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EFFECT OF LATE SUMMER TREATMENTS BY STROBILURINES ON STORAGE DISEASES OF APPLES

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Abstract

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Biological efficacy of strobilurines (trifloxystrobin and kresoxim-methyl) was evaluated to compare the effect of late treatments of apples against post-harvest diseases with the effect of widely used reference products (captan, tolylfluanid, dithianone, dodine). One treatment 3–4 weeks before the harvest was applied (1000 l/ha water). Tested and reference products were used in doses authorised in the Czech Republic against the apple scab (*Venturia inaequalis)*. Strobilurines effectiveness overcame all the products compared and showed an effect on reduction of weight decrease during the storage. In total 8 field tests were performed in 2000–2004 were efficacy, effect on fruit quality and weight decrease during storage was assessed.

apple, storage diseases, fungicides, strobilurines

Apple diseases of the late summer and post-harvest diseases can cause severe damages on fruit during the storage. The infection pressure and the occurrence of individual pathogens differ between years, however under conditions favourable for their development the quality and quantity of stored apples can be reduced. More than 90 fungal species have been described that cause decay of apples during storage.

Temperatures and rainfall during late summer, sufficient chemical protection before the harvest, timing and method of harvest, mechanical damage during the harvest and manipulation as well as conditions in the store are the main factors affecting occurrence of post-harvest diseases on apples.

Most of present studies on the effect of the last preharvest treatment on the infection pressure of apple post-harvest diseases evaluated the effectiveness of fungicidal preparations and substances of the older type, i.e. benzimidazoles, imidazoles, dialkyldithiocarbamates and ftalimides. Possibilities of use against post-harvest diseases of apples of environmentally and toxicologically more prospective active ingredients from the chemical group of strobilurines have not been evaluated sufficiently yet and results of strobilurin effects available are not consistent (Agnello et al., 1999; Lánský, 2000).

The current study was conducted to compare the efficacy of the range of plant protection products available for the late treatments of apple trees in the Czech Republic. It was focused especially on the efficacy evaluation of trifloxystrobin and kresoxim-methyl which are now commonly used for the protection of apple trees against the apple scab. Individual preparations reference and tested were chosen to enable the comparison with studies conducted by Research Institute of Fruit Growing in Holovousy in 1997–2000 (Lánský, 2000).

MATERIAL AND METHODS

Tests were performed following OEPP/EPPO standard guideline PP 1/18 (1996) (*Storage diseases of apples – Pre-harvest application*) and further general OEPP/EPPO standards PP 1/152 (1998) (*Design and Analysis of Efficacy Evaluation Trials*) a OEPP/EPPO PP 1/18 (1996) (*Conduct and Reporting of Efficacy Evaluation Trials*).

Field trials were set out as small plot trials with complete randomised blocks. Each plot was formed by 3 trees plus one more untreated tree isolating two neighbouring replications. All tests were done with variety Golden Delicious which is relatively susceptible to many post-harvest diseases.

Individual treatments (Tab. I) were applied by the hand-held air-assisted motor sprayer Stihl SR-320. One pre-harvest treatment was performed at the same date with all products. The appropppriate application date was identified taking into account the safety pre-harvest interval prescribed and the local method for determination of the date for harvesting.

I: *Treatment schedule*

Treatment No	Product	Active ingredient	Application rate
1	**Untreated**	-	-
2	**DISCUS**	kresoxim-methyl	0.2 kg.ha^{-1}
3	**EUPAREN MULTI**	tolylfluanid	2 kg.ha^{-1}
4	**SYLLIT 65**	dodine	1 kg.ha^{-1}
5	**ZATO 50 WG**	trifloxystrobin	0.15 kg.ha^{-1}
6	**MERPAN 80 WG**	captan	2 kg.ha^{-1}
7	**DELAN 700 WDG**	dithianon	0.7 kg.ha^{-1}

The experimental area was harvested following the date of harvest of neighbouring commercial plots to ensure the minimum difference between testing methodology and normal procedures of the local practice.

Apples from each plot were put to individual standardised PE box (15 kg). Taking into account technical limits and tree fertility 50–60 fruits were taken as one sample from each experimental plot. Fruits of extreme size or infected by any disease were excluded. Harvest was stored in the store rooms commercially used for that purpose without controlled atmosphere and temperature 2–6 °C.

The uniformity of any fungal infection of fruits on the experimental area was assessed before the treatment. Before placing to the store apples were assessed as regards to the possible fytotoxic effects. Disease severity was assessed as % of infected fruits when the storage of other commercial parts of stored fruits was finished (February – March). This evaluation also comprised the assessment of any side effects on the fruit quality (colour, taste, smell). The last assessment of % of infected fruits was performed 3 weeks after the storage was finished. The average weight decrease during the storage of each sample was measured.

The statistical analysis of results was done using two-way analysis of variance and multiple comparison testing (Tukey, Scheffe).

RESULTS AND DISCUSSION

In total 8 field trials in 2000–2004 were conducted. The apples were stored under conditions which are common in commercial practice without any significant deflections in individual years. Effectiveness against blue mold rot, gloeosporium rot was assessed individually. The occurrence of other diseases (brown rot, storage scab, grey mould, alternaria rot) was lower then 1% therefore a further summary characteristic was used for the evaluation „efficacy against postharvest diseases“ which covered apples infected by any disease.

All preparations showed an effect against gloeosporium rot pathogen. The percentage of infected apples following individual treatments is shown in Table II. In 6 from 8 trials products based on strobilurines, tolylfluanid and captan were significantly effective in comparison with untreated control. Treatments with kresoxim-methyl and trifloxystrobin products showed the highest effectiveness in 7 from 8 trials. In 3 trials trifloxistrobine and kresoxim-methyl products were significantly more effective then products based on dodine and dithianon. In 4 trials products based on dithianon and dodine did not differ significantly from the untreated control. Those results did not confirm conclusions of Agnello at al. (1999) who found out efficacy of strobilurines against gloeosporium rot pathogen as low. The very good efficacy of tolylfluanid described by Lánský (2000) was confirmed. It is to be pointed out the safety interval prescribed for tolylfluanid enables to make an application at a later date which can likely increase its effectiveness in practice. In our experiments the earlier date of application was chosen to unify the time of treatment for all products concerned. Efficacy of dithianon was significantly lower the results published by Lánský (1998, 2000) in spite of the fact the date of application was the comparable with that recommended by the author.

II: *Percentages of apples affected with Gloeosporium album and G. perennans*

Treatment	2000/1		2001/2		2002/3		2003/4	
	Velké Němčice	Lysice	Velké Němčice	Lysice	Starý Lískovec	Lysice	Starý Lískovec	Lysice
UNTREATED	13.75 [1)]A	9.00 A	7.00 A	4.00 A	5.75 A	6.50 A	5.00 A	10.75 A
DISCUS	1.75 DE	0.75 CD	2.00 B	3.00 A	0.25 B	0.50 B	0.25 B	1.25 D
EUPAREN MULTI	3.25 CD	1.00 BCD	1.25 B	3.75 A	0.50 B	0.50 B	1.00 B	1.25 D
SYLLIT 65	4.50 BC	2.25 BC	2.50 AB	4.00 A	2.25 AB	1.75 B	1.50 AB	2.50 BCD
ZATO 50 WG	1.25 E	0.25 D	1.00 B	1.00 A	0.50 B	0.25 B	0.25 B	1.50 CD
MERPAN 80 WG	3.75 BCD	1.00 BCD	2.25 AB	1.00 A	1.75 B	1.25 B	1.00 B	2.75 BC
DELAN 700 WDG	7.00 B	3.00 B	3.25 AB	0.75 A	2.00 AB	1.50 B	1.75 AB	3.75 B

[1)] Values with the same letter are not significantly different ($\alpha = 0.05$).

The efficacy against blue mold rot was similar, however, results with captan in comparison with other products were more variable. Results from 2001 (Tab. III) were slightly inconsistent with other years which can be explained by low infection pressure and hail-storm damage on fruits. Dodine in 4 trials and dithianon in 3 trials did not differ significantly from the untreated control. This result is not compliant with conclusions of Lánský (2000) where the effectiveness of dodine and dithianone against grey mold rot was sufficient.

III: *Percentages of apples affected with Penicillium spp.*

Treatment	2000/1		2001/2		2002/3		2003/4	
	Velké Němčice	Lysice	Velké Němčice	Lysice	Starý Lískovec	Lysice	Starý Lískovec	Lysice
UNTREATED	5.25[1)] A	3.25 A	4.50 A	3.00 A	5.75 A	5.25 A	3.25 A	3.25 A
DISCUS	0.50 BC	0.00 D	0.00 B	0.75 AB	0.75 B	0.75 BC	0.25 B	0.50 C
EUPAREN MULTI	0.75 BC	0.75 BCD	1.50 AB	0.00 B	0.75 B	1.25 BC	0.75 B	1.00 BC
SYLLIT 65	1.50 B	1.75 AB	0.75 B	0.75 AB	1.25 B	1.50 BC	1.25 AB	2.25 AB
ZATO 50 WG	0.25 C	0.25 CD	0.00 B	0.00 B	0.50 B	0.25 C	0.50 B	1.25 BC
MERPAN 80 WG	0.75 BC	1.00 BC	0.50 B	0.00 B	0.25 B	1.25 BC	1.50 AB	2.50 AB
DELAN 700 WDG	1.50 B	2.00 AB	0.50 B	0.00 B	1.50 B	1.75 B	1.50 AB	2.25 AB

[1)] Values with the same letter are not significantly different ($\alpha = 0.05$).

Summary evaluation of efficacy against postharvest diseases (Tab. IV) confirmed again very good efficacy of trifloxystrobine, kresoxim-methyl and tolylfluanid. Dodine and dithianone did not differ significantly from the untreated control in 2 trials and in 6 trials the efficacy of dithianone was significantly lower then of trifloxystrobine. In general, taking into account the differences between results of this study and conclusions of Lánský (2000) and Agnello et al. (1999) it can be concluded the results achieved shall be confirmed by a serie of large-scale trials.

IV: *Percentages of apples affected with storage diseases (summarised)*

Treatment	2000/1		2001/2		2002/3		2003/4	
	Velké Němčice	Lysice	Velké Němčice	Lysice	Starý Lískovec	Lysice	Starý Lískovec	Lysice
UNTREATED	20.25 [1)]A	13.25 A	12.25 A	7.25 A	12.25 A	12.00 A	8.50 A	14.25 A
DISCUS	2.25 CD	1.25 D	2.75 B	3.75 AB	1.25 C	1.50 BC	1.00 D	2.50 C
EUPAREN MULTI	4.50 BC	2.25 CD	3.75 AB	3.75 AB	1.75 BC	2.25 BC	2.50 BCD	3.00 C
SYLLIT 65	6.75 B	4.75 BC	4.50 AB	4.75 AB	3.75 BC	3.50 B	3.00 BC	5.75 B
ZATO 50 WG	1.50 D	1.00 D	1.50 B	1.00 B	1.00 C	0.50 C	1.50 CD	3.50 C
MERPAN 80 WG	4.75 BC	2.50 BCD	3.25 AB	1.00 B	2.00 BC	2.50 BC	3.25 BC	6.75 B
DELAN 700 WDG	9.75 B	6.25 AB	5.25 AB	1.00 B	4.25 B	3.75 B	4.00 AB	7.25 B

[1)] Values with the same letter are not significantly different ($\alpha = 0.05$).

No effect of any product applied on the fruit quality or any fytotoxic effect was observed.

Results of measurments of the weight decrease during storage brought an information about potential regulation effect of products based on strobilurines (Tab. V). In 4 from 6 trials the decrease of the average weight of a non-infected fruit was lowest after treatments with trifloxystrobin and kresoxim-methyl. In 1 further trial they were overcome by captan and in 1 trial by tolylflanid.

V: *Percentages of reduction of weight decrease of apples during storage*

Preparation	2001/2		2002/3		2003/4	
	Velké Němčice	Lysice	Starý Lískovec	Lysice	Starý Lískovec	Lysice
UNTREATED	96.85 [1)]A	97.74 A	99.02 A	98.34 A	97.82 ABC	98.56 A
DISCUS	98.81 B	98.59 A	99.02 A	98.77 A	99.02 AB	99.18 A
EUPAREN MULTI	97.63 A	97.79 A	99.41 A	98.16 A	98.62 ABC	97.97 A
SYLLIT 65	97.61 AB	97.39 A	98.80 A	97.98 A	97.62 BC	98.37 A
ZATO 50 WG	98.61 AB	98.77 A	99.41 A	98.79 A	99.21 A	98.79 A
MERPAN 80 WG	96.81 B	97.74 A	99.01 A	98.97 A	97.05 C	98.13 A
DELAN 700 WDG	97.40 AB	97.51 A	98.82 A	98.18 A	97.24 BC	98.20 A

[1)] Values with the same letter are not significantly different ($\alpha = 0.05$).

What is notable was the stable efficiency after treatment of strobilurines whereas effect of other treatments was very variable. However the differences between individual preparations were not statistically significant.

Results obtained with strobilurins are in compliance with Levinskaite et al. (2005), who refers to good efficiency of combinations of the active ingredients nicobifen + pyraclostrobin, tolylfluanid + kresoxym-methyl and trifloxystrobin against *Penicillium spp.* and reduction of mycotoxines produced after the treatment.

SOUHRN

Účinek ošetření strobiluriny v pozdním létě na výskyt skládkových chorob jablek

Byla hodnocena biologická účinnost účinných látek ze skupiny strobilurinů (trifloxystrobin a kresoxim-methyl) za účelem porovnání efektu pozdního ošetření jabloní proti skládkovým chorobám s účinnos-

tí některých běžně používaných referenčních přípravků (captan, tolylfluanid, dithianone, dodine). Byla provedena jedna aplikace 3–4 týdny před sklizní (při 1000 l/ha vody). Testované a referenční přípravky byly aplikovány v dávkách v dávkách registrovaných v České republice pro ochranu proti strupovitosti jabloně (*Venturia inaequalis)*. V letech 2000–2004 bylo provedeno celkem 8 polních testů, v nichž byla hodnocena účinnost, vliv na kvalitu plodů a na redukci úbytku hmotnosti plodů během skladování. Strobiluriny překonaly účinek všech porovnávaných přípravků a vykázaly efekt na redukci ztrát hmotnosti během skladování.

jabloň, skládkové choroby, fungicidy, strobiluriny

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