Quassia, an Effective Aphid Control Agent for Organic Hop Growing

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Abstract

In the first three decades of the 20th century, quassia extract was widely used in hop growing as a chemical agent to control Phorodon humuli *and other insect pests. In the first years of the 21st century this compound was rediscovered by German organic hop growers. In several efficacy trials conducted during five field seasons, quassia products proved to be effective control agents for* P. humuli *in organically grown aroma cultivars. A systemic variant developed by painting a suspension of quassia extract to the bines was the best method of application. This method proved not only to be very effective, but was also best from an environmental point of view. The optimal systemic application rate was determined as 24 g/ha of the active ingredient quassin. In order to generate the data necessary for registration of quassin in Annex I of the EU Council Directive 91/414/EEC, further efficacy trials were conducted during 2007. The results emphasize the importance of this compound as currently the only suitable aphid control agent in organic hop growing, especially when applied systemically.*

Introduction

In organic hop growing, the control of diseases and pests is a crucial problem. The most prevalent pests are damson-hop aphid *Phorodon humuli* (Schrank) and two-spotted spider mite *Tetranychus urticae* Koch. Without control measures, both are able to damage the quantity and quality of harvested cones, and in some years they may completely destroy a crop (Neve 1991). The earliest materials used to control *P. humuli* by spraying were nicotine, soft soap and quassia (*e.g.* Theobald 1909). The latter two compounds are still listed today as approved substances for pest control in German organic farming (*e.g.* Bioland 2007). According to these guidelines today's quassia products have to originate exclusively from the wood of the South American tree species, *Quassia amara*, with quassin as active ingredient (a.i.). At the beginning of the 21st century, aphid control by the pyrethrins registered for organic farming proved unsatisfactory, and German organic farmers rediscovered that spraying of quassia solutions, extracted by homebrews from *Q. amara* wood chips was an alternative. This option for aphid control was accompanied with efficacy trials from the first day onwards (Engelhard & Weihrauch 2005), and was advanced in the following five years (Engelhard *et al*. 2007). The best method of application was a systemic variant, developed by painting a suspension of quassia extract to the bines. This was not only very effective, but was also best from an environmental point of view, because sprayed quassia extracts from homebrews had side effects on non-target organisms such as leafhoppers (Cicadellidae) (Engelhard & Weihrauch 2005). The optimal systemic application rate was determined to be 24 g/ha quassin.

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Therefore, previous results show that organic growers in Germany are dependent currently on quassia products in order to ensure satisfactory control of *P. humuli*. No other effective compounds or control strategies are registered for organic farming in Germany. At the moment no industrial quassia product is registered for aphid control in the EU, and the current modus operandi of organic growers, *i.e*. the use of homemade quassia brews, occupies a legal grey area. Hence, in order to make this compound available within the EU, it is most important to register quassin as an active ingredient for the control of aphids in Annex I of the EU Council Directive 91/414/EEC. The first and most important step towards registration is to generate sufficient data so further efficacy trials were performed with a new industrial quassia extract and these are presented below.

Materials and methods

The study was conducted during 2007 in the Hallertau, Bavaria, Germany. The Hallertau is the world's largest coherent hop-growing region, with almost 30 % of the world's area of this crop. It is situated south of the River Danube in central Bavaria and has an area totalling 1,500 km². Three hop gardens of three farms were chosen as study sites: Haushausen (cv. Hallertauer Tradition), Eichelberg (cv. Perle), and Schweinbach (cv. Hallertauer Magnum). As the experimental procedures and results from all three sites were similar, only Haushausen – the site with the highest aphid infestation level during 2007 - is presented below as that site was representative for all three. Plots of 84 hop plants (six rows with 14 plants each; *c*. 300 m^2) were laid out in three replications, respectively, for the following applications of quassin: 12 g/ha sprayed; 18 g/ha sprayed; 18 g/ha applied systemically; 24 g/ha applied systemically; and untreated control. The experimental dry quassia extract (0.6 % a.i.) was provided by Trifolio-M GmbH, Lahnau, Germany. The date of the single systemic application, a manual painting of quassin in an oily suspension to the bines, was 31 May, when the hop plants were in full extension growth. Quassin was sprayed twice at the above rates a.i., on 14 June, when the aphid migration was finished completely, and on 13 July, when it became obvious that the first spraying was not sufficient. Aphid population development was monitored weekly on 50 leaves sampled from each plot, respectively, for 14 weeks from late May to late August. These counts were compared by repeated measures ANOVA followed by a Bonferroni post hoc test. An experimental harvest was conducted on 29 August, which assessed yield and alpha acids (measuring unit for hop quality) from 10 bines per application in four replications taken from two experimental plots, respectively, and was compared to the grower's own treatment, which included three sprayings of quassia homebrew ('practice' in Fig. 1). Harvest data was compared by ANOVA followed by a Bonferroni post hoc test.

Results

All treatments significantly reduced the aphid population density on the plants throughout the field season (df = 4, F = 2580.402, $P<0.001$). Among all treaments, the 24 g/ha systemic treatment gave significantly the best control of aphid population development ($P<0.001$). The 18 g/ha systemic treatment had significantly fewer aphids than the two sprayed treatments ($P<0.001$), between which there were no significant differences. Compared to the untreated control, on 24 June – the day with the highest recorded aphid numbers - the 12 g/ha spray application reduced aphid numbers by 69.5 % and the 24 g/ha systemic variant by 87.6 %. Table 1 shows the progress of aphid population development in the different plots at that site which, as noted above, had the highest general infestation level during 2007.

Tab. 1: The influence of various quassia applications on the aphid population development in an organic hop garden. Haushausen, Hallertau, 2007, cv. HT. Mean numbers of aphids leaf $^{-1}$ ± s.e. of 50 assessed leaves (n = 3 replications each). Systemic application 31 v 2007, spray applications (full amount) 14 vi and 13 vii 2007.

date / treatment	control untreated	[12 g/ha] sprayed	[18 g/ha] sprayed	[18 g/ha] systemic	[24 g/ha] systemic
30 v	8 ± 5	6 ± 3	8 ± 1	6 ± 1	5 ± 1
06 vi	25 ± 3	23 ± 2	25 ± 4	17 ± 5	13 ± 4
12 vi	70 ± 16	62 ± 16	79 ± 27	20 ± 5	13 ± 2
18 vi	124 ± 7	63 ± 11	88 ± 4	31 ± 8	12 ± 3
25 vi	545 ± 37	228 ± 47	285 ± 37	25 ± 13	12 ± 7
03 vii	415 ± 20	239 ± 28	316 ± 52	44 ± 25	22 ± 15
09 vii	722 ± 145	315 ± 83	337 ± 150	43 ± 23	16 ± 4
17 vii	662 ± 168	170 ± 35	122 ± 13	131 ± 127	39 ± 21
24 vii	1229 ± 280	375 ± 214	305 ±180	343 ± 271	153 ± 97
30 vii	1138 ± 170	288 ± 81	240 ± 180	228 ± 216	64 ± 40
07 viii	325 ± 109	82 ± 33	70 ± 44	75 ± 51	28 ± 12
14 viii	43 ± 11	47 ± 19	34 ± 17	10 ± 4	14 ± 4
20 viii	8 ± 3	8 ± 2	9 ± 1	6 ± 3	7 ± 1

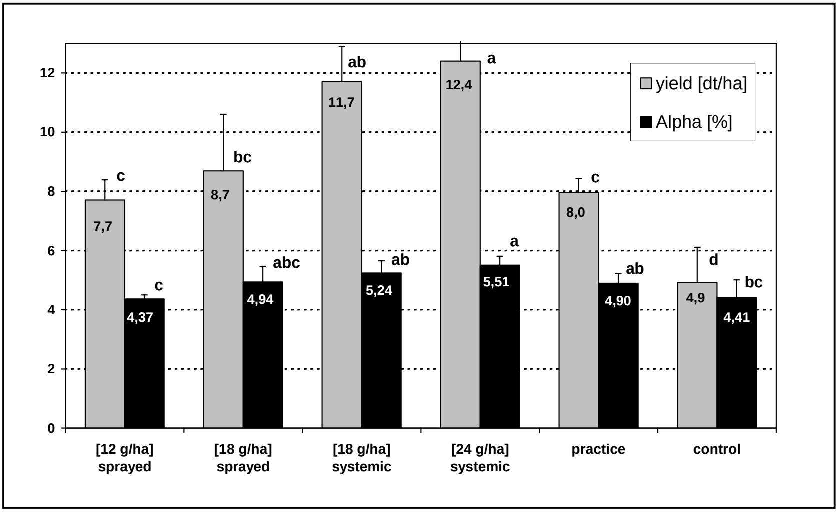

Figure 1: The influence of various quassin applications on hop yield and alpha acids in an organic hop garden. Haushausen, Hallertau, 29 viii 2007, cv. HT

Bars with the same letters are not significantly different by ANOVA, at P<0.05.

The aphid infestation records were mirrored by the results from the experimental harvest. The systemic treatments were significantly the best, and the control plot was significantly lower in yield than any quassin treatment (Fig. 1).

Discussion and Conclusions

The results achieved during the 2007 quassia efficacy trials confirm the conclusions of Engelhard *et al*. (2007). The 24 g/ha quassin systemic treatment proved to be the best and most reliable treatment. Although we tried to reduce the amount of a.i. to 18 g/ha, as a consideration to the costs of this compound, the higher quassin application rate was needed to ensure satisfactory aphid control. As we detected some heterogeneity in the aphid infestation of single plants in the systemic plots, especially in the 18 g/ha treatment, we think that probably those plants with increased infestation did not receive sufficient a.i. during the application. The amount of a.i. painted to each bine is intended to be only 4.5 mg in the 18 g/ha variant, and if the oily suspension prepared for the application is not absolutely homogeneous, some bines will get more and some probably too little quassin. This problem seems to occur less frequently with the higher dosage, which additionally may help to postpone the probable development of aphid resistance to this compound.

The spray applications were generally less effective than bine painting and led to only an approximate reduction of 70 % of aphids. This efficiency, however, may be unsatisfactory when the general infestation level is very high, as was the case at Haushausen during 2007. Furthermore, the painting of bines in the systemic application is not dependent on the calm weather conditions required for spraying, and a tractor with power sprayer is not needed, which will lead to less soil compaction in the fields. In conclusion, the systemic application of 24 g/ha quassin has to be regarded currently as the method of choice for aphid control in organic hop growing.

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References

Bioland (2007): Bioland-Richtlinien. Pflanzenbau, Tierhaltung, Verarbeitung. Stand 23. April 2007. Bioland e.V. Verband für organisch-biologischen Landbau, Mainz, http://www.bioland.de/fileadmin/bioland/file/bioland/qualitaet%20+%20richtlinien/erzeuger-richtlinien.pdf, (accessed 2007-10-05).

Engelhard, B., Weihrauch, F. (2005): Prüfung produktionstechnischer Maßnahmen für den Ökologischen Hopfenbau. Abschlussberischt des Forschungsprojektes, gefördert vom Bayerischen Staatsministerium für Landwirtschaft und Forsten, http://www.lfl.bayern.de/ipz/hopfen/23409/endbericht.pdf, (accessed 2007-10-05).

Engelhard B., Bogenrieder A., Eckert M., Weihrauch F. (2007): Entwicklung von Pflanzenschutzstrategien im ökologischen Hopfenbau als Alternativen zur Anwendung kupfer- und schwefelhaltiger Pflanzenschutzmittel. Schriftenr. Bayer. Landesanstalt Landwirtsch. 9/2007:1-49.

Neve R. A. (1991): Hops. Chapman & Hall, London, 266 pp.

Theobald F. V. (1909): The insect and allied pests of the hop (Continued). J. Board Agric. 16:617-628.