Control of *Hoplocampa testudinea* using the extract from *Quassia amara* in organic apple growing

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Abstract


In 2008 and 2009 the effects of quassin and neoquassin (oxygenated triterpenes) on apple sawfly (*Hoplocampa testudinea* Klug, 1814) were studied. In the Czech Republic, monitoring was carried out in small-plot trials and in one laboratory experiment. The extract containing quassin and neoquassin was made by boiling wood chips of a tropical shrub *Quassia amara* L. (*Sapindales: Simaroubaceae*). The experimental dosages were 3, 4.5, 6, and 9.25 kg of wood chips/ha. Spray treatment with the quassia extract was carried out just before most larvae hatched out. It was statistically proven that the extract from the wood of *Q. amara* reduced the apple sawfly infestation of fruitlets. Extract in the dosage corresponding to 3-4.5 kg of quassia wood chips for 1/ha appeared as optimal. The efficacy of these dosages was approximately 40-50%, and the efficacy above 80% was recorded.

Keywords: apple orchard; organic farming; *Malus domestica*; pest control; apple sawfly

Apple sawfly (*Hoplocampa testudinea* Klug, 1814) (*Hymenoptera: Tenthredinidae*) overwinters as a prepupa within the cocoon in the soil (Alford 2007). It has one generation per year. Imagos hatch out during the blossom time of early and mid early apple tree varieties (Graf et al. 2001). This pest causes significant losses and damages on apple fruits in organic orchards in Europe (Kienzle et al. 2006a; Graf et al. 2002).

The possible method acceptable in organic growing is spraying on the basis of natural bitter compounds quassin and neoquassin (Wein et al. 1994; Zijl Blokkee 2002). These substances belong among oxygenated triterpenes and are contained in the wood of plants of the Simaroubaceae family (Goo et al. 2005). The source of quassin and neoquassin is a shrub *Quassia amara* L. (*Sapindales: Simaroubaceae*), its wood contains, depending on the age, 0.14-0.28% of quassinoids (quassin and neoquassin) (Villalobos et al. 1999).

In 2002–2003 a series of experiments with a standard solution containing quassin were performed in Germany. Dosages of pure quassin of 2, 3, 4, 6, and 9 g/ha/m tree height were tested. The efficacy in most cases was over 80%; 6 g of quassin/ha/m tree height being determined as the optimal dosage (Kienzle et al. 2006a). In Germany and Switzerland a commercial preparation with standardized quassin content supported by the Internal Grant Agency of the Faculty of Agriculture, Mendel University in Brno, Czech Republic, Project No. IG 290041/2183/224 and NAZV, Project No. QJ02179.
One replication included 4 trees in location 1, and 5 trees in location 2. Flight of apple sawfly adults was monitored using white sticky traps based on the method of Lukás and Kocurek (1998).

The level of apple sawfly infestation was high. Therefore in 2009 the experiments were carried out with natural level of infestation without any artificial infestation.

EXPERIMENT CONDUCTED IN 2009

In 2009 artificial infestation was performed. On April 17 the first apple sawflies were recorded on white sticky traps. On April 25 trapping of the adults was carried out. Captured flies were closed to monoflament isolators. One shoot at full blossom (April 25) on each tree was covered with the treatment was conducted the following day. The tested dosages of quassia wood were 3, 4.5, and 9.25 kg wood/ha in one application (May 7) and the dosage of 3 kg/ha which was applied twice, the second spraying was carried out after five days, it means on May 12. The control variant was only treated with water containing the wetting agent.

On May 16 the infestation on the marked shoots was evaluated. Within each replication, fruitlets with apple sawfly eggs were counted and then compared with a number of fruitlets infested by hatched apple sawfly larvae.

RESULTS

Year 2008 (small-plot trial)

In this season, heavy apple sawfly infestation was achieved by use of isolators. Infestation in the control variant was 56.7%. The efficacy of the one spray treatments of 3, 4.5, and 9.25 kg/ha was 55.03%, 58.02%, and 65.43%, respectively. Surprisingly, the variant with two spray treatments of 2 × 3 kg/ha was the least efficient (only 37.92%) (Table 1).

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The dosage affected the level of infestation statistically significantly (P < 0.01). All three dosages differed from the control statistically significantly and also the variant with two spray treatments differed statistically significantly from the variant with one treatment. No statistically signi-
**Table 1.** Infestation, efficacy, and statistical difference of the treatments in location 1 in 2008

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Infestation (%)</th>
<th>Efficacy (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quassia 3 kg</td>
<td>6.13</td>
<td>50.53</td>
<td>B</td>
</tr>
<tr>
<td>Quassia 4.5 kg</td>
<td>8.79</td>
<td>38.72</td>
<td>AB</td>
</tr>
<tr>
<td>Quassia 6 kg</td>
<td>7.42</td>
<td>39.86</td>
<td>AB</td>
</tr>
<tr>
<td>Quassia 3 kg - 2 x</td>
<td>5.70</td>
<td>39.19</td>
<td>AB</td>
</tr>
<tr>
<td>Quassia 4.5 kg - 2 x</td>
<td>7.75</td>
<td>41.22</td>
<td>AB</td>
</tr>
<tr>
<td>Control</td>
<td>13.33</td>
<td>-</td>
<td>A</td>
</tr>
</tbody>
</table>

Differences between the treatments were determined with the Tukey's test.

**Table 2.** Infestation, efficacy, and statistical difference of the treatments in location 2 in 2009

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Infestation (%)</th>
<th>Efficacy (%)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quassia 3 kg</td>
<td>2.00</td>
<td>82.61</td>
<td>BC</td>
</tr>
<tr>
<td>Quassia 4.5 kg</td>
<td>1.50</td>
<td>86.96</td>
<td>BC</td>
</tr>
<tr>
<td>Quassia 6 kg</td>
<td>0.75</td>
<td>93.48</td>
<td>BC</td>
</tr>
<tr>
<td>Quassia 3 kg - 2 x</td>
<td>1.25</td>
<td>89.13</td>
<td>BC</td>
</tr>
<tr>
<td>Quassia 4.5 kg - 2 x</td>
<td>0.25</td>
<td>97.83</td>
<td>C</td>
</tr>
<tr>
<td>NeemAzal T/S</td>
<td>2.25</td>
<td>80.45</td>
<td>B</td>
</tr>
<tr>
<td>NeemAzal 31 - 2 x</td>
<td>1.75</td>
<td>84.78</td>
<td>BC</td>
</tr>
<tr>
<td>Mospilan 20 SP</td>
<td>1.00</td>
<td>91.30</td>
<td>BC</td>
</tr>
<tr>
<td>Control</td>
<td>11.50</td>
<td>-</td>
<td>A</td>
</tr>
</tbody>
</table>

Differences between the treatments were determined with the Tukey's test.

**DISCUSSION**

The present results show that the extract prepared directly from wood chips of *Quassia amara* is statistically significantly efficient against apple sawfly larvae. In 2009, in location 2 this extract was statistically equally effective as the conventional synthetic insecticide Mospilan 20 SC (Table 3). The achieved efficacy results of the individual experiments show that the optimal dosage is 3-4.5 kg of *Quassia amara* wood chips/ha of an orchard. According to Villalobos et al. (1999) it corresponds to 4.2-8.4 g of quassinoids (3 kg/ha) and 6.3-12.6 g of quassinoids (4.5 kg/ha). Although releasing of quassinoids to water solutions was already confirmed by Röark (1947) we do not suppose that all the quassinoids contained in wood get into the extract. We can assume that the size of chips, i.e. size of the active surface, affects the extraction rate and quantity of the substance extracted into the solution. However, the results indicate that under the conditions of the method used by us, a sufficient amount of the effective substances was extracted into the water solution. The treatment with higher dosages of Quassia extract (6 kg/ha or 9.25 kg/ha) did not achieve statistically significantly higher efficacy. In 2009 in location 1 the most efficient dosage was 3 kg/ha. This result could be affected by considerably uneven infestation of the individual replications.

Kienzle et al. (2006a) recommended the optimal dosage of 6 g of pure quassin/ha. This dosage can be achieved with standardized commercial preparations containing quassin without any problems, however acquisition costs are high. In the case of simply prepared wood extract, not only quassin but also neoquassin get into the extract. Both these substances are effective to newly hatched larvae. In the laboratory trial, the efficacy of only 36.36% was achieved in the variant with one spray treatment of 3 or 4.5 kg/ha. In the small-plot trials, the efficacy achieved with these dosages was considerably higher. This difference could be caused by the absence of the wetting agent in the laboratory trial. Therefore, we assume that the wetting agent plays an important role in the case of the use of quassia wood extract. It was also confirmed by Kienzle et al. (2006b) who determined higher efficiency of quassin in case a wetting agent was added to the solution. Silwett L-77, the wetting agent used, is not permitted by the Czech law for organic agriculture. The possible wetting agents for organic agriculture are e.g. on the basis of plant oils and natural ten­_sides (State Phytopharmacological Institute 2010, Zebitz 2005). In addition, quassia wood extract can be used in integrated production where a wide spectrum of wetting agents (including Silwett L-77) can be applied. Volume of water is also significant. Kienzle et al. (2006b) determined that the efficacy increases with the volume of applied water and the optimal water volume appears to be 500 l/ha.

Based on the results achieved, it is possible to conclude that the use of the aqueous extract prepared from 3 or 4.5 kg quassia wood chips/ha reduced the apple sawfly infestation of apple fruitlets from 50-85%. Extract prepared from higher dosages of quassia wood chips or two consecutive sprays were not statistically significantly more efficient. Further research should focus on the evaluation of quassia extract application in practice; the experiment should be tested in the scale of several hectares.

**Reference**


Kienzle J., Zimmer J., Märsel P., Batten H., Bathon H., Zebitz C.P.W., 2006b. Control of the apple sawfly *Hop­
Effect of low oxygen storage conditions on volatile emissions and anaerobic metabolite concentrations in two plum fruit cultivars

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Abstract


By harvest time, small amounts of acetaldehyde were accumulated in the flesh of plums, such as 0.31 mg/l for the cv. Stanley and 1.03 mg/l for the cv. Valjevka. This relative difference in concentrations remained constant throughout the whole period of storage in a regular atmosphere. The long-term effects of higher concentrations of CO2 are the same as for very low oxygen concentrations; and significant amounts of ethanol accumulate in the tissue. Out of a total number of 42 different odour compounds identified in the juice, there were 11 alcohols, 6 aldehydes, 17 esters, 2 terpenes, 3 organic acids, and 1 lactone. Very low oxygen atmospheres slow down the production of esters and aldehydes, but have little effect on the production of lactones and terpenes. It was shown that a very low oxygen concentration, without much CO2 (Fluctuating anaerobiosis treatment), does not encourage the production of significant amounts of ethanol and acetaldehyde in the fruit flesh, but does significantly slow the biosynthesis of aromatic volatiles.

Keywords: plum fruit; volatiles; ethanol; acetaldehyde; firmness; headspace gas analysis

The quality of plum fruit following harvest is essentially influenced by the temperature and composition of the ambient atmosphere. The storage period is limited by fruit softening, visible signs of wilting and a physiological disease manifested as an internal browning adjacent to the stone (TAYLOR et al. 1993; GOLIÁŠ 2004; TOYANOVA, BRANNMULL: 2008). Knowing the lower oxygen limit for effective aerobic metabolism is critical for managing the composition of the gaseous atmosphere (GRAN, BEAUDRY 1993; BEAUDRY 1999; MÜNCH et al. 2006). A gas atmosphere where the ethanol concentration does not increase over time is considered to be optimal for long-term storage (SMAGULA, BRAMLAGE 1977; NICHOLS, PATTERSON 1987; PETH 2005). If oxygen levels drop below a certain critical point for the aerobic conversion of storage substrates, then pyruvate is converted into acetaldehyde and ethanol with adverse affects on fruit quality. Fermentation processes which proceed as a consequence of fruit ripening, even without low oxygen levels in the ambient atmosphere, also result in the accumulation of ethanol and consequently the production of ethyl esters in concentrations which may cause off-flavours. Specifically, an unpleasant odour and taste results from the production of ethyl acetate, ethyl butanoate, ethyl 2-methylbutanoate, ethanol, and acetaldehyde (LARA et al. 2007), whereas there