Degradation behaviour of potassium K-phosphite in apple trees

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Abstract

Although potassium phosphite is not registered for organic fruit production in Europe, it has long been regarded as a potential alternative to sulphur- and copper-containing fungicides. In 2005/2006 a field trial was carried out to verify the presence of residues of phosphoric acid over time in apples after applications of potassium phosphite at different time-points. No residues were present on fruits if treatments were applied before flowering, whereas treatments after flowering, in the summer or in autumn resulted in comparable residue levels irrespective of the period of application. Residues were eveneven found in leaves and fruits of the following years, 2006 and 2007.

Keywords: apple, organic farming, phosphite, potassium phosphite

Introduction

Potassium phosphite (K-phosphite) is an efficient compound for the control of several fungal plant diseases (Guest & Grant, 1991). However, in Europe this active substance is not officially registered as a plant protection product, and therefore at the moment it cannot be included in Annex II B of Regulation EEC 2092/91. Nevertheless, in conventional wine-growing it is commonly applied in different countries under the disguise of a foliar fertilizer or plant strengthener to control downy mildew, *Plasmopara viticola* (Fuchs *et al*., 2004). Very few fungicides are available to organic wine and fruit growers, essentially limited to copper- and sulphur-based products. In addition, the amount of copper that can be applied is limited by regulation EEC 2092/91 and by different national regulations, and thus there is great interest in other products which may at least partially replace copper. K-phosphite is such an active substance which has continuously been taken into consideration. One of the major concerns about K-phosphite is the possible presence of undesired residues of phosphoric acid in fresh and processed fruits ser *et al*., 2000). Organic produce should not contain any chemical and/or synthetic residue. A field trial was set up in 2005 to determine whether applications of K-phosphite on apple at different moments of the growing season (prior to flowering, after flowering, in summer, in autumn) would result in detectable levels of phosphoric acid in fruits. Furthermore, the persistence as well as the build-up of residues in leaves and fruits of successive years (2006 and 2007) was investigated.

Material and Methods

The trial was conducted in an established IPM apple orchard (cv 'Golden Delicious') at the Research Centre Laimburg in Pfatten (Bozen, Italy). The orchard was managed according to common agricultural practices. To compare the different treatments (Table 1), a randomized block design with 7 plants per experimental plot and 4 replicates per treatment was used. Treatments of K-phosphite (Fosfid'Or; Agrimport) were applied with a motorized sprayer for experimental trials (Waibl transverse current blower), and the applied spray volume was 500 l/ha and mater foliage height. The application rates and the timing of the applications of the different treatments are reported in Table 1. Samples of 20 fruits and 50 leaves per experimental plot were collected and analysed as follows:

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Fruits were analysed in September 2005 at harvest, in March 2006 after cold storage, in September 2006 at harvest, in March 2007 after cold storage, and in September 2007 at harvest. Leaves were analysed in April 2007 after flowering.
The apples were first washed with distilled water and dried. Once the core had been removed, the fruits were grinded and homogenized. Fifty grams of homogenized material were then mixed with 100 ml of distilled water. After one hour of extraction time, the sample was filtered and analyzed. The phosphoric acid ($PO_3$3-) content was determined using ion chromatography (DIONEX DX 120). To exclude analytical mistakes, each sample was analyzed twice. The detection level was 5 mg H_3PO_3 / kg fresh weight.

Statistical analysis
The residue levels from fruits and leaves were compared across treatments using one-way ANOVAs, followed by the Tukey test for posthoc comparison of means ($P<0.05$). All analyses were performed with the software package SPSS 12.0 for Windows.

Table 1: Applied rates of K-phosphite (formulated product: Fosfid'Or[1]), and timing and number of applications in the different treatments.

Treatment no.	Formulated product	Applied Rate	Timing of applications	Year of application		No. applic.s	Time interval between applic.s
1	Fosfid'Or	410 g/hl	Before flowering	2005	-	4	4-5 days
2	Fosfid'Or	410 g/hl	After flowering	2005	-	4	4-5 days
3	Fosfid'Or	410 g/hl	Summer	2005	2006	4	4-5 days
4	Fosfid'Or	410 g/hl	Autumn	2005	-	4	4-5 days
5	Untreated control	-	-	-	-	-	-

[1] Fosfid'Or (Agrimport) = 44.2 g K_3HPO_3 / 100 ml formulated product

Table 2: Phosphoric acid residues (mg H_3PO_3 / 100 g fresh weight) in fruits (at harvest and after cold storage) and leaves (after flowering) exposed to treatments with Fosfid'Or in different moments during the growing season and in the untreated control.

Treatment	Timing of applic.s	Year	mg H_3PO_3 / kg fresh weight					
			Fruits Harvest 2005	Fruits Cold storage March 2006	Fruits Harvest 2006	fruits cold storage March 2006	Leaves April 2007	Fruits Harvest 2007
1 - Fosfid'Or	Before flowering	2005	**<5 a**	**-**	-	-	-	-
2 - Fosfid'Or	After flowering	2005	**78 b**	**-**	-	-	-	-
3 - Fosfid'Or	Summer	2005 2006	**73 b**	**93 b**	**90 b**	**105 b**	**458 c**	**<5 a**
4 - Fosfid'Or	Autumn	2005	**85 b**	**111 b**	**9 a**	**12 a**	**203 b**	**<5 a**
5 – Untreated control	-	-	**<5 a**	**<5 a**	**0 a**	**<5 a**	**<5 a**	**<5 a**

Results

No detectable residues of phosphoric acid (H_3PO_3) were found in fruits of the plots treated with Fosfid'Or before flowering and in fruits of the untreated control plots, while the residue levels in fruits of the plots treated after flowering, in summer and autumn ranged from 73 to 85 mg phosphoric acid per kg fresh weight, with differences among the latter treatments not being significant (Table 2). Comparable residue levels were also detected in fruits after cold storage. Fruits from trees that had been treated in autumn 2005 still showed detectable residue levels of phosphoric acid (9 mg / kg) at harvest 2006. In treatments 3 and 4 (see Table 1), residues of phosphoric acid were detected even in leaves collected from young shoots in spring 2007 immediately after flowering (458 und 203 mg/kg, respectively). In fruits harvested in 2007, residues were no longer detectable.

Discussion

The results of this study show that applications of K-phosphite can result in considerable residue levels of phosphoric acid (H_3PO_3) in apple fruits. The absence of detectable residues in fruits of the plots treated with K-phosphite 4 times prior to flowering may be due to the fact that the leaf mass present on the trees at this stage was very low, and therefore the uptake of the active ingredient may have been limited. No residue decomposition seems to have occurred during cold storage.The residue levels of phosphoric acid detected in leaves after flowering and the low levels of residues found in fruits 2 years after the last treatment application are evidence for the incorporation of the substance in the wood.

References

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