* did not pollinate cranberry flowers during the periods of observation from 25 June to 1 July. This lack of activity is unexplained since the colony was otherwise healthy and active. Thus no results were obtained from the caged experiment with this species. *Bombus impatiens* was highly active beginning 26 June, the day after the colony was placed in the cage. In most instances during observation periods two to five bees were outside the next box and active in pollen or nectar collection within the cage. In four plots in the cage a total of 44 fruit were obtained, 36 resulting from one bee visit, 8 from two bee visits to the same flower (Table 1). No fruit were obtained from the few flowers visited 3 times by bees. Except for one berry, all fruit occurred on the 1st or 2nd (basal) flower position on the upright. Where one or two bee visits occurred, fruit set was low but within percentages normally obtained in the field under open pollinated conditions (Table 2). Fruit weight and size were comparable to both control comparisons, either caged open pollinated or uncaged open pollinated fruit. Direct fruit set comparisons are not possible since the open pollinated samples consisted only of fruiting uprights. Despite substantially lower viable seed counts in fruit pollinated once or twice, results suggest single pollinations by effective “buzz” pollinators such as *B. impatiens* are adequate to result in economic fruit size. Slight increases in fruit weight and size occurred with two bee visits to flowers, although increases in viable seed set as a result are not apparent with the limited data obtained in this test.

Experiment II

At the three locations where paired comparisons of beds containing a colony of reared *B. impatiens* and a control not containing a colony occurred, none showed distance effects from the central point within the concentric circles for either control or treated plots (data not shown). Except for a slight increase in berry weight at location C, no effect of location (control vs bee plot) was measured (Table 3).

At locations A and B, directional effects (East-West, North-South) were not noted in flowering or fruiting responses. At location C a directional response was noted. Percent fruit set and total fruit weight per upright were slightly increased along either the western or eastern axis in comparison to north or south directions from the colony in the treated plot (Table 4). Only fruit bearing uprights were selected in sampling thus fruit set percentages are substantially higher than typically occur when all flowering uprights are sampled.

Observations: Reared bumblebee behavior

Projecting from counts of bee trips in the smaller colonies used in this test and numbers of flowers visited per/minute, it is possible to estimate the numbers of flowers a full sized colony (250 workers) might visit in one day (Table 5). High values indicated for daily trips are actual counts from a full colony of *B. impatiens* in another study.

Assuming that an 8% deficit exists in pollination (30% vs 38%) and that the entire deficit could be recovered by bumble bee pollination, the estimated returns to a colony purchase for a 2 week pollination season can also be projected. Cur-rent costs for a colony in this projected scenario do not appear to be economically feasible under ideal field pollination conditions. Under less favorable pollination conditions, results might be dramatically different, since bumble bees are known to be highly efficient, able to pollinate for longer daily periods and under less favorable weather conditions than alternate pollinators.

Because of the presence of honeybees and other native pollinators, it is impossible in this study to document either that the addition of reared bumblebees can increase fruit set to the maximum potential or to determine how many bees are necessary to achieve that goal.

That reared bumble bees are as highly efficient and effective as wild native bumblebees in pollination in the field is however clearly established.

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Table 1. Number of fruit obtained from one or two bee visits *(B. impatiens)* to flowers in caged trails with 'Searles' cranberry.

Replicate	No. of tagged flowering uprights	No. of fruit (1 visit)	No. of fruit (2 visits)	No. of uprights with 1 fruit	No. of uprights with 2 fruit
1	25	7	6	11	2
2	24	10	0	10	0
3	18	8	1	8	1
4	18	11	1	11	1
Total	85	36	8	40	4

Table 2. Fruit set, fruit size and seed numbers under caged, controlled bee visits vs caged, open pollinated and non-controlled field conditions in 'Searles' cranberry, 1991.

Treatment	Fruit set (%)	Fruit weight (g)	Fruit length (mm)	Fruit diameter	No. of viable seed	No. of nonviable seed
Caged, screened (1 visit)	-	1.15	15.6	12.1	7.1	18.4
(2 visits)	-	1.20	16.6	12.3	5.9	18.2
Mean	28	1.18	16.3	12.4	6.6	18.3
Caged, open pollinated	63	1.13	16.8	13.7	15.1	12.4
Uncaged, open pollinated	57	1.15	17.8	14.4	11.7	16.7

Table 3. Flowering and fruiting in 'Searles' cranberry in beds containing one (location A, B) or multiple (location C) colonies of reared bumble bees vs native pollinators and honeybees.

Treatment	No. of fruit./ upright	No. of flowers/ upright	Fruit set (%)	Fruit weight/ upright (g)	Mean fruit weight (g)
Location A					
Control	1.4	2.9	51	1.55	1.07
Bee plot	1.4	2.9	51	1.66	1.10
significance	ns	ns	ns	ns	ns
Location B					
Control	1.5	2.8	55	1.74	1.13
Bee plot	1.5	2.8	54	1.74	1.16
significance	ns	ns	ns	ns	ns
Location C					
Control	1.3	2.3	57	1.43	1.09
Bee plot	1.2	2.2	58	1.59	1.25
significance	ns	ns	ns	*	**

ns, *, ** = nonsignificant; significant at P = .05, P = .01 respectively.

Table 4. Directional effects on flowering and fruiting in 'Searles' cranberry in beds containing multiple small colonies of reared bumblebees.

Treatment (direction)	No. of fruit/ upright	No. of flowers/ upright	Fruit set (%)	Fruit weight/ upright (g)	Mean fruit weight (g)
West	1.3	2.3	59	1.77	1.29
East	1.3	2.1	62	1.62	1.26
South	1.2	2.4	51	1.42	1.22
North	1.2	2.1	56	1.40	1.18
significance	ns	ns	**	*	ns

ns, *, ** = nonsignificant; significant at P = .05, P = .01 respectively.

Table 5. Estimated responses to reared bumblebee activity and potential economic returns in cranberry.

Reared bumblebee activity and economic returns	Estimated Responses		
	Low	Medium	High
No. of trips per day (250 workers)	862	1325	1788
Length of trip (minutes)	5.3	10.2	15.1
No. of flowers visited per minute	14	14	14
No of flowers per colony per day	63,915	189,075	377,713
Economic value of colony (2 weeks)*	$114	$339	$677

*Assuming full recovery of 8% pollination deficit, fruit averaging 1.2 g/berry and $0.60 per pound of fruit.