UNACCEPTABILITY OF CULTIVARS OF HIGHBUSH BLUEBERRY BY ADULT BLACK VINE WEEVILS (COL.:CURCULIONIDAE)[1]

W. T. CRAM

ABSTRACT

When isolated adults of the black vine weevil, **Otiorhynchus (Brachyrhinus) sulcatus** (F.), were fed highbush blueberry foliage at constant 20°C and 16 hours photoperiod, the related cultivars Cabot and Weymouth were unacceptable, whereas Jersey, Rancocas, June, Pemberton, Bluecrop, Rubel, Dixi and Stanley were acceptable, judged mainly on weight gains, feeding rates, fecundity, and survival. The presence of a feeding deterrent is indicated in the two unacceptable cultivars but other possibilities are a lack of some necessary nutrient(s) or an imbalance or unavailability of nutrients which may invoke the response of inadequate feeding. Adults appear to die from starvation.

INTRODUCTION

The black vine weevil, *Otiorhynchus (Brachyrhinus) sulcatus* (F.), (Zimmerman, 1968), a parthenogenetic European species, occurs on many species of plants and is a major pest on several economic crops, and many ornamentals such as strawberry, cranberry, blueberry, yew, cyclamen, and azalea. These plants are obviously different in many respects and represent a broad range of acceptability by the pest. In earlier studies on the acceptability of plants found in peat bogs where highbush blueberry is grown, Cram and Pearson (1965) found that excised leaves from certain weeds were more efficient sources of food for the adults than blueberry itself. These results led to a study of the acceptability of leaves from several highbush blueberry cultivars grown in peat bogs near Vancouver, British Columbia.

MATERIALS AND METHODS

The general methods were the same as those described earlier (Cram and Pearson, 1965). Besides collecting newly emerged adults in the field, mature larvae were collected from soil under blueberry bushes in late May, and placed singly in holes made with a planting board in a standard greenhouse flat containing peat soil from the collection site. The holes were covered lightly, the soil was watered as required, and the larvae were allowed to pupate and the adults to emerge in the laboratory. In this way adults were obtained which had never fed on foliage. Adults were prevented from escaping from the open flats by stapling a strip of polyethylene film around the outside of the flat. This strip extended about 2 cm above the top of the flat and the inside surface was coated with fluon[2] applied with a swab of plastic foam.

Recently an improved method was devised for measuring the relative area of leaf consumed. After feeding a leaf was placed on a glass plate over graph paper with dots marked at alternate millimeter intersects. The area of leaf consumed was determined by counting the dots that were visible within the feeding notches. Each dot was equivalent to 4 sq. mm of leaf area. Excretion was rated by examining the relative amount of frass in the vials. All experiments were conducted in commercial bench-top rearing cabinets[3] at a constant 20°C and 16-hour photoperiod.

Studies in 1966

Newly emerged adults and all blueberry foliage were collected from the same farm. The cultivars tested, the mean weight gain in 3 weeks, mortality, and the mean of viable eggs from 10 weevils each for 13 weeks appear in Table 1. The adults lost weight

Table 1. Response of adults of the black vine weevil fed excised leaves from highbush blueberry cultivars at constant 20° C and 16-hour photoperiod for 13 weeks.

Cultivar	Mean wt gain (mg) in 3 weeks	No. surviving to oviposit/13	Mean viable eggs
Weymouth	-5.4	0	0.0
Jersey	14.8	12	308.7
Rancocas	14.4	12	313.1
June	13.5	12	347.6
Pemberton	18.0	13	392.5
Bluecrop	17.6	13	449.0

[1] Contribution No. 183, Research Station, Canada Agriculture, 6660 N.W. Marine Drive, Vancouver 8, British Columbia.

[2] Fluon is a polytetrafluoroethylene dispersion manufactured by Imperial Chemical Industries, Welwyn Garden City, Herts. U.K.

[3] Manufactured by Sherer-Gillett, Marshall, Michigan, U.S.A.

and died even before eggs could be laid when they were fed on Weymouth, but the other cultivars were all acceptable and there were no significant differences in the weight gains or eggs laid.

Table 2. Response of adults of the black vine weevil fed excised leaves from highbush blueberry cultivars at constant 20°C and 16-hour photoperiod for 10 weeks. Leaves from 4 farms to offset any local effects.

Cultivar	Farm[1]	Mean wt gain (mg) in 3 weeks	No. surviving to oviposit/13	Mean viable eggs[2]
Weymouth	A	-4.6	0	0.0 a
Weymouth	B	-4.5	0	0.0 a
Weymouth	C	-2.4	1	29.4 ab
Weymouth	D	1.2	3	2.7 a
Cabot	A	-6.4	0	0.0 a
Cabot	D	-7.6	0	0.0 a
Rubel	A	9.6	10	229.9 d
Rubel	B	14.2	11	101.4 bc
Rubel	C	15.4	12	171.1 cd
June	C	11.4	12	239.5 d
June	D	13.6	12	176.9 cd
Dixi	C	15.3	13	230.4 d
Stanley	D	15.0	12	247.0 d

[1] A — Erickson; B — Illis; C — Blue Boy; D — Makara.

[2] Mean of 10 randomly selected survivors. Means sharing the same letter are not significantly different ($p = .05$).

Studies in 1967

The preliminary results of 1966 stimulated interest in other cultivars, especially any that were genetically related to Weymouth. The cultivar Cabot is one parent of Weymouth, June is the other and Rubel is a grandparent (Moore, 1966). In 1967 newly emerged adults from the fields and leaves from the different cultivars were collected from more than one farm to offset any local climatic or soil effects. The mean weight gain in 3 weeks, the number of laying eggs, and the mean of viable eggs for 10 randomly selected weevils for 10 weeks appear in Table 2. The unacceptable nature of Weymouth was again evident and its parent Cabot also produced a similar response. Leaves from different farms did not alter this response significantly. The cultivars Rubel, June, Dixi and Stanley were all acceptable on the basis of the parameters measured.

Another series was observed to show the response to Cabot and Stanley using adults that had fed on strawberry foliage since emergence. These were all ovipositing at a high rate. Ten individuals were then fed on Cabot, on Stanley or continued on strawberry (Northwest). Those on strawberry and Stanley continued to oviposit at normal, comparable levels, whereas there was a sharp reduction in oviposition in those on Cabot (Table 3).

Studies in 1969

To clarify and substantiate the earlier findings, studies were concentrated on one acceptable cultivar, Stanley, and one unacceptable cultivar, Cabot. Leaves from both were collected at the Makara farm. All adults were from larvae collected in the field and allowed to pupate and emerge in the laboratory. Emphasis was on the weight change, amount of feeding and fat content of individual adults fed for 2, 3, 4 and 5 weeks at a constant 20°C and at a 16-hour photoperiod. When the adults emerged from the soil they were weighed, and assigned to a cultivar and a time period. In this way 34 unfed adults from every date within the 10-day emergence period were included in each time period. Adults were fed at weekly

Table 3. Response of 13 actively ovipositing adults of the black vine weevil fed at first on strawberry then changed to the blueberry cultivars Cabot or Stanley or continued on strawberry at constant 20 C and 16-hour photoperiod.

	Mean viable eggs/week							
	Weeks after change							Mean eggs
Host	1	2	3	4	5	6	7	/week
Blueberry								
Cabot	6.9	14.8	5.0	2.6	0.3	2.6	13.5	6.5
Stanley	40.7	13.2	28.5	32.3	26.2	31.8	38.4	30.2
Strawberry								
Northwest	13.2	30.3	40.9	34.1	52.8	37.5	28.7	33.9

intervals as before. When their assigned time period had elapsed they were weighed, killed in ethyl acetate vapour, weighed again, dried at 90° C for at least 48 hours, weighed, extracted, dried, and finally weighed. The extraction was similar to the method of Nijholt (1967) and was accomplished by placing a single dried adult with its numbered label in a small extraction thimble which was stoppered with a loose plug of glass wool. Nine thimbles were placed in a large soxhlet extractor and extracted with petroleum ether for at least 7 hours. Tests revealed that longer periods did not result in further extraction of petroleum ether solubles.

Significant differences ($p = .05$) between the cultivars were recorded for weight changes, feeding, excreting, moisture and fat contents (Table 4). After 5 weeks 31.4% of the weevils were dead on Cabot but only 5.7% on Stanley. The effect of Cabot was evident within the first 2 weeks of feeding when all parameters but fat content were significantly different. The fat contents after 2, 3, 4 and 5 weeks on Cabot were significantly lower than after only 3 weeks on Stanley. The effect of Cabot appears to be related to the presence of an unknown feeding deterrent, since feeding, although normal at first, soon changes to an atypical small notching or tasting of the leaf edge rather than the normal, deep and large notching observed on acceptable cultivars. Under the conditions of these experiments even the Cabot foliage that was consumed was: not sufficient to sustain the normal growth of the fat body and the immature reproductive system (Cram, 1958); or all the necessary nutrients were not present; or they were present in a form that was not readily available to the weevil; or they were present in unbalanced concentrations. Gordon (1961) says that in general, nutritionally adequate foods induce feeding and inadequate foods do not. Therefore, in this instance, there may not be a chemical deterrent but rather the negative response might be due to nutritional inadequacy. The exact cause of the unacceptability of Weymouth and Cabot has not been found despite many attempts to establish a qualitative or quantitative difference in the chemical composition of the leaves. The effect of varying the temperature regimes sheds some light on these observations (Cram, 1970).

Acknowledgements

The help of Mr. W. D. Pearson, Mr. R. Hlatky and Mrs. Susan Burt, while serving as student assistants, is gratefully acknowledged.

Table 4. Response of adults of the black vine weevil fed excised leaves from the blueberry cultivars Cabot or Stanley for 2, 3, 4 or 5 weeks at constant 20° C and 16-hour photoperiod.

Cultivar	No. adults	Weeks of feeding	Mean wt gain (mg)[1]	Mean feeding /week (Sq mm of leaf)	Mean frass /week[2]	Mean % moisture	Mean % fat[3]	% Mortality
Cabot	34	2	-5.3 a	182.0 a	1.3 a	76.8 a	8.4 ab	5.6
	31	3	-6.6 a	158.2 a	1.6 b	76.6 a	6.8 a	13.9
	31	4	-6.3 a	144.0 a	1.4 ab	74.8 ab	8.1 ab	8.6
	24	5	-6.7 a	138.8 a	1.6 b	73.5 b	8.5 ab	31.4
Stanley	34	2	6.4 b	346.6 b	2.4 c	68.6 c	13.0 bc	5.6
	35	3	8.8 bc	324.1 b	2.7 d	64.2 d	15.8 c	0.0
	31	4	11.2 c	335.2 b	2.2 c	57.7 e	17.6 c	2.8
	33	5	11.9 c	318.7 b	2.5 c	55.8 e	18.3 c	5.7

[1] Means sharing the same letter are not significantly different ($p = .05$).
[2] Rated as amount of frass in vial.
[3] Petroleum ether solubles. Mean of 34 freshly transformed adults was 5.3%.

References

Cram, W. T. 1958. Gross anatomy and growth of the reproductive system of the black vine weevil, **Brachyrhinus sulcatus** (F.) (Coleoptera:Curculionidae). Can. Entomol. **90**:569-579.

Cram, W. T. and W. D. Pearson. 1965. Fecundity of the black vine weevil, **Brachyrhinus sulcatus** (F.), fed on foliage of blueberry, cranberry and weeds from peat bogs. Proc. Entomol. Soc. Brit. Columbia **62**:25-27.

Cram, W. T. 1970. Acceptability of cultivars of highbush blueberry at varying temperatures by adult black vine weevils (Col.:Curculionidae). J. Entomol. Soc. Brit. Columbia **67**:6.7.

Gordon, H. T. 1961. Nutritional factors in insect resistance to chemicals. Ann. Rev. Entomol. **6**:27-54.

Moore, J. N. 1966. Breeding **in** Blueberry Culture ed. P. Eck and N. F. Childers. Rutgers University Press, New Brunswick. 45-74.

Nijholt, W. W. 1967. Moisture and fat content during the adult life of the ambrosia beetle, **Trypodendron lineatum** (Oliv.). J. Entomol. Soc. Brit. Columbia **64**:51-55.

Zimmerman, E. C. 1968. **Otiorhynchus** versus **Brachyrhinus** (Insects, Coleoptera, Family Curculionidae). Bull. Zool. Nomencl. **25**:29-35.

ACCEPTABILITY OF CULTIVARS OF HIGHBUSH BLUEBERRY AT VARYING TEMPERATURES BY ADULT BLACK VINE WEEVILS (COL. :CURCULIONIDAE)[1]

W. T. CRAM

ABSTRACT

Adults of the black vine weevil, **Otiorhynchus (Brachyrhinus) sulcatus** (F.), fed and oviposited at normal, expected rates when fed excised foliage of the acceptable highbush blueberry cultivars, June and Stanley, in variable temperature regimes of 7 to 15, mean 10; 12 to 19, mean 15; and 16 to 29, mean 22°C. However, on the unacceptable cultivars, Cabot and Weymouth, they laid some eggs at the high and very few eggs at the medium regimes, whereas in earlier work they laid no eggs at a constant 20°C. These results indicate that Cabot and Weymouth provide barely adequate nutrition to the weevils and that environmental stresses such as a constant 20°C demand more nutrients than the unacceptable cultivars can provide. Variable conditions, probably due to a lower turn-over rate during the cool periods, allow the insect to obtain the nutrients necessary for fat body development and some oviposition.

INTRODUCTION

A clear pattern of unacceptability of the highbush blueberry cultivars Cabot and Weymouth to adults of the black vine weevil, *Otiorhynchus (Brachyrhinus) sulcatus* (F.), was shown at the constant laboratory conditions of 20°C and 16 hours photoperiod (Cram, 1970). Further tests at three variable temperature regimes were conducted to see if this response also occurred in somewhat more natural environmental conditions.

MATERIALS AND METHODS

The general methods were the same as those described earlier (Cram and Pearson, 1965). One half of the adults in each series was collected in the field, the rest were collected as mature larvae and allowed to transform to adults in the laboratory. Ten adults per treatment were observed for 13 weeks. The cultivars tested were the unacceptable Cabot and Weymouth, and the acceptable June and Stanley (Cram, 1970). All foliage was collected from the Makara farm.

The temperature regimes were selected to approximate a cold, a cool or a hot summer. The regimes were attained by setting the electronic programmer on three bench-top growth cabinets (Sherer-Gillett, Marshall, Mich., U.S.A.) to hourly settings which produced acceptable temperature curves with daily temperatures of 7 to 15, mean 10; 12 to 19, mean 15; and 16 to 29, mean 22°C. The photoperiod was kept at 16 hours. From six randomly selected survivors per cultivar per regime, data were collected on weight change in three weeks, preoviposition period, number ovipositing and numbers of total and viable eggs after eight weeks from the first egg.

These data were analyzed by computer and the egg data were found to be highly heterogeneous often with significant interaction between regimes and cultivars, thereby invalidating the very highly significant differences between the three regimes and between the two sets of cultivars. For this reason, significant differences are not given in Table 1, but examination of the means indicates the trends.

[1] Contribution No. 184, Research Station, Canada Agriculture, 6660 N.W. Marine Drive, Vancouver 8, British Columbia.