Project title	Apples: Increasing the efficacy of potassium hydrogen carbonate (potassium bicarbonate) for powdery mildew control by a range of adjuvants and sulphur.
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The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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CONTENTS

GROWER SUMMARY

Headline

Potassium bicarbonate is an effective control for powdery mildew in apple when combined with the use of *Bacillus subtilis* (Sentry S, Serenade)

Background and expected deliverables

Powdery mildew (*Podosphaera leucotricha*) in apple is a regular problem in many orchards. Conventional control relies on synthetic fungicides and cultural practices such as cutting out primary mildew. These methods can be time consuming and expensive and alternative methods of control were therefore sought. One alternative method of control is through the use of potassium bicarbonate which acts as an eradicant fungicide. However repeated applications are required as potassium bicarbonate is not persistent and has no protectant properties.

This project firstly assessed the physical compatibility and then efficacy against powdery mildew of potassium bicarbonate with a range of adjuvants and sulphur to improve control of Powdery mildew in apple. In addition to these treatments a *Bacillus subtilis* treatment (Sentry S, Serenade) was applied in combination with potassium bicarbonate to provide protectant and eradicant modes of action.

As a naturally occurring substance, potassium bicarbonate has a low risk of pathogen resistance and therefore is likely to be useful in the long term. If improved control of powdery mildew can be achieved through a combined approach of using adjuvants, sulphur or other protectant materials, this will help to reduce the chances of resistant strains of powdery mildew arising.

Summary of the project and main conclusions

The first part of the project was to assess the physical compatibility of potassium bicarbonate with Flowable Sulphur, Nu-Film-17 (pinolene based), Nu-Film-P (pinolene based) and Slippa (silicon based). At label recommended rates there were no physical incompatibility problems with any of the products tested.

The second part of the project was to assess the effect of combinations of these products on the occurrence of powdery mildew. Sixteen treatment combinations (Table 1) were applied to a Cox orchard and the effect on powdery mildew was observed. Potassium bicarbonate and sulphur applications were made at pink bud and petal fall as recommended in HDC project CP 48. Serenade applications were replaced by applications of Sentry S (Plant Health Care) which is an equivalent *Bacillus subtilis* product and was also applied at these timings and also 1 week after petal fall.

Table 1. Treatment combinations.

	No adjuvant	**Nu-Film-17 (1ml/L)**	**Nu-Film-P (1ml/L)**	**Slippa (1ml/L)**
Potassium bicarbonate (15g/L)	1	2	3	4
Potassium bicarbonate (15g/L) + Flowable Sulphur (5.5ml/L)	5	6	7	8
Potassium bicarbonate (15g/L) + Sentry S (20ml/L) (*Bacillus subtilis*)	9	10	11	12
Control	13	14	15	16

Assessments of powdery mildew were made weekly until the end of July. Ten leaves on each of the five trees for each treatment in each block were assessed for the presence or absence of mildew.

In all treatments powdery mildew levels increased throughout the season. However those treatments that did not include potassium bicarbonate had greater levels of the disease present at the first observation (4-5%) than the treatments where potassium bicarbonate was applied (0-2%). Treatments where Sentry S (Serenade equivalent) was applied in conjunction with potassium bicarbonate, had the lowest initial levels of inoculum present (0-1%).

The addition of Flowable Sulphur to potassium bicarbonate did not improve control over the disease. In both cases, incidence then increased equally to the end of the assessments. For these two chemical applications, the use of any of the adjuvants did not appear to enhance the action in reducing mildew.

Where a *Bacillus subtilis* product was added to the treatment, a reduced incidence of mildew was observed throughout the experiment. Potassium bicarbonate is an eradicant with no protectant properties whereas the *Bacillus subtilis* product acts as a protectant. The initial reduction in mildew levels due to the potassium bicarbonate was enhanced by use of a protectant which resulted in a continued low level of infection rather than an escalating one.

Where potassium bicarbonate was not applied at all and only the individual adjuvants were applied, mildew levels were the greatest. Where the two pinolene products (Nu-Film-P and Nu-Film-17) were applied, initial levels of mildew were reduced compared to where the silicon based product (Slippa) was applied and to the control, where nothing was applied. This reduction in incidence of mildew for the pinolene products compared to the silicon product and the control, continued over the course of the experiment.

It is apparent that potassium bicarbonate has an effect on the observed incidence of powdery mildew in apple, effectively reducing incidence of the disease. It is also apparent from the results that although initial levels are controlled after the use of potassium bicarbonate has stopped, incidence of the disease can then increase as the potassium bicarbonate offers no protectant action.

The addition of sulphur, Nu-Film-P, Nu-Film-17 or Slippa did not increase efficacy of potassium bicarbonate in controlling powdery mildew. However the use of Sentry S (Serenade) increased control of the disease.

The results indicate that best control of powdery mildew in apple can be achieved by reducing initial inoculum early in the season through the use of potassium bicarbonate. The application of the protectant Sentry S will help to maintain control through the remainder of the season.

Action points for growers

- Use potassium bicarbonate to eradicate occurrences of powdery mildew in apple.
- Use *Bacillus subtilis* (Sentry S, Serenade) as a protectant for powdery mildew in apple.

SCIENCE SECTION

Introduction

Powdery mildew (*Podosphaera leucotricha*) in apple is a regular problem in many orchards. Conventional control relies on synthetic fungicides and cultural practices such as cutting out primary mildew. These methods can be time consuming and expensive and therefore alternative methods of control were therefore sought.

One alternative method of control is through the use of potassium bicarbonate which acts as an eradicant fungicide. However repeated applications are required as potassium bicarbonate is not persistent and has no protectant properties. The efficacy of potassium bicarbonate against powdery mildew has been investigated for a range of horticultural crops including apple (HDC Project CP 48) and recommendations on spray volume and timing were made. However it has been found that control is often less than 100%. As there were no specific recommendations for the addition of adjuvants in apple there is potential to improve the efficacy of potassium bicarbonate in the control of powdery mildew.

This project firstly assessed the physical compatibility and then efficacy against powdery mildew of potassium bicarbonate with a range of adjuvants and sulphur to affect an improved control of Powdery mildew in apple. In addition to these treatments a *Bacillus subtilis* treatment (Serenade) was applied in combination with potassium bicarbonate to provide protectant and eradicant modes of action.

Improved efficacy of potassium bicarbonate would give greater control of powdery mildew in apple orchards. This naturally occurring substance has a low risk of pathogen resistance and therefore is likely to be used in the long term, if greater control of powdery mildew is achieved through the use of adjuvants or sulphur this will help to 'protect' potassium bicarbonate from resistant strains of powdery mildew arising.

Materials and methods

Firstly the physical compatibility for potassium bicarbonate with Flowable Sulphur, Nu-Film-17 (pinolene based), Nu-Film-P (pinolene based) and Slippa (silicon based) was determined.

Sixteen treatment combinations (Table 2) were applied to a Cox orchard and the affect on powdery mildew was observed. The sixteen combinations were laid out as a randomised

block experiment with four blocks of five trees per treatment. Potassium bicarbonate and sulphur application was at pink bud and petal fall as recommended in HDC project CP 48. Serenade applications were replaced by applications of Sentry S (Plant Health Care) which is an equivalent *Bacillus subtilis* product and was also applied at these timings and also 1 week after petal fall.

Table 2. Treatment combinations.

	None	**Nu-Film-17 (1ml/L)**	**Nu-Film-P (1ml/L)**	**Slippa (1ml/L)**
Potassium bicarbonate (15g/L)	1	2	3	4
Potassium bicarbonate (15g/L) + Flowable Sulphur (5.5ml/L)	5	6	7	8
Potassium bicarbonate (15g/L) + Sentry S (20ml/L) (*Bacillus subtilis*)	9	10	11	12
None	13	14	15	16

Assessments of powdery mildew were made weekly until the end of July. Ten leaves on each of the five trees for each treatment in each block were selected randomly and assessed for the presence or absence of mildew.

Results

Physical compatibility

As can be seen from the findings shown in Table 3, there were no physical compatibility issues when mixing potassium bicarbonate with any of the tested products.

Table 3. Physical compatibility of potassium bicarbonate

	Physical incompatibility (precipitate)
Flowable sulphur	No
Nu-Film-17	No
Nu-Film-P	No
Slippa	No

Occurrence of Mildew

The percentage of leaves infected with mildew at different stages of the season is shown for each treatment in Table 4.

Table 4. Occurrence of Powdery Mildew throughout the season related to treatment (% of leaves infected).

		Week	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**
1	Potassium bicarbonate	none	2	1	2	3	3	3	5	3	4	5	5
2	Potassium bicarbonate	Nu-Film-17	1	1	2	3	2	3	3	4	4	5	3
3	Potassium bicarbonate	Nu-Film-P	1	2	2	2	3	4	3	4	3	5	5
4	Potassium bicarbonate	Slippa	2	3	2	4	2	3	3	4	5	5	4
5	Potassium bicarbonate + Flowable Sulphur	none	2	2	1	3	4	3	3	4	4	5	5
6	Potassium bicarbonate + Flowable Sulphur	Nu-Film-17	2	3	2	1	3	3	4	3	3	4	5
7	Potassium bicarbonate + Flowable Sulphur	Nu-Film-P	1	2	3	3	2	3	5	3	4	4	4
8	Potassium bicarbonate + Flowable Sulphur	Slippa	2	2	1	2	2	4	3	4	4	5	5
9	Potassium bicarbonate + Sentry S	none	0	1	0	2	1	2	2	3	2	3	3
10	Potassium bicarbonate + Sentry S	Nu-Film-17	0	0	1	0	2	2	3	2	3	3	3
11	Potassium bicarbonate + Sentry S	Nu-Film-P	0	1	0	1	2	3	3	3	3	3	3
12	Potassium bicarbonate + Sentry S	Slippa	1	0	2	1	2	2	3	2	2	3	3
13	None	none	5	5	6	6	5	7	8	10	9	10	10
14	None	Nu-Film-17	4	4	4	5	5	6	6	7	8	9	9
15	None	Nu-Film-P	4	5	4	5	6	6	7	6	7	7	8
16	None	Slippa	5	5	5	6	5	7	7	6	8	9	10

- From Table 4 it can be seen that in all cases powdery mildew levels increased throughout the season.
- However those treatments that did not include potassium bicarbonate had greater levels of the disease present at the first observation (4-5)% than the treatments where potassium bicarbonate was applied (0-2%).
- Treatments where Sentry S (Serenade equivalent) was applied had the lowest initial levels of inoculum present (0-1%).
- There was a general trend of incidence increasing over the assessment period in all treatments.
- Mildew levels at the end of the season were far greater where initial levels of mildew were not reduced.

Discussion

Potassium bicarbonate alone was effective at initially reducing levels of mildew compared to treatments where potassium bicarbonate was not applied. The addition of Flowable Sulphur to the tank mix did not however improve control over the disease, in both cases incidence then increased equally to the end of the assessments. For these two chemical applications, the use of any of the adjuvants did not appear to enhance the action in reducing mildew.

Where a *Bacillus subtilis* product was added to the treatment, a reduced incidence of mildew was observed throughout the experiment. Potassium bicarbonate is an eradicant with no protectant properties whereas the *Bacillus subtilis* product acts as a protectant. The initial reduction in mildew levels due to the potassium bicarbonate was enhanced by use of a protectant which resulted in a continued low level of infection rather than an escalating one.

Where potassium bicarbonate was not applied at all and only the individual adjuvants were applied, mildew levels were the greatest. Where the two pinolene products (Nu-Film-P and Nu-Film-17) were applied, initial levels of mildew were reduced compared to where the silicon based product (Slippa) was applied and to the control where nothing was applied. This reduction in incidence of mildew for the pinolene products compared to the silicon product and the control continues over the course of the experiment.

Conclusions

It is apparent that potassium bicarbonate does have an effect on the observed incidence of powdery mildew in apple, reducing incidence of the disease. It is also apparent from the

results that although initial levels are controlled, after the use of potassium bicarbonate has stopped, incidence of the disease can then increase as the potassium bicarbonate offers no protectant action.

The addition of sulphur, Nu-Film-P, Nu-Film-17 or Slippa did not increase effacy of potassium bicarbonate in controlling powdery mildew. However the use of Sentry S (Serenade) increased control of the disease.

From these results it can be seen that there is great importance of reducing initial inoculum by the use of potassium bicarbonate to control levels of the disease later in the season. It can also be seen that the application of the protectant Sentry S reduced disease levels to a greater extent still.

It could be surmised that methods of effective control of powdery mildew could be achieved by continued use of potassium bicarbonate to eradicate inoculum or use of potassium bicarbonate coupled with a protectant product such as Sentry S or Serenade later into the season to confer protection into the season.

