Evaluation of Chemical Control of *Botrytis Cinerea* in Relation to Covering Red Current Shrubs

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Summary

Covering red currant during the development of the fruits guarantees high quality fruits and delays picking time. Because of these reasons the number of fruit growers using cover production system is increasing. Covering red currant affects fungicide action and efficacy. Furthermore the climate conditions are altered in the shrub resulting in a different infection risk/pressure for certain fungal diseases. The effect of the timing of covering on the control of *Botrytis cinerea* which is the cause of the mayor fruit rot disease of red currants was studied. The results from the trials clearly show the positive effect of covering during bloom on the chemical control of *Botrytis* on red currant. The chemical control of plants during bloom which were covered from bloom equals that of a full season chemical control of uncovered plants or plants covered after fruit set. The full season chemical control of plants covered from bloom was only statistically better then all other objects tested in one of the two trials. Covering alone without chemical control had only a limited effect.

Key words

Rubus sp., *Botrytis*, fungicide, sustainable fruit production

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Received: April 21, 2006 | Accepted: July 2, 2006

ACKNOWLEDGEMENTS
Research was subsidized by the Ministry of the Flemish Community

Introduction

At this moment 70% of the Belgian fruit growers growing red currants cover their shrub. When looking at timing of covering two different systems are being used by the fruit growers: permanent cover and covering from fruit set until harvest. The reason why some do not cover the shrub during flowering has to do with the pollination of the red currant. Red currant can be pollinated in two ways, namely by wind pollination or by insect pollination. By covering the shrub, the wind movement will be reduced and concordantly also the wind pollination. For this reason permanent cover is often placed higher then temporary cover to allow air movement true the shrub. Chimneys or openings in or between the covers of the shrubs are also used to increase air movement in the shrubs. Beside the influence on pollination, covering during flowering possibly also has some influence on the chemical control of *Botrytis cinerea*. As the shrub does not come into contact with rain, fungicide retention will increase. The fungicide redistribution effect of the rain will however disappear. The end result of these two phenomena associated with covering the shrub on the efficacy of the fungicides is unknown. Furthermore covering the shrub will also change the climate conditions in the shrub, which results in a change in *Botrytis* infection risk. The *Botrytis* infection risk was studied in detail and infection models were developed for strawberry (Xu et al., 2000) and grapes (Broome et al., 1995). According to these models the infection will be lower if the leaf wetness period of the shrub shortens. Higher humidity and higher temperatures increases *Botrytis* infection risk. As covering the shrubs results in shorter leaf wetness periods but also higher humidity and temperature, it is unclear how this will affect *Botrytis* infection risk in covered shrubs. The questions asked in this study were: Does covering reduce *Botrytis* fruit rot in red currants? Has covering an effect on the efficacy of the fungicides applied and if so, can the number of fungicide sprays be decreased without loss in efficacy?

Material and methods

Two field trials were carried out in the growing seasons of 2000 and 2001. The trials comprised a total of four replicates per object and 6 shrubs per replicate. In 2000 two different covering periods were under investigation, namely permanent cover and covering after fruit set. In 2001 permanent cover was compared with uncovered. To distinguish the chemical control of the two *Botrytis* infection risk periods (infection of the flowers and of the fruits) and also to determine the effect/necessity of after bloom fungicides sprays, two different spraying schedules were tested: including or discarding fungicide application after bloom. During bloom the following weekly spraying schedule was applied: 1x Pomarsol F 80 WG (thiram, dose 0.250%), 1x Teldor 50 WG (fenhexamid, 0.100%) and 1x Euparen M 50 WG (tolylfluanide, 0.250%). After bloom a fortnightly schedule alternating a Teldor 50 WG treatment with a Euparen M 50 WG treatment was applied. The spraying liquid was applied to the plants by means of a motor knapsack sprayer (Stihl SR 420). With this type of mist blower the air is used as an extra means of transport to spread the product. The untreated control in 2000 was uncovered during the total time of experiment. In 2001 two untreated controls were included, one with and another without cover.

Evaluation was performed at harvest and after storage. Storage conditions differed between the two years. In 2000 the currants were stored under normal atmosphere at 6°C for 3.5 weeks. In 2001 storage was performed under controlled atmosphere (0.5°C, 20% CO_2, 2.5%O_2) and lasted 4 months. Each year only one picking is looked upon. The evaluation comprises the determination of the infestation percentage on three different heights in the shrub (0.5m-1m; 1m-1.5m; 1.5m-2m).

Weather data for calculating *Botrytis* infection risk were obtained from a mety weather station (Bodata, Netherlands) belonging to the agricultural meteorological network and was situated in the vicinity of the field and placed at a height of 1.5 m. *Botrytis* infection risk was calculated using Botem infection model (Xu et al., 2000).

Statistics were executed using Unistat software (version 5.5, Unistat Ltd., London, UK). Transformation [log (1+x)] of the observations was used to stabilize the variance. The homogeneity of variance was tested with a Bartlett's Chi-Square and a Bartlett-Box F test. If homogeneity was proved, analysis of variance (ANOVA) was executed. If homogeneity was not proved, no analysis was carried out. If significant differences between objects at the 95% confidence level were obtained, a multiple comparison was executed with a Duncan test. Values followed by the same letter are not significantly different ($p<0.05$).

Results

In 2000 permanent cover was compared with cover after fruit set (table 1). The infestation in the untreated control of the trial was the highest at the bottom half of the shrub and the lowest at the top. Cover after fruit set in combination with treatments during flowering was only significantly different from the control at harvest when looking at the total evaluation. At harvest no statistical differences were observed between the two objects with permanent cover and the long treatment

Table 1.
Botrytis infestation observed on fruits of red currants in the trial of 2000. Evaluation at harvest (2/8/00) and after storage (29/8/00). In the statistical analyses (Anova, Duncan p<0.05) the combination of the different treatments/protection were looked upon. Separate analyses were performed for the different heights and fruit rot evaluations.

Protection	Treatment schedule	Evaluation at harvest				Evaluation after storage			
		0.5-1m	1-1.5m	1.5-2m	0.5-2m	0.5-1m	1-1.5m	1.5-2m	0.5-2m
Unprotected	Control	24.9 a	21.3 a	10.9 ab	19.0 a	50.4 a	40.9 a	27.9 a	39.7 a
Permanent	During flowering	7.7 bc	6.3 b	2.4 c	5.5 b	29.1 ab	20.0 bc	6.9 c	18.7 bc
cover	Flowering-harvest	3.0 c	3.1 bc	4.1 bc	3.4 b	6.1 c	6.0 d	6.8 c	6.3 d
Cover after	During flowering	12.6 ab	17.1 a	16.1 a	15.3 a	29.0 ab	29.5 ab	22.2 ab	26.9 b
fruit set	Flowering-harvest	4.1 c	1.6 c	11.0 ab	5.6 b	13.3 bc	10.4 cd	17.8 b	13.8 cd

Table 2.
Botrytis infestation observed on fruits of red currants in the trial of 2001. Evaluation at harvest (10/8/01) and after storage (3/12/01). In the statistical analyses (Anova, Duncan p<0.05) the combination of the different treatments/protection were looked upon. Separate analyses were performed for the different heights and fruit rot evaluations.

Protection	Treatment schedule	Evaluation at harvest				Evaluation after storage			
		0.5-1m	1-1.5m	1.5-2m	0.5-2m	0.5-1m	1-1.5m	1.5-2m	0.5-2m
Unprotected	Control	6.5 a	4.7 ab	8.3 a	6.5 a	7.9 a	5 ab	8.8 a	7.2 a
	During flowering	6.7 a	4.2 b	6.3 ab	5.7 ab	9.1 a	5.9 a	9 a	8 a
	Flowering-harvest	2.5 bc	2.0 c	4.8 bc	3.1 c	3.1 bc	2.8 bc	5.7 ab	3.8 b
Permanent	Control	4.9 ab	6.0 a	2.6 cd	4.5 bc	5.7 ab	7.9 a	5.1 ab	6.2 ab
cover	During flowering	2.1 c	2.4 c	1.5 d	2.1 d	2.1 cd	2.4 c	1.8 c	2.2 c
	Flowering-harvest	1.2 c	1.3 c	2.0 d	1.5 d	1.2 d	1.5 c	2.8 bc	1.8 c

schedule in combination with cover after fruit set. They were however significantly better than the control. When looking in detail at harvest, in the presence of permanent cover the same tendencies were observed at the different heights. There was no significant difference between the long and the short treatment schedule with permanent cover. The infestation observed with cover after fruit set in combination with the long treatment schedule was significantly higher at the middle of the shrub and significantly lower at the top of the shrub in comparison to permanent cover in combination with treatments during flowering. When including the evaluation at harvest, the best results were obtained with permanent cover and fungicide applications from flowering until harvest. This is the only combination which is significantly better than the control at all heights at both evaluations. However at the total evaluation the efficacy obtained with the long schedule with permanent cover and cover after fruit set was not statistically different. Cover after fruit set with the long treatment schedule was also not significantly different from the combination of permanent cover and treatments during flowering. When looking in detail at the evaluation after storage, it is remarkable that with permanent cover no differences are observed at the top of the shrub, whereas at the other heights the long treatment schedule resulted in a significant lower infestation degree. Cover after fruit set in combination with the long treatment schedule is significantly better than permanent cover in combination with the short treatment schedule at the bottom of the shrub. However, at the top of the shrub both objects with permanent cover have a lower infestation then the objects with cover after fruit set.

In 2001 shrubs with permanent cover were compared with unprotected shrubs (table 2). The infestation was the highest at the top of the shrub when not covered during the season. When covered, the infestation was the highest in the middle of the control shrub. Cover alone significantly reduced the infestation only at the top of the shrub at harvest. Also when looking at the mean infestation at harvest a statistical significant decline was observed. Again this difference disappeared when including the evaluation after storage. In this trial no statistical differences were observed between the long and the short treatment schedule when cover was present. The objects with permanent cover were at all evaluation and at all heights significantly better than the objects with no cover in combinations with treatments during flowering. In the case of the unprotected shrubs, fungicides

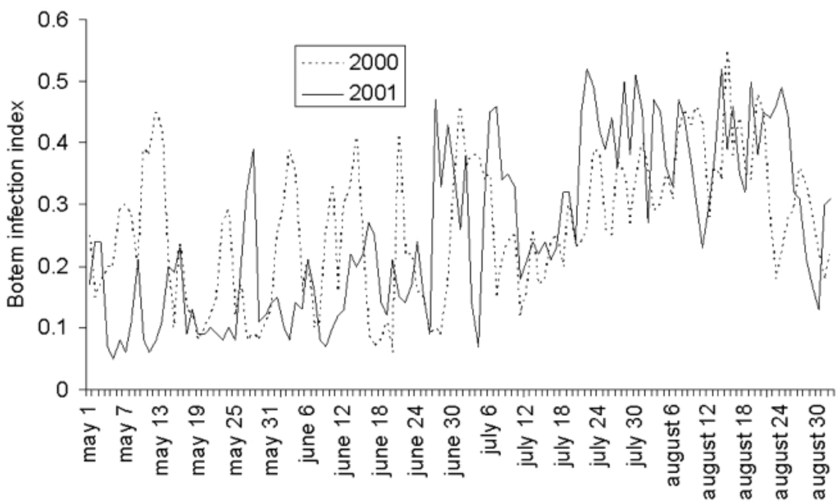

Figure 1.
Botrytis infection risk in 2000 and 2001 according to the Botem infection model and based on data coming from weather station placed in the vicinity of the field trials.

sprays during flowering did not result in a reduction of infestation, making these fungicide sprays unnecessary. This was not the case when the shrub was covered. The unprotected shrub in combination with the long treatment schedule resulted in a significantly higher infestation at the top of the shrub then at the objects with permanent cover at harvest. The same was observed when looking at the total evaluation at harvest and the total evaluation after storage. Furthermore the long fungicide schedule was more effective at the bottom of the shrub after storage when the shrub was protected by permanent cover. At the top of the shrub, the short fungicide schedule applied on the covered shrub was more effective after storage than the long fungicide schedule on uncovered shrubs.

Discussion

Although permanent cover alone does not seem to make a big difference when looking at the infestation, it does make the fungicide sprays applied during flowering more effective. In the trial of 2000 a statistical relevant effect was observed at harvest. In 2001 this is also observed after storage. The question remains if permanent cover makes treatments after flowering unnecessary. In trial of 2001 this was the case. However in 2000, the treatments after flowering gave a surplus effect. A further reduction of the infestation was observed with the long treatments schedule. This surplus effect was due to a more efficient control of the fungal infection at the bottom and the middle of the shrub. At the top no significant differences were observed. Covering the shrub seems to have the greatest effect on the fungal infestation at the top of the shrub. The same phenomenon was observed in the trial of 2001 when comparing the uncovered and the covered check object. The lower infestation at the top of the shrub at harvest was the only significant difference observed between these objects. By covering the shrub, the change of the climate conditions at the top of the shrub is more intensive than in the rest of the shrub. This change seems to be unfavorable for *Botrytis* infections.

The lower infestation degree in 2001 is a possible explanation why no post flowering treatments were necessary in 2001 when permanent cover was present. *Botrytis* infection risk according to the Botem *Botrytis* infection model for strawberries was lower in 2001 than in 2000 (Figure 1). The difference in infection risk was mainly situated during flowering. The results obtained in 2001 with the uncovered shrub confirm this. When unprotected, the fungicides sprays applied during flowering had no effect on the infestation observed later on. Maybe *Botrytis* infection risk should be included for determining the necessity for pre or post flowering fungicide treatments. Another solution can be found in spraying only the bottom half of the shrub, as at the top extra post flowering treatments in both trials were unnecessary when permanent cover was present. However bottom sprays of the shrub will result in a sub lethal fungicide dose at the top of the shrub, which favors resistance development by the fungi. Therefore a good anti-resistance strategy is a necessity, based on alternating fungicides groups when spraying or using combination treatment.

Conclusions

Research relating to *Botrytis* control on currants was in the past mainly focused on finding the best chemical for reducing the *Botrytis* infestation (Duben et al.,2002; Merabet et al., 2002). In this report it is shown that placing permanent cover increases the efficacy of the fungicide sprays performed. In some years probably temporary cover from the beginning of flowering until harvest can have the same effect depending on the infection risk present during flowering. More important, in the case of permanent cover chemical control after flowering is sometimes even unnecessary. These observations have several benefits. Not only is it possible to reduce fungicide use, but also the problem of residues on red currants can be avoided without increasing the fungal infestation of the currants. The only question that is still open relates to the use of *Botrytis* infection risk for determining the necessity for post flowering fungicide treatments when permanent cover is present. Furthermore an extra reduction in fungicide use can probably be obtained when infection risk is also used for positioning pre flowering treatments when permanent or temporary cover is used.

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acs71_17