Armicarb® - a new bio-fungicide for use in organic and conventional fruit growing in Europe

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Abstract

Armicarb® is a bio-fungicide being developed across Europe by Agronaturalis Ltd. for use in a wide range of crops; grapevines, hops, pome fruit, soft fruit, stone fruit, vegetables and ornamentals. Armicarb® is a specially optimised formulation of potassium bicarbonate; the result of extensive testing by researchers at Cornell University, USA, for use as an agricultural fungicide. The proprietary wetting system ensures a complete and thorough covering of plant surfaces, whilst at the same time limiting wash-off of the highly water-soluble active substance by rain. It is this critical balance of 'sticking' and 'spreading' by the formulation that delivers a level of field performance, outdoors as well as in protected conditions, equivalent to conventional fungicide standards.

Armicarb® has a broad spectrum of activity against important fungal pathogens, including but not limited to powdery mildews, Botrytis *and* Venturia spp*. While it acts exclusively through direct contact to spores and fungal hyphae on the plant surface, laboratory studies on apple seedlings maintained under high relative humidity conditions demonstrated a limited curative activity against infections of* Venturia inaequalis*. The mode of action of the fungicide active substance is very rapid, allowing infections to be prevented as long as fungal hyphae have not yet penetrated through the cuticle. Results of development trials against* Botrytis *in grapevines and powdery mildew in protected vegetables are presented here.*

Keywords: Apple scab, Armicarb®, *Botrytis*, potassium bicarbonate, powdery mildew

Introduction

The fungicidal activity of bicarbonate salts has been known for at least 80 years (Marloth, 1931). Specific control of numerous different fungi has been reported subsequently (Punja & Grogan, 1982; Horst *et al*., 1992; Palmer *et al*., 1997; Jamar *et al*., 2007). The mode of action of bicarbonate salts is linked to the perturbation of pH, osmotic pressure and the bicarbonate/carbonate ion balance of sensitive fungi. Bicarbonate acts by contact to fungi in aqueous solution and inhibits the development of fungal mycelium and spores. Due to its multi-site mode of action it is thought that the risk of resistance developing is low.

Potassium bicarbonate is now included in Annex I of Directive 91/414/CEE for use as a fungicide, and is authorised for use in organic production by the European Commission ruling n°. 404/2008. Indistinguishable from natural potassium and bicarbonate, residues are considered not to be relevant, and the product is exempt from MRLs in the EU. Available commercially in Switzerland since 2008, Armicarb®, a soluble powder containing 85 % (w/w) potassium bicarbonate, is being developed by Agronaturalis Ltd. and its partners across Europe for use against target diseases in a wide range of fruit and vegetable crops.

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Material and Methods

To evaluate the effective timing of Armicarb® applications against *V. inaequalis*, apple seedlings of Golden Delicious at 4-6 leaf stage, 6 plants per treatment, were treated with 0.5 % (w/v) Armicarb® at different times post-inoculation with spores of *V. inaequalis* (100,000 spores/ml). Plants were incubated at 100 % relative humidity, 21 ˚C, for 24 h post-inoculation, and then at 60 % relative humidity, 20 ˚C, for 10 days until disease assessments.

Armicarb® was tested against *Botrytis cinerea* in grapevines in 3 trials in Austria in 2010. Three applications were made at the classical treatment timings, A, B and C; full flowering to end of flowering (BBCH 65-69), pre-bunch closure (BBCH 77), and beginning of colour change (BBCH 81-83). Unformulated potassium bicarbonate was tested alongside, and in one trial the reference product, fludioxonil+cyprodinil, was tested at stages B and C only. Spray volumes were 1000 l/ha at all treatment timings, with applications made to the whole crop canopy. Efficacy was assessed on at least 100 bunches per plot.

Four field trials were carried out in Spain in 2011 against powdery mildew, *Leveillula taurica*, in protected tomatoes (2 trials) and peppers (2 trials). Armicarb® was applied 4 times at 7-10 day intervals, starting applications when first symptoms were observed. Spray volumes at all application timings were 1000 l/ha. Disease assessments were made before the first application (0-DAA), at each application timing (0-DAB, 0-DAC, 0-DAD), and 7 days after D (7-DAD). Disease severity was assessed on 25 leaves per plot.

Results

Disease incidence and severity of *V. inaequalis* on untreated apples seedlings were 56 % and 24 % respectively. Armicarb® applied 2, 5 or 8 h after inoculation resulted in the highest efficacy against the pathogen, always above 90 % for both disease incidence and severity (Fig. 1). From 12 to 24 h post-inoculation applications, the efficacy started to decline, and by 36 h post-inoculation, efficacies were reduced to only 38 % and 52 % for disease incidence and severity respectively.

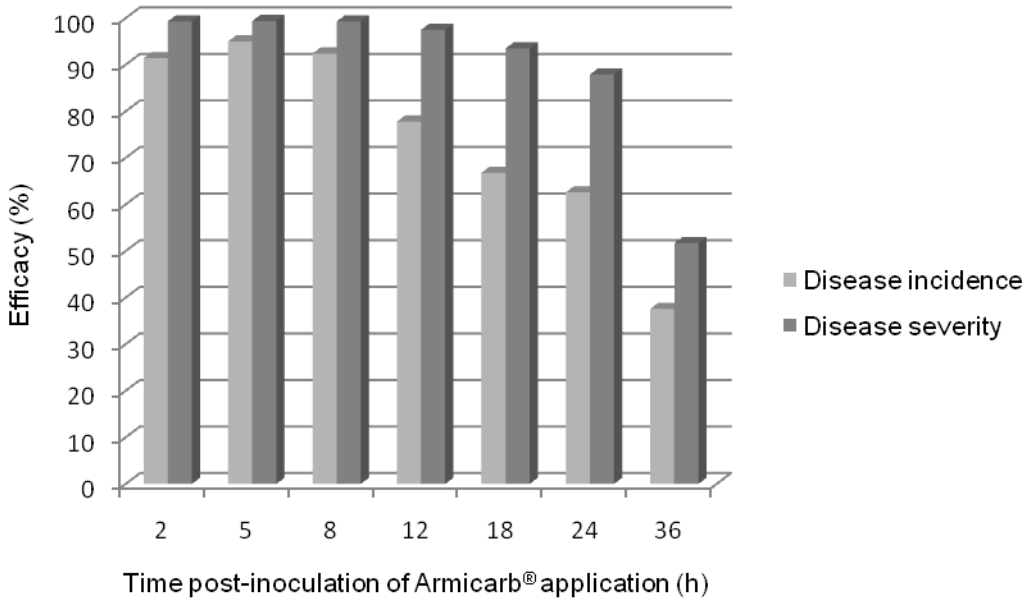

Figure 1 Effects of post-inoculation applications of Armicarb® against *V. inaequalis* infections of apples seedlings

Levels of infection with *B. cinerea* in the 3 trials in grapevines varied from 'low' to 'medium' to 'high'. Armicarb® gave very good levels of disease control, 64-85 % efficacy on disease severity, independent of disease pressure, and comparable to the conventional fungicide standard. In contrast unformulated potassium bicarbonate, applied at 2.3 times the active substance rate, was significantly less effective under medium-high disease pressure conditions. Armicarb® did not cause any phytotoxic effects either on leaves or bunches.

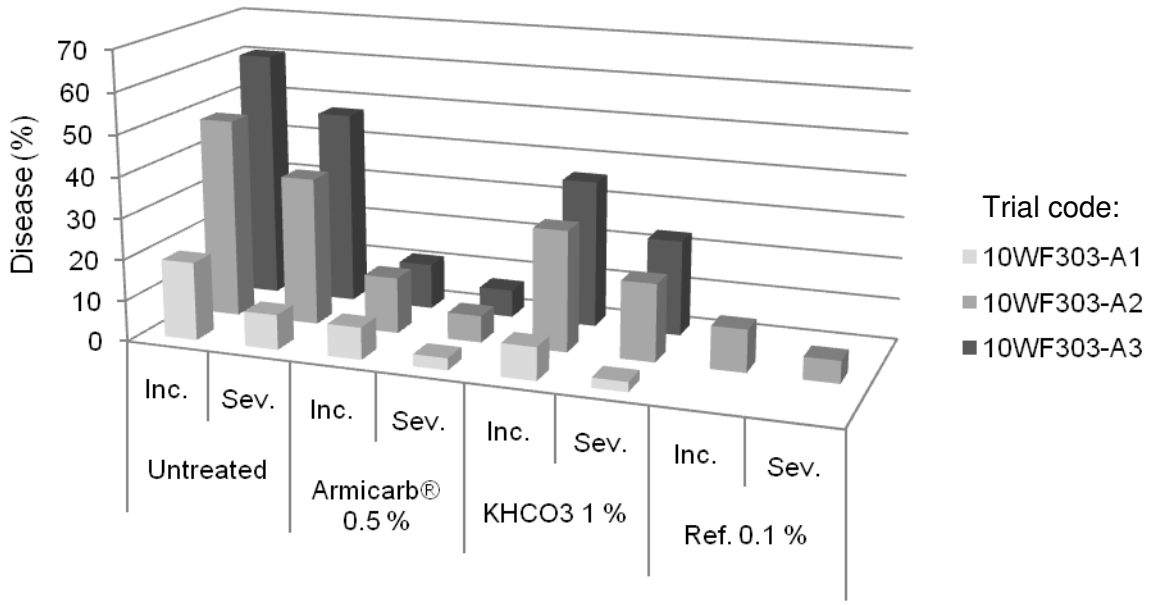

Figure 2 Efficacy of Armicarb® against *B. cinerea* in grapevines in 3 trials in Austria, 2010. Disease incidence (Inc.) and severity (Sev.) data are shown

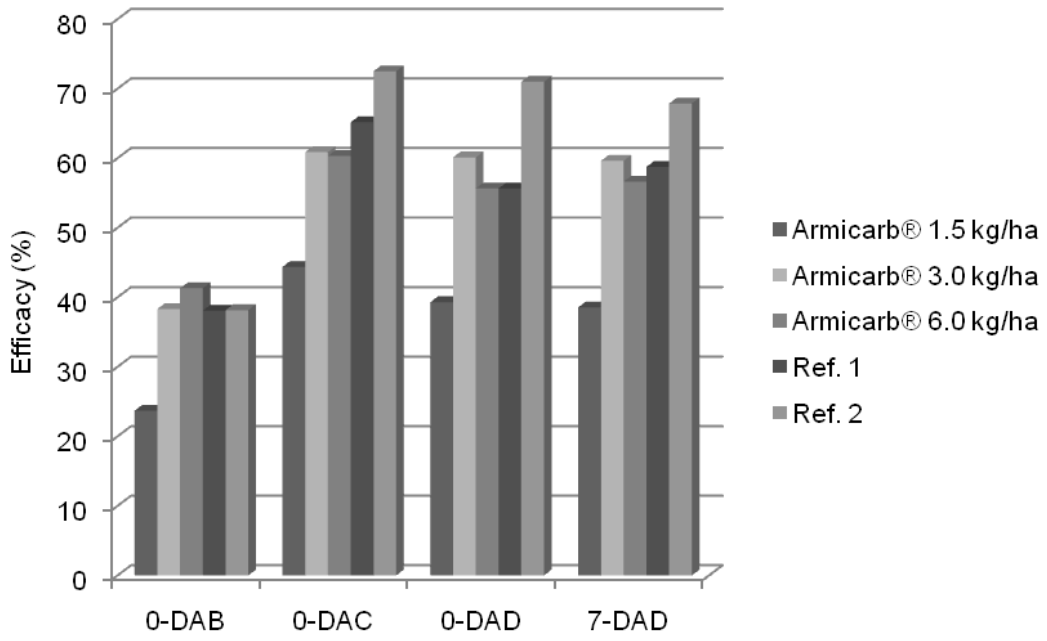

Figure 3 Efficacy of Armicarb® against powdery mildew of tomato and pepper (average of 4 trials) in Spain, 2011

Disease severity of *L. taurica* in the Spanish tomato and pepper trials increased steadily during the course of the trials, rising from just 2 % before the first fungicide treatments to reach 37 % at the end of the trials (average of 4 trials). A strong dose-effect was observed with Armicarb® between 1.5 and 3.0 kg/ha (Fig. 3). No difference was found between 3.0 and 6.0 kg/ha. Armicarb® achieved a good level of disease control, 60-61 % efficacy at the three later assessment timings, comparable to cyproconazole (ref. 1) and somewhat less than azoxystrobin (ref. 2). No symptoms of phytotoxicity were observed in any of the trials, at the 3 dose-rates of Armicarb® evaluated.

Discussion

Results of timed applications with Armicarb® against apple scab demonstrated the effectiveness of the product for up to 8 h post-infection (disease incidence and severity), and for as long as 12-18 h in terms of disease severity. These data suggest there may be some flexibility in application timing with respect to weather conditions in the field, but Armicarb® should always be applied as close to infection events as possible. In was noted that in these trials, plants were maintained under very high humidity for 24 h after infection, meaning that the potassium bicarbonate would have remained dissolved on the leaf surfaces during this time.

The improved performance of Armicarb® in comparison to unformulated potassium bicarbonate was demonstrated in the field in grapevines against *B. cinerea*. The enhanced rainfastness and more uniform coverage of plant surfaces delivers a level of efficacy comparable to conventional fungicide standards.

Similarly, in glasshouse trials in tomatoes and peppers, the efficacy of Armicarb® against powdery mildew was on the level of the triazole reference product. With its exemption from EU MRLs, Armicarb® will be especially suitable for use in programmes with conventional fungicides, as well as in organic fruit production.

Acknowledgements

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