Phenology of the strawberry blossom weevil and damage in strawberries

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Abstract

The strawberry blossom weevil, Anthonomus rubi *Herbst (Col., Curculionidae) is a key pest in strawberries. Depending on the strawberry cultivar and the temperature profile in spring, it can reduce yield up to 60 %. The primary damage is caused by the females of the overwintering generation, cutting the petiole of the flower buds after oviposition into them. These buds usually wither after a short period of time and are eventually dropped off. Hatched larvae feed for ca. 3 weeks on the buds until pupation inside the buds. Emerging adults leave the buds and feed on the petals of abundant strawberry flowers without causing further damage and migrate to their hibernation sites. Thus,* A. rubi *is an univoltine species directly reducing strawberry yield and necessary to control. However, little is known about the phenology and damage caused by* A. rubi *to different strawberry cultivars and plant age. Since the hibernation sites are not clearly identified yet, soil and litter samples were taken from the survey areas and the nearby forests in a time series at different distances from the field border to assess the phenology and abundance in the field. Furthermore, intact and damaged flower buds, flowers in different developmental stages (BBCH-stages), and fruits were collected to determine damage level. The results showed that the infestation in plants was highest near the field borders adjacent to forests, and decreasing in intensity with increasing distance to the forests. Damage was higher in older than in younger plantations. Between cultivars, the early flowering cv. "Daroyal" showed a higher loss of flowers than the later flowering and ripening cv. "Salsa" or "Malwina". From our results, we recommend to start infestation monitoring particularly on fields near to forests and on early flowering cultivars. Rich flowering cultivars, such as cv. "Salsa" can possibly compensate yield loss.*

Introduction

The major host plant of the strawberry blossom weevil (*Anthonomos rubi* Herbst 1795) is the strawberry (*Fragaria* sp.), but it also feeds and reproduces on raspberries (*Rubus idaeus* L.) (Araújo *et al.*, 2005) and, rarely, on blackberries (Höhn *et al.,* 1989).

The overwintering adults emerge in strawberry fields in spring, at sunny weather and soil temperatures of *ca.* 10-14 °C, and start to feed ("Naschfraß") on leaves and later on blossoms without causing damage. After mating, the primary damage is caused by the females of the overwintering generation, cutting the bud petiole after oviposition into blossom buds. These buds usually wither after a short period of time and are eventually dropped off. The duration of the oviposition period is about 1-2 months, starting usually in May (at ≥18 °C), and on average 20-30 blossom buds are destroyed per female. However, also a mean fecunditiy of 157.6 eggs have been reported (Höhn *et al*., 1989; Easterbrook *et al.*, 2003; Aasen *et al*., 2004).Percentage of bud damage may vary between 5-90 %, in total resulting in a yield reduction of *ca.* 60 % or even more (Svensson, 2002; Kovanci *et al.*, 2005).

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After about 5-10 days, the larvae hatch from the eggs and, protected inside the buds, feed on the withering parts of the blossom (Höhn *et al.*, 1989). After a 14-20 days larval development they finally pupate inside the buds. Emerging adults leave the buds and feed on the petals of abundant open strawberry blossoms without causing further damage (Höhn *et al.*, 1989).

Adults of the new generation appear in June and migrate to the hibernation sites in late July. Thus, *A. rubi* is an univoltine species (Kovanci *et al.*, 2005). Depending on the temperature, a complete life cycle from egg to adult emergence takes up to five weeks (Aasen *et al.*, 2004). An economical threshold has not been defined yet, because damage level depends on strawberry cultivar and the number of blossoms at a given time (Höhn *et al.*, 1989).

However, little is known about the phenology and damage caused by *A. rubi* to different strawberry cultivars and plant age.Thus, neither reliable infestation-yield loss relations nor effective control methods are available in organic strawberry production. Since hibernation sites are not clearly identified yet, the phenology of the pest is not known (Aasen *et al.*, 2004), this study addressed these open questions.

Material and Methods

This study was conducted in Baden-Württemberg on four survey areas in two different locations with a total of three different varieties of strawberries ("Daroyal", "Salsa", "Malwina") of different age. All surveys were conducted on farms with "Bioland"-certification (Table 1).

The areas in Eberdingen were located in close proximity eastward to a forest of deciduous trees and wild blackberries. South of the strawberry field a raspberry plantation was cultivated. In Rohrbronn, orchards and cereal fields were located around the area. In addition, a forest, ca. 500 meters away.

Table 1: Characteristics of the survey areas

Location	Field size (a)	n Strawberry rows	Cultivars	Age (years)
Eberdingen	45	32	Salsa, Daroyal	2
	40	32	Salsa	1
	38	24	Malwina	3
Remshalden – Rohrbronn	11	14	Malwina	2

Soil and litter samples were taken from the survey areas in a time series from April 8 till May 6 2013 at different distances from the field border (at 15-24 survey points, depending on the size of the area), and the nearby forests. After beginning adult flight, intact and damaged flower buds, flower developmental stages (BBCH-stages), and fruits were assessed weekly on 15-20 plants at three distances from the field border respectively (Table 2). Fruits were distinguished into quality class 1, 2 and fruit loss.

Table 2: Monitoring grid in the strawberry fields

Location	Cultivar / age	Rows monitored / total n rows / field	Distance from field border (m)		
Eberdingen	Salsa, 2 yrs. Daroyal, 2 yrs.	4, 11, 18, 25 / 32	0,5	60	120
	Salsa, 1 yr.	4, 11, 18, 25 / 32	0,5	60	120
	Malwina, 3 yrs.	12, 15, 18 / 24	20	100	180
R.- Rohrbronn	Malwina, 2 yrs.	5, 8, 11 / 14	10	50	90

Results and Discussion

Soil and litter samples

Neither in the soil and litter samples from the survey areas nor from the nearby forest overwintering adults were found, except few specimens in uprooted plants. This may indicate that *A. rubi* does not overwinter in the soil or in the litter, rather elsewhere in the field far from the field in adjacent field structures. Also, grubbing litter or straw of the previous year early in the monitoring period also speaks against hibernation in litter or soil. Adults emerge in strawberry fields at sunny weather and soil temperatures of ca. 10-14 °C. At ≥18 °C the first females begin to oviposit and the first damages could be observed already when the flower buds were visible (BBCH 55).

Loss assessment

Percent damage (cut or dropped buds) increased with time in all cultivars and both locations and was dependent from cultivar, age and location. In general, percent damage was higher in Eberdingen than in Rohrbronn, increasing with rising temperature and increasing number of blossom buds.

A slightly higher damage level could be observed in 2-year old than in 1-year old “Salsa” plants (39.9 and 33.5 % respectively). Also 3-year old “Malwina” in Eberdingen suffered from a higher damage than the 2-year old “Malwina” in Rohrbronn. However, in this case the location may have affected this parameter also. These observations support the results reported by Aasen *et al*. (2004) who found the population density doubled within two years, possibly after establishing an initial population after immigration into the young strawberry fields.

Damage decreased with distance of the plants to the field border in all cultivars, particularly when bordering to forests. This correlation was superior in 2-year old than in 1-year old plantations. In a 3-year old field of cv. “Malwina”, the damage was almost independent from distance to the field border (Table 4). Since this decrease of damage intensity could be observed already in the beginning of the monitoring period and for the entire fields, it maybe assumed that the weevils immigrated from the forest or border structures into the fields.

Comparing damage levels between cultivars, “Daroyal” suffered from a significantly higher damage compared with “Salsa” (51.26 and 39.91 % respectively, t-test: $p < 0.0024$). This may be explained by the different maturity groups of the two cultivars, as “Daroyal” is ripening earlier than “Salsa” and more buds are available at an earlier time. However, it was not possible to assess the overall damage over the full harvesting period; a long-term damage assessment would provide better information. Particularly flowering phenology, fruit sizes depending from flowering date, cultivar-specific yield level, and market price could be considered then.

Table 3: Mean percent fruit damage (± SE) of strawberry cultivars ("Daroyal" not shown) at various distances to the field borders (D) (oneway ANOVA, followed by Tukey-Kramer HSD –Test at α = 0,05; means with the same index letters do not differ significantlyat p ≤ 0,05)

„Salsa“			„Malwina“			
D (m)	**1 yr.**	**2 yrs.**	**D (m)**	**2 yrs.**	**D (m)**	**3 yrs.**
0,5	40,76 ± 3,75 a n = 20	55,62 ± 3,13 a n = 20	**10**	28,93 ± 3,81 a n = 15	**20**	36,04 ± 3,89 a n = 15
60	29,85 ± 3,85 a n = 19	34,43 ± 3,13 b n = 20	**50**	24,31 ± 3,81 ab n = 15	**100**	37,42 ± 3,89 a n = 15
120	29,27 ± 3,75 a n = 20	38,19 ± 3,13 b n = 20	**90**	11,25 ± 3,81 b n = 15	**180**	49,12 ± 3,89 a n = 15

However, the highest damage occurs at late-flowering short day varieties or day-neutral varieties, where blossom period coincides with the phenology of *A. rubi* (Höhn *et al*., 1993; Bell *et al*., 1997). Also, the susceptibility of a cultivar for *A. rubi* may from the plant structure. Heavily infested cultivars in a screening at Wädenswil in 1991/92 were characterized by flower buds with very long petioles, flowering in height of the foliage or above, which also given in "Daroyal" (Höhn *et al*., 1993).

Concerning fruit damage, *A. rubi* infestation of "Daroyal" resulted in the lowest percent marketable fruits, followed by "Malwina" and "Salsa" (22.0, 30.7 and 38.7 % respectively).

Conclusions and recommendations

Lacking measures for effective direct control of the strawberry weevil gives preventive measures a higher importance. Monitoring of weevil abundance is particularly recommended and necessary at the field margins near to potential hibernation sites, raspberry, blackberry, or existing strawberry fields. Strawberry fields near to forests should be avoided, or these fields should be planted with more robust, rich blossoming cultivars because these revealed to have a higher loss compensation capacity compared to cultivars with a poorer set of blossoms. Even a slight infestation may result in a better product quality by „natural thinning“.

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