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Influence of summer and post-harvest application of succinic acid 2,2-dimethyl hydrazide (Alar) on winter hardiness of apple trees

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Summary

The effects of succinic acid 2,2-dimethyl hydrazide on the winter hardiness of apple trees were studied during 1970-72 at the State Research Station Blangstedgaard. Alar was applied to »Rogers McIntosh« trees during the vegetative season, and after harvesting to trees of »Close«, »Milton«, »James Grieve« and »Golden Delicious«. Determinations were made by means of the electrical conductivity method and by measurements of K+ concentration in water extract of thawed shoots. No change was observed in the winter hardiness of the trees, even when treated with extremely high concentrations (from 6000 to 16 000 ppm). Only trees of the cultivar »Close« showed less frost injury after treatment with Alar.

Introduction

Conflicting opinions are found in the literature concerning the effect of Alar on winter hardiness. *Säkö*/6/ reported that apple trees not subjected to Alar spraying survived the cold winter of 1967-68 better than did treated trees. He also observed in another experiment with 3-year-old trees, that those treated during summer months (between 21st June and 11th July) were injured more severely than their counterparts treated in the autumn. According to *Thorsrud*/8/, applications of Alar and CCC in concentrations of 1000 ppm around the middle of June, together with an additional spray of the same concentration two weeks later, had a positive and significant effect on the winter hardiness of raspberry canes. In addition, their berry yield was increased during the following summer. *Irving* /3/ found weekly applications of Alar under short day conditions to cause a significant increase in the winter hardiness of Acer negundo. *Kacperska-Palac et al.* /4/ reported a favourable effect of 4000 ppm Alar treatment on the winter hardiness of cabbage.

In recent years Alar is being used on a larger scale, primarily to reduce growth, induce earlier bearing and to improve the colour of fruits. Promising results have been obtained from experiments aimed at delaying bloom as a protection from late spring frosts. For this reason it is important to determine whether summer or post-harvest treatments of Alar have an effect on the winter hardiness of treated trees.

Material and method

Trees and cultivars. The 1970-71 study involved 12-year-old trees of the cultivars »Close«, »Milton«, »Red James Grieve« and »Rogers McIntosh« growing in the experimental orchard of State Research Station Blangstedgaard. For the 1971-72 experiments 13 year-old trees of »Golden Delicious« were taken.

Spray. Batches of three trees of the cultivar »Rogers McIntosh« were sprayed with 2000 ppm of Alar in June, July, August and Sep-

tember, respectively. After the autumn 1970 harvest single trees of »Close«, »Milton« and »Red James Grieve« were sprayed with 0, 8000, 12 000 and 16 000 ppm of Alar.

Experiments. The first artificial frost experiments was carried out on 8th February, 1971. Shoots from »Close«, »Milton« and »Rogers McIntosh« were frozen for 8 hours at – 17 ° C and for 5 hours at – 32 ° C. On 16th March another experiment was made with shoots of »Milton«, »Close« and »Red James Grieve«. Because warmer weather by now had set in, the shoots were frozen only for 8 hours at – 17 ° C. On 23rd March shoots of »Rogers McIntosh« were frozen for 8 hours at – 17 ° C and for 4 hours at – 30 ° C. Electrical conduceivity (EC) and potassium concentration (K^+) were measured as described by Stoyanov /7/.

The experiments were repeated during 1972. On 26th January and on 6th March samples of »Golden Delicious« were exposed to – 17 ° C for four and half hours and to – 32 ° C for one and half hours. The frost injury was determined only by measurements of potassium concentration.

Results

The effect of Alar application during the vegetative season was studied on trees of the »Rogers McIntosh«, treated from June until September, respectively. The experiments were carried out on 8th February and 23rd March, and the values determined were the percentage of EC and K^+ resulting from frost treatment (compared to the total values for EC and K^+ concentration measured after boiling of the samples).

As may be seen from Table 1 no significant differences were found in the levels of EC and K^+ concentration in the solutions prepared from shoots from control trees and from trees treated with Alar during previous summer.

The effect of different concentrations of Alar on winter hardiness was studied in both years. The concentrations used during the first year of the study were higher (8000, 12 000 and 16 000 ppm) than concentrations used in normal orchard practice; they were deliberately chosen such to present a clear picture of the influence of Alar on the frost resistance of apple trees.

The 1971 results (Table 2) show Alar to have no effect on the winter hardiness in cultivars »Milton« and »Red James Grieve«. The differences in percentage EC and K^+ released by exposure to low temperatures are not significant.

The data from the cultivar »Close« experiment in March show the shoots from Alar-treated trees to have lower values for the EC and the K^+ concentration, i. e., they have suf-

Tabel 1. Effect of 2000 ppm Alar application during the vegetative season on winter hardiness of the »Rogers McIntosh« cultivar

(Per cent potassium $|K^+|$ and electroconductivity |EC| in the solutions, released by artifical frost treatment, compared with total K^+ and EC, released by boiling the same samples)

	K^+		EC	
Treatment	8. Feb. 1971	23. Mar. 1971	8. Feb. 1971	23. Mar. 1971
No Alar	33.1	39.5	35.8	45.3
Alar applied on:				
16.6.1970	30.0	41.6	33.5	46.6
15.7.1970	35.0	39.6	38.0	44.5
6.8.1970	34.1	41.3	40.0	46.0
6.9.1970	33.0	41.1	36.0	44.8
	n.s.	n.s.	n.s.	n.s.

Tabel 2. Effect of different concentrations of Alar on winter hardiness of three cultivars (Per cent potassium [K+] and electroconductivity [EC] in the solutions, released by artifical frost treatment on 8 February and 16 March 1971. The Alar treatments were given in October 1970)

Concentration	K+					EC				
	Milton		Close		J. Grieve	Milton		Close		J. Grieve
	Feb.	March	Feb.	March	March	Feb.	March	Feb.	March	March
0 ppm	24.5	19.3	33.3	27.8a[1])	22.6	28.1	31.3	38.8	38.6a	32.1
8000 ppm	27.1	23.5	30.8	24.8ab	20.0	28.1	31.1	35.6	33.0b	34.8
12000 ppm	26.5	21.6	28.0	24.1b	21.5	29.0	32.8	34.8	33.8b	31.5
16000 ppm	31.1	21.6	32.5	24.3b	22.6	30.8	32.5	38.6	35.0b	34.1
	n.s.	n.s.	n.s.	*	n.s.	n.s.	n.s.	n.s.	*	n.s.

[1]) Values not followed by the same letter differ significantly at level 95 %.

fered less frosts damage than the untreated trees.

On January 26th 1972 shoots of »Golden Delicious« were tested. In this case also there was no difference in frost resistance between shoots from treated and untreated trees (Fig. 1).

As may be seen from the figure the first experiment was carried out during a period when the outside temperature was very low and when consequently the natural frosts resistance of the trees was supposed to be at high level. The second experiment was done after a period of about 30 days when average temperature was above 0 ° C. The frost resistance of the trees was expected to have been reduced, and the possible differences caused by the Alar treatment should have been more pronounced. However, the results still show no effect of Alar treatment on winter hardiness.

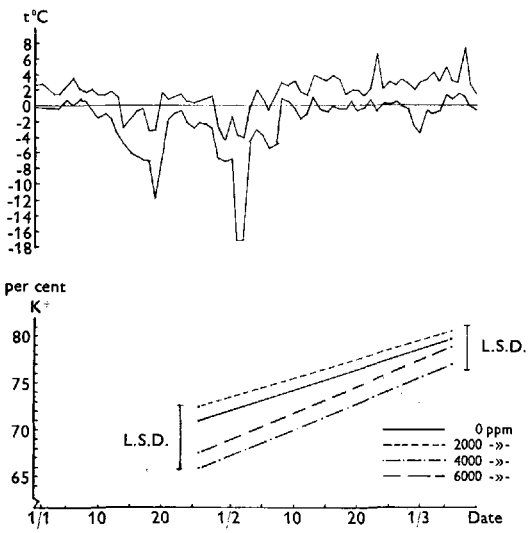

Fig. 1. Min and max temperature from 1st January till 10 March and percent of K+ released at artifical frost tests on 26 January and 6 March 1972. The total concentration of K+ is determined after boiling of samples.

Discussion

The present experiment with the »Rogers McIntosh« cultivar is similar to that described by *Säkö*/6/. In both cases the trees were treated with Alar during vegetative season, however the results are different. The present findings revealed no reduction in winter hardiness due to Alar treatment, whereas Säkö records more severe frost injuries in Alar treated trees. This may be explained by Säkö using higher concentrations (from 2000 to 6000 ppm) and younger trees (3-6 years old), compared to the 2000 ppm and 12 year-old trees used in the present experiments. Another reason could be a difference in natural frost resistance between the varieties employed /1/.

The very high concentrations of Alar sprayed after harvesting on trees of »Milton« and »Red James Grieve« did not affect their frost resitance (Table 2). Alar did not affect the winhardiness of »Golden Delicious« trees.

Certain authors reporting increases in the winter hardiness of plants caused by Alar/5/ suggest that it may be due to biological changes at cellular level following treatment with retardants. They associate high level of polysaccharides, and in particular of pentosan, with increased cold hardening.

Under the present investigations failure to obtain an effect may be explained by the late application of Alar, when leaves were already beginning to drop, and the Alar was unable to affect either synthesis or distribution of assimilates.

Table 2 shows that shoots from treated trees (»Close«, 16th March) have released less potassium and have a lower EC. This suggests that Alar may have increased the winter hardiness of these trees. They were sprayed at the same time as those of the other varieties, and it seems unlikely that Alar should have caused biological changes in this cultivar only. According to *Howell* and *Weiser* /2/ the frost resistance is very closely releated to air temperature. »Close« is an earlier variety than the rest of the cultivars and warm weather caused more pronounced de-hardening in the control trees. The Alar treated trees have been slower to react and have maintained their previously higher hardiness.

A noticeable higher percentage (more than 70 %) of potassium was released from frost treated shoots of »Golden Delicious) as compared to the other varieties. This is probabely due to weaker binding of the potassium in the tissues of this cultivar. Intact shoots of »Golden Delicious« were found to have released about 40 per cent more K^+ than intact shoots from the other cutivars.

Phenological observations in the springs of 1971 and 1972 revealed no frost injury to the trees, regardless of the concentrations used for Alar treatment, and despite the fact that the temperature in both years dropped to a minimum of – 17 ° C.

Conclusions

1. Concentrations of 2000 ppm of Alar applied during the vegetative season (June-September) had no effect on the winter hardiness of the treated trees of the »Rogers McIntosh« cultivar.

2. Even post-harvest application of extremely high concentrations (6000-16 000 ppm) of Alar to trees, tested by artifical frost of – 32 ° C, the temperature that very seldom occur in nature in Denmark, did not appear to affect the trees.

3. Alar reduced the frost injury to shoots of cultivar »Close«.

4. The use of Alar to delay blooming, improve the colour of fruits or to retard growth does not appear to introduce any risk of reducing the winter hardiness of apple trees.

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