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Report no. 1572

Post harvest and early summer Ca-spraying effect on fruit Ca content, Bitter pit and Jonathan spot in apple c.v. 'Rother Ananasapfel'

Effekt af calcium sprøjtninger efterår eller tidlig sommer på frugtens Ca-indhold og på angreb af priksyge og jonathan plet hos æblesorten 'Rød Ananas'

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Summary

In a pot experiment with apple trees, $CaCl_2$ sprayings either after fruit harvest or in late June/early July were compared to control. Early summer spraying resulted in a marked increase (50 per cent) of fruit Ca content in the fruitlets. Both treatments failed to control internal Bitter pit, while early summer sprayings achieved almost complete control of Jonathan spot. The critical prevention limit for this disorder seems to be 30 mg/kg of fresh weight at harvest, corresponding to 50–55 mg/kg in the fruitlets.

Key words: Calcium, Jonathan spot, apples.

Resumé

I et karforsøg med æbletræer, 'Rød Ananas', blev sprøjtning med calcium efter høst eller kort efter blomstring sammenlignet med usprøjtede træer. 3 sprøjtninger med 0,75 pct. $CaCl_2$ efter frugthøst kunne ikke spores i blades eller frugters Ca-indhold det følgende år. 3 sprøjtninger kort efter blomstring øgede småfrugters og blades Ca-indhold. Ved frugthøst kunne disse tidlige sprøjtninger ikke spores i frugtens Ca-indhold. Der var ingen effekt på priksyge, hvorimod 3 sprøjtninger kort efter blomstring viste en betydelig effekt imod Jonathan plet. Forekomst af Jonathan plet indicerer, at især frugter med under 30 mg Ca pr. kg friskvægt ved høst er disponeret for denne fysiologiske skade.

Nøgleord: Calcium, Jonathan plet, æbler.

Introduction

Insufficient Ca in apples causes several physiological disorders, as reviewed by *Shear* (1975). Therapy can be carried out by spraying the fruit with, or immersing it into Ca solutions, as reviewed by *Vang-Petersen* (1980a). However, some cultivars are so susceptible that this therapy fails and 100 per cent prevention is seldom achieved. *Poulsen* and *Jensen* (1964) and *Martin* (1967) have shown that some of the leaf Ca is withdrawn and stored in the stem during winter. *Terblanche et al.* (1979) proved that this Ca contributes considerably to the Ca supply in next year's new growth. An increase in these reserves could thus be valuable in obtaining higher Ca concentrations at the early stages of fruit development. Especially in cultivars very prone to Ca related disorders.

Materials and methods

A pot experiment was carried out according to the following plan:

1. Control
2. 3 sprayings with $CaCl_2$ after fruit harvest
3. 3 sprayings with $CaCl_2$ in early summer

Two years old 'Rother Ananasapfel'/MM 106, potted in April 1978 with 6 replicates in 30 litre drained plastic pots with mixed sand and perlite, were irrigated with a low Ca-solution, containing N_{10}, P_4, K_8, Ca_2, Mg_5, and $Na_{1,3}$. The indices are m.eqv./l of nutrients in the irrigation water, to which were also micronutrients added. To ensure tree growth, all fruits were removed after fruit set in 1978.

Treatment 2 and 3 were sprayed with 0.15 per cent Captan 83 + 0.75 per cent $CaCl_2$ and treatment 1 with only 0.15 per cent Captan 83 according to the schedule below. As all trees were sprayed at each spraytime, trees receiving no $CaCl_2$ were sprayed as treatment 1 with Captan only.

	Spray no.	1978	Spray schedule 1979	1980
After harvest	1	20 Sept.	24 Sept.	
(treatment 2)	2	25 Sept.	28 Sept.	
	3	29 Sept.	3 Oct.	
Early summer	1		26 June	1 July
(treatment 3)	2		2 July	4 July
	3		5 July	9 July

On 16 July 1979 and 1980 the fruits were thinned to one per cluster. A bulk sample (60–70 fruitlets) of 1 kg per treatment were analysed for Ca. In the 1979 and 1980 harvest Ca content is determined according to treatments and, across the treatments, different degrees of disorders. Each sample consisted of 15–18 randomly selected, whole fruits without stalk. For treatments and degrees of Bitter pit fruit size in the samples was 60–70 mm, and for degrees of Jonathan spot it was 50–70 mm.

Leaves for analysis, 1 sample/treatment, were picked without petioles in early September on the middle third of the laterals (*Vang-Petersen et al.*, 1973). All analyses were done at Central-analytical Department, Vejle, according to standard procedures. Total nitrogen (N) was measured by micro-Kjeldahl, K by flame photometric, Mg complexometric, P by vanadomolybdate method, and Ca by atomic absorption spectrophotometric.

Results

The leaf analysis showed Ca concentrations far below optimum, corresponding to the established low Ca concentration in the nutrient solution (Table 1). Ca applied in autumn gave no and Ca applied early summer only a slight increase of leaf Ca. In general the trees were sufficiently supplied with N, P, and K, but somewhat low in Mg according to the optimum levels.

The 1979 yield showed a slight, but not significant increase for summer $CaCl_2$ treatment, being significant in the 1980 yield. On 16 July, after

Table 1. Leaf analysis 1978–80

		Per cent of dry matter N	P	K	Ca	Mg
1978	All treatments	2.98	0.28	2.23	0.22	0.14
1979	Control	2.92	0.25	2.44	0.19	0.16
	Spraying, autumn	2.91	0.23	2.46	0.19	0.14
	Spraying, summer	2.65	0.22	2.19	0.23	0.13
1980	Control	2.74	0.17	2.00	0.25	0.14
	Spraying, autumn	2.70	0.18	2.14	0.25	0.14
	Spraying, summer	2.69	0.17	2.06	0.36	0.14

Table 2. Yield, number of fruits, Jonathan spot, and Bitter pit

	Number of fruits per tree		Yield kg/tree		Number with Bitter pit %		Number with Jonathan spot %		Number with rot %		Shoot growth cm 1980, shoots
	1978	1980	1979	1980	1979	1980	1979	1980	1979	1980	> 5 cm
1. Control	28	63	2.0	3.9	100	78.9	37.6	53.1	1.2	6.8	728
2. $CaCl_2$, autumn	29	58	2.1	3.8	100	91.3	37.2	52.0	2.8	4.1	798
3. $CaCl_2$, summer	38	80	2.5	5.1	100	64.2	3.9	9.9	0	1.0	585
Sign.	n.s.	*	n.s.	**	n.s.	n.s.	**	**	n.s.	n.s.	n.s.
LSD_{95}		14		0.8			23.1	24.3			

summer $CaCl_2$ treatment, the fruit Ca content and concentration in the fruitlets (Table 3) had increased considerably, compared with control and autumn application, the two latter with no difference. At harvest there was a tendency to decreased Ca content in the fruits for $CaCl_2$ treatments. It can be calculated that fruitlets and fruits in treatment 2 in total received 10 per cent and in treatment 3, 19 per cent more Ca from the trees than did the control. Still the Ca effect on fruit number/size has over rided this, causing a slight Ca dilution at this very restricted Ca nutrient level.

The very low final Ca concentration caused a 100 per cent Bitter pit in all treatments in 1979 and a heavy attack without significant differences in 1980 (Table 2). Jonathan spot (Fig. 1, Table 2) occurred in about one third of the fruits in 1979 and in half the fruits in 1980 in control and in fruits with autumn application of Ca, compared to 3 per cent and 9 per cent respectively in fruits with summer application of Ca.

Bitter pit and Jonathan spots, depending on the corresponding fruit Ca concentrations, are shown in Table 4. Both disorders show a great increase within a narrow range. The severity of Bitter pit from light to heavy attacks takes place at fruit Ca concentrations of around 30–25 mg/kg.

Jonathan spot seems to occur from none to heavy attacks in the range of approximately 25–20 mg/kg of fruit Ca. Dividing the fruits after increased attack of Jonathan spots was, at the same time, dividing them after increased dry matter content.

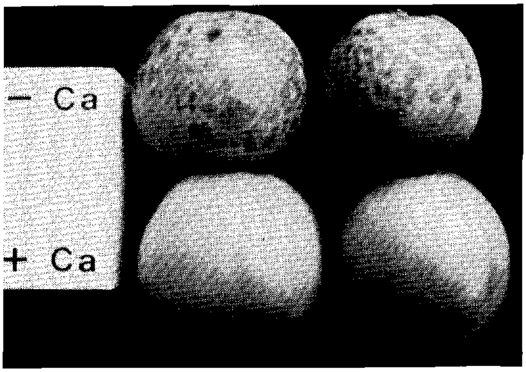

Figure 1. Fruits with Jonathan spots from trees not treated with Ca as compared to the fruits from treated trees.

Discussion and conclusion

According to the leaf analysis the Ca supply was far below optimum range (*Vang-Petersen et al.*, 1973), and far below expected values experienced in former experiments (*Vang-Petersen*, 1980b and 1980c). This confirms that the used cultivar is very prone to Bitter pit caused on Ca-problems, following a low netto Ca uptake. On this low Ca level additional Ca, spray applied in early summer, increased the yield in agreement with *Chiu* and *Bould* (1977) and *Vang-Petersen* (1980b).

The Ca sprayings caused a reduction in fruit Ca content at harvest, most pronounced for summer application. Normally Ca sprays increase fruit Ca content, but the same pattern as here can be seen in field experiment (*Van der Boon et al.*, 1968). As fruit dry matter was characteristically decreased following summer application, indices here are

Table 3. Ca content, Ca- and D.M. concentration in fruitlets and fruits

	Ca in fruitlets 16 July 1979		Ca in fruitlets 16 July 1980		Ca in fruits 20 August 1979		Ca in fruits 26 August 1980		D.M. contr. at harvest	
	mg/fruit	mg/kg	mg/fruit	mg/kg	mg/fruit	mg/kg	mg/fruit	mg/kg	1979	1980
1. Control	0.85	48	0.60	43	2.43	34	2.48	40	14.1	13.4
2. $CaCl_2$, autumn	0.91	47	0.60	44	2.03	28	2.09	32	14.1	13.8
3. $CaCl_2$, summer	1.18	77	0.73	62	2.03	30	1.91	30	13.4	12.9

Table 4. Dry matter and Ca-concentration in fruit correspondent to degree of injury

	Bitter pit				Jonathan spot			
	% dry matter		Ca, mg/kg f. wgt.		% dry matter		Ca, mg/kg f. wgt.	
	1979	1980	1979	1980	1979	1980	1979	1980
None	–	–	–	–	13.9	12.8	31	32
Light	13.6	12.4	31	27	13.9	13.3	21	27
Medium	13.6	13.1	30	24	14.3	13.8	23	22
Heavy	13.6	13.2	26	25	14.6	14.2	20	20

for an effect on the generative growth. Number of fruits was enhanced and the restricted Ca supply distributed to these caused a dilution effect.

The effect of autumn application on fruit Ca content is unexplainable, but it seems likely that vegetative growth was slightly improved, making a stronger Ca competition to the fruits.

Injury by Bitter pit was heavy in both years, but without significant differences between the treatments. As the Ca concentration in the fruits in all cases was at or below 40 mg/kg this seems to correspond well with the established limit of 55 mg/kg Ca of fresh weight in fruit flesh (*Perring*, 1968) to prevent Bitter pit.

In the case of Jonathan spot there was a very clear effect. The exceptionally low Ca net uptake induced, without any doubt, this disorder, and the Ca sprays in summer reduced it significantly. *Schumacher* (1964) found some effects of late Ca sprayings on Jonathan spot and *Bangerth* (1970) confirmed this by immersion of ripe fruits in $CaCl_2$-solution. In both cases there was only a slight effect, presumably due to relatively late treatment. *Fukuda* (1972a and b) obtained good effect of 4 mid-season, but no effect of 2 late Ca sprayings in Jonathan orchards. In the present experiment, early and intensive sprayings only a few days apart achieved almost complete control in 1979 and good control in 1980. *Krapf* (1961) found stomatas and weak or defective points on the fruit surface most prone to Jonathan spot. Accordingly, the early sprayings provided enough Ca to prevent weaknesses in fruit cuticula, but not enough to penetrate deep into the fruit flesh to prevent Bitter pit. Jonathan spot seems to occur at a lower Ca level than do Bitter pit, and 30 mg/kg seems to be the limit at fruit harvest. As there is some evidence that the injury takes place early in the season, some attention should be paid to fruit Ca concentration at that time. The critical limit in the fruitlets seems to be of 50–60 mg Ca/kg fruit fresh weight.

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Manuskript modtaget den 8. maj 1981.