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Reviewed paper

Injector nozzles in organic apple growing - trials at the Laimburg Research Centre

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Abstract

Drift on non-target areas is a serious problem in crop protection. To deal with this problem, the legislator in South Tyrol requires the use of drift-reducing injector nozzles at all nozzle positions of the sprayers. Before the introduction of these nozzles, practitioners were concerned that the effectiveness of the preparations used in organic farming could be impaired by a coarser application technique. To investigate this, a series of trials on the regulation of apple scab, powdery mildew, codling moth and thinning were carried out at VZ Laimburg from 2014 to 2020. About the effectiveness of the preparations applied by means of injector nozzles, no significant differences could be found in these trials compared to the previous application by means of hollow cone nozzles.

Introduction

In 2020, after a transitional phase, the legal requirement came into force in South Tyrol that all sprayers must be equipped with drift-reducing injector nozzles at all nozzle positions to prevent or reduce drift onto non-target areas (Provincial Law of the Autonomous Province of Bolzano, 2021). This mandatory introduction has caused several concerns and fears among South Tyrolean organic fruit producers. To check whether the prevailing skepticism among practitioners is justified, a series of trials on the subject have been carried out by the Working Group Organic Farming of RC Laimburg since 2014. Trials were conducted on the regulation of scab (*Venturia inaequalis*), powdery mildew (*Podosphaera leucotricha*) and codling moth (*Cydia pomonella*). In addition, it was investigated whether differences in effectiveness occur due to the different types of nozzles used for flower thinning by means of lime Sulphur or fruit thinning with oils.

Material and methods

All tests were carried out with a towed sprayer from Waibl. This is an experimental sprayer with 4 separate tanks and circuits. The device has an axial fan with cross-flow attachment, a total height of 2.20 m and a total of 16 nozzle positions. The water input in all trials was 500l per m of foliage wall. All trials were carried out in yield facilities at the experimental center Laimburg, (222m above sea level, GPS coordinates: 46.38268, 11.28774). All trials were carried out in local apple orchards with planting system single row, rootstock M 9, training form spindle, and planting distances of 3.0m x 0.8m to 3.0m x 1.0m, whereby the height of the trees was approx. 3.5 - 4.0m, depending on the trial site. Scab regulation trials were evaluated in 2014, 2018, and 2019 at RC Laimburg. In 2014 and 2018, the scab trials were carried out on the variety Golden Delicious, in 2018 on the variety Fuji. The powdery mildew regulation trials were conducted in 2018 and 2019 on the variety Jonathan. The trials on the topic thinning, were carried out in 2018 and 2019 on the variety Braeburn, those on codling moth control in 2018 on the variety Granny Smith.

Apple scab

In 2014, 9 targeted treatments were carried out in 3-fold concentration with 4.5 kg/hl of lime Sulphur. Further trial plots were treated 8 times in 3-fold concentration with 0.3 kg/hl copper sulphate as a preventive measure. The effect of hollow cone nozzles type Albuz ATR brown

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and injector nozzles Lechler orange, which were attached to all nozzle positions of the sprayer, were compared. The hollow cone nozzles were used with 10 bar pressure, the injector nozzles with 9 bar, the driving speed was 3.8 km/h in each case.
After the end of the primary season, leaf, and fruit infestation as well as fruit infestation intensity were evaluated.
In the scab trial 2018, 4 targeted treatments in 3-fold concentration with 3.6 kg/hl of lime Sulphur were carried out. Furthermore, 9 preventive treatments in 3-fold concentration with 0.15 kg/hl copper sulphate were carried out in other trial plots. The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the travel speed was 3.8 km/h in each case. In this trial, the russeting of the fruits was evaluated.
In the 2019 scab trial, 13 treatments in 3-fold concentration with 0.15 kg/hl copper sulphate were carried out. The effect of hollow cone nozzles type ATI yellow and injector nozzles type CVI yellow, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the driving speed was 7 km/h in each case. In addition, another variant with 5-fold concentration with 0.25 kg/hl copper sulphate was included in the trial, in which the nozzle type CVI orange, with 12 bar pressure and the same driving speed was used. After the end of the primary season, leaf, and fruit infestation as well as the infestation intensity of the fruits were evaluated.

Powdery mildew

In the powdery mildew trial 2018, 8 preventive treatments in 3-fold concentration with 0.6 kg/hl Sulphur were carried out. The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the driving speed was 3.5 km/h in each case. The leaf infestation and the infestation intensity of the russetted fruits were evaluated.
In 2019, 7 preventive treatments in 3-fold concentration with 0.6 kg/hl Sulphur were carried out. The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the driving speed was 3.5 km/h in each case. The leaf infestation and the infestation intensity of the proportion of russet fruit were evaluated.

Thinning

In 2018, 2 treatments were carried out in 3-fold concentration with 4.5 l/hl paraffin oil to promote June fruit fall. The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the driving speed was 3.5 km/h in each case. The thinning effect and the re-blooming in the following year were evaluated.
In 2020, 2 treatments in 3-fold concentration with 6 kg/hl lime Sulphur were carried out as flower thinning. The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the travel speed was 3.5 km/h in each case. The thinning effect was evaluated separately in the upper and lower part of the tree.

Codling Moth

In 2018, a trial was set up to regulate codling moth. For the trial, 16 treatments were carried out in 3-fold concentration with 21 ml/hl granulose virus (Madex Top). The effect of hollow cone nozzles type ATI orange and injector nozzles type CVI orange, which were placed at all nozzle positions of the sprayer, were compared. All nozzles were used with 8 bar pressure, the driving speed was 3.5 km/h in each case.

Statistics

The analyzed data were compared using 1-way ANOVA and SNK test (P<0.05) for post-hoc comparisons. All analyses were conducted using IBM SPSS Statistics 27 software.

Results

Apple scab

Trials on scab control were carried out at the RC Laimburg in 2014, 2018 and 2019.
In 2014, after the primary scab season, the leaf and fruit infestation as well as the infestation intensity of the fruit infestation were determined:

Table 1: Results of the scab trial 2014

Treatment	Product	Strategy	% affected leafs	Sig.	% affected fruits	Sig.	% infestation intensity fruits	Sig.
Hollow cone nozzle (3x)	Lime sulfur	targeted	4.7	a	4.3	a	33.9	b
Injector nozzle (3x)	Lime sulfur	targeted	4.2	a	6.9	a	28.6	b
Hollow cone nozzle (3x)	Copper sulfate	preventive	19.1	a	0.6	a	32.4	b
Injector nozzle (3x)	Copper sulfate	preventive	5.5	a	5.6	a	31.7	b
Untreated	-	-	46.0	b	42.5	b	22.3	a

In none of the evaluations carried out was a significant difference found between the nozzle variants, only the untreated control showed significant differences.
In the 2018 trial, the proportion of fruits showing fruit russeting of > 20%.

Table 2: Results of the scab trial 2018

Treatment	Product	Strategy	% russet fruit surface > 20%	Sig.
Hollow cone nozzle	Lime sulfur	targeted	60,7	a
Injector nozzle	Lime sulfur	targeted	54,6	a
Hollow cone nozzle	Copper sulfate	preventive	45,7	a
Injector nozzle	Copper sulfate	preventive	33,3	a
Untreated	-	-	53,7	a

No significant difference between the nozzle variants and the untreated control could be found in any of the evaluations carried out.
In 2019, after the primary scab season, the leaf and fruit infestation as well as the infestation intensity of the fruit infestation were surveyed.

Tab 3: Results of the scab trial 2019

Treatment	Product	Strategy	% affected leafs	Sig.	% affected fruits	Sig.	% infestation intensity fruits	Sig.
Hollow cone nozzle (3x)	Copper sulfate	preventive	0.4	a	0.0	a	0.0	a
Injector nozzle (3x)	Copper sulfate	preventive	0.4	a	0.8	a	0.0	a
Injector nozzle (5x)	Copper sulfate	preventive	2.8	a	5.0	a	0.1	a
Untreated	-	-	61.2	b	88.3	b	2.1	b

Also, in this trial regarding the regulation of apple scab, the only variant that differed was the untreated control.

Powdery mildew

About Powdery mildew control, practical trials were carried out at RC Laimburg in 2018 and 2019.
The powdery mildew trial carried out in 2018 surveyed leaf infestation and the severity of russeting occurring on the fruit.

Tab. 4: Results of the powdery mildew trial 2018

Treatment	Product	Strategy	% affected leafs	Sig.	% infestation intensity russet fruits	Sig.
Hollow cone nozzle	sulfur	preventive	4.3	a	8.70	a
Injector nozzle	sulfur	preventive	3.8	a	9.20	a
Untreated	-	-	11.6	a	8.43	a

In the evaluations of infested leaves in July and fruit russeting in September, no significant difference could be found between the trial variants.
In the powdery mildew trial 2019, leaf infestation and fruit russeting were evaluated.

Tab. 5: Results of the powdery mildew trial 2019

Treatment	Product	Strategy	% affected leafs	Sig.	% infestation intensity russet fruits	Sig.
Hollow cone nozzle	sulfur	preventive	0.4	a	16.0	a
Injector nozzle	sulfur	preventive	0.1	a	16.7	a
Untreated	-	-	1.2	a	16.6	a

As in the previous year, no significant differences could be found between the trial variants in the evaluations of infested leaves in July and fruit russeting in September.

Thinning

In 2018 and 2020, trials on fruit thinning with paraffin oil and lime Sulphur, respectively, were carried out at RC Laimburg and it was investigated whether differences in thinning effect and re-blooming in the following year occur due to the different nozzle technology.

2018

Tab 6: Results of the thinning trial 2018

Treatment	Product	% thinning effect	Sig.	% rebloom	Sig.
Hollow cone nozzle	paraffin oil	57.4	b	14.3	a
Injector nozzle	paraffin oil	64.3	b	14.3	a
Untreated	-	0.0	a	7.9	a

In the trial, only the untreated control differed significantly regarding the thinning effect as the only trial variant, no significant difference could be found for flowering in the following year.

2020

Tab 7: Results of the 2020 thinning trial by position

Treatment	Product	% thinning effect upper part	Sig.	% thinning effect lower part	Sig.
Hollow cone nozzle	Lime sulfur	3.1	a	-4.5	a
Injector nozzle	Lime sulfur	17.1	a	8.9	a
Untreated	-	0.0	a	0.0	a

When evaluating different tree parts, no significant difference in the thinning effect could be found.

Tab 8: Results of the thinning trial 2020 total

Treatment	Product	% thinning effect total	Sig.
Hollow cone nozzle	Lime sulfur	-1.5	a
Injector nozzle	Lime sulfur	12.1	a
Untreated	-	0.0	a

Codling Moth

In 2018, trials were carried out to regulate codling moth. In this trial, too, it was evaluated whether differences exist between the nozzle variants.

Tab 9: Results codling moth trial 2018

Treatment	Product	Strategy	% live larvae	Sig.	% infestation total	Sig.
Hollow cone nozzle	Granulosev.	preventive	11.0	a	53.3	a
Injector nozzle	Granulosev.	preventive	12.6	a	44.5	a
Untreated	-	-	5.3	a	47.0	a

Neither in an evaluation regarding surviving larvae nor in the evaluation of the total infestation could significantly differences between the treatment variants be found.

Discussion

When looking at the trial results, it is noticeable that there are hardly any differences in the effect of the preparations applied with different nozzles. This is largely in line with the results published by colleagues from the IP production (Rizzoli et al.2013). Despite a larger droplet spectrum and poorer coating formation, successful regulation of the harmful organisms was possible. Of course, this only applies if the application technique (height, air flow) is optimally adapted to the plants to be treated. It should be noted, however, that the effect of injector nozzles reaches its limits in special cases such as bedding systems. Another point to consider is the fact that injector nozzles can be more easily affected by blockages due to their design. Since many preparations used in organic farming tend to flocculate or form encrustations in or on the sprayers, these pose a non-negligible risk to successful crop protection, which must be countered with attention and appropriate countermeasures.

References

Landesgesetz der Autonomen Provinz Bozen - Südtirol vom 15. April 2016, Nr. 8, kundgemacht im Beiblatt Nr. 4 zum Amtsblatt der Autonomen Region Trentino-Südtirol vom 19. April 2016, Nr. 16; vgl. Beschluss der Landesregierung der Autonomen Provinz Bozen - Südtirol vom 03. März 2020, Nr. 141, veröffentlicht im Amtsblatt der Autonomen Region Trentino-Südtirol vom 12.03.2020, Nr. 11, abgeändert durch Beschluss der Landesregierung der Autonomen Provinz Bozen - Südtirol vom 19. Jänner 2021, Nr. 29, veröffentlicht im Amtsblatt der Autonomen Region Trentino-Südtirol vom 28.01.2021, Nr. 4.

Rizzolli W., Acler A. (2013). Grobtropfige Applikation mit Injektordüsen (ID). Langjährige Versuche zur Wirksamkeit und Pflanzenverträglichkeit (Teil 1). Obstbau*Weinbau 50 (6), 192–197

Rizzolli W., Acler A. (2013). Grobtropfige Applikation mit Injektordüsen (ID). Langjährige Versuche zur Wirksamkeit und Pflanzenverträglichkeit (Teil 2). Obstbau*Weinbau 50 (7/8), 232–236

Rizzolli W., Acler A. (2013). Grobtropfige Applikation mit Injektordüsen (ID). Langjährige Versuche zur Wirksamkeit und Pflanzenverträglichkeit (Teil 3). Obstbau*Weinbau 50 (9), 271–273