EAST MALLING TRUST FOR HORTICULTURAL RESEARCH REPORT

Project SP113: Effects of foliar application of trace elements on Bramley apple quality

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This project is re-evaluating the guidelines for the optimum use of boron and zinc foliar sprays. A further two new and separate experiments were conducted from autumn 1998 to harvest 1999. The treatments were the same as those used in the previous trials, but were applied to trees in a different orchard. One experiment investigated the use of boron and the other investigated the use of zinc. Different trees were used for each experiment. The experimental trees were Bramley/M.9 planted in 1990 at 2.5 m x 5 m spacing.

Treatments consisted of a control (no application of boron) and boron application at three different stages of growth: post-harvest (before leaf drop), bloom and cell division (i.e. after petal fall). In addition, another treatment consisted of boron application at each growth stage (Table 1). The same procedure was used for the experiment investigating application of zinc (Table 1). The application rates were deliberately quite high in order to maximise the physiological effects of the treatments.

1998 experiments

Fruit quality ex-store

Apples from the boron and zinc experiments were put into controlled atmosphere (4^{o}C, 9% CO_2, 12% O_2) after harvest 1998. The fruit was removed on 21 June 1999 and those from the boron experiment were examined on 21-24 June and those from the zinc experiment were placed in air storage (4%C) until examination on 15-16 July. The quality assessment included firmness, skin colour, storage disorders and rots (Table 2).

Boron application caused a small difference of firmness ex-store. Apples that had received boron during cell division were slightly firmer and those from the trees that received the autumn (post harvest 1997) treatment were softer than the untreated apples. However, this effect was not significant at <5% level. The quantities of rots, internal and external corking were unaffected by boron application. Background colour was not influenced by boron, as no treatment effects were found on colorimeter (L, a, b) measurements (data not presented).

Zinc application at any stage of development had no influence on firmness. None of the zinc applications significantly changed the amount of internal corking compared to the untreated trees. However, the amount of internal corking was significantly greater in fruit from the bloom than those from the post-harvest application. Background colour (colour cards) were similar for fruit for all treatments.

1999 experiments

Boron experiment

Results

The total numbers of floral buds per tree were low for all trees and were not influenced by autumn boron application (Table 3). First flowering occurred on 20 April; full bloom occurred 30 April. All secondary blossom was removed. Overall fruit set was reduced by frost damage that occurred during the nights of 14-17 April when air temperatures dropped below 0°C. Total fruit set per tree was generally unaffected by boron application, except when it was applied at all growth stages (i.e. post-harvest, bloom and cell division), which reduced set (Table 4). This latter effect was due to a reduction in the numbers of fruit that set in all positions.

The major role of boron in fruit trees involves fruit set, and flowers contain high concentrations of boron. The receptacle of the flower contains the carpel that surrounds the ovule, which in turn develops into the fruit after fertilisation with pollen. Therefore changes in the boron concentration of these tissues are most likely to influence fruit set and quality. Open flowers were taken from all the trees at late bloom (17 May 1999) and the petals removed to leave the receptacle; the concentrations of boron, nitrogen, phosphorus, potassium, calcium and zinc were measured. Only the results for boron and calcium are presented in Table 5, as the concentrations of none of the other minerals were affected. The post-harvest application of boron had only a small statistically non-significant effect on the concentration of boron in the receptacles, whereas the application at bloom increased the concentration by 128% (Table 5). This effect persisted after fruit set, as fruitlets sampled (5 July 1999) from trees receiving boron application at bloom contained concentrations of boron 27% higher than the control fruit that had received none. Application of boron at cell division doubled the concentration found in fruitlets (Table 6). The greatest concentration was found in fruitlets that received boron treatments at all stages of development. The concentration of none of the other minerals measured in the fruit was affected (data not presented). Due to the small size of the fruitlets, the skin and flesh (excluding the seed) were pulped for analysis. Prior to chemical analysis, the fruitlets were washed; therefore the increase in boron concentration as a result of the application at "cell division" was not due to the chemical residues on the skin surface. None of the boron applications influenced calcium concentration in the receptacles or fruitlets.

The total yield per tree varied between 12.8–20.0 kg per tree (10–16 tonne ha^{-1}), but was highly variable from tree to tree (Table 7). There were no statistical differences in the mean yield per tree between any of the boron treatments. However, the data for fruit numbers at harvest were consistent with the data for fruit set as the trees receiving boron at all growth stages also had the lowest numbers of fruit at harvest. The quantity of fruit in the commercially important grade of Class 1 80-110 mm was unaffected by boron application.

At harvest, fruit samples were taken for mineral analysis and determination of fruit quality after storage. Leaf samples were taken in August for mineral analysis.

Zinc Experiment

Results

The total numbers of floral buds per tree were low for all trees and the application of zinc post-harvest had no influence on the numbers of fruit buds that developed (Table 8). The numbers of fruit set were low partially because of frost damage between 14-17 April; in addition all secondary blossom was removed. However, application of zinc at bloom reduced the total numbers of fruit that set per tree compared to the untreated control. This was due to reductions in the numbers of fruitlets in the spur and terminal positions (Table 9). This difference was reflected at harvest when the numbers of fruit per tree were lowest for trees receiving zinc during bloom and highest for trees receiving zinc during cell division. However, it should be noted that the fruit set on trees treated at cell division was not significantly greater than the untreated control. The reduction in fruit numbers per tree also reduced the total weight of fruit per tree (Table 10). The greatest weight of Class 1 80-110 mm fruit was found for the trees receiving zinc at cell division and the lowest weight was from the trees receiving zinc at full bloom. These results contrast with those found in 1998 (see report September, 1998) when the cell division application of zinc caused a reduction in initial set and the bloom application had no influence.

Open flowers were taken from all the trees at late bloom (17 May 1999) and the petals removed to leave the receptacle. The concentrations of zinc, phosphorus, potassium, calcium, magnesium, manganese and boron were measured. The application of zinc at bloom significantly increased the concentration of zinc recovered in the receptacle and slightly increased the calcium concentration. None of the other mineral elements was influenced by zinc application (only results for zinc and calcium are presented in Table 11). After fruit set the concentration of zinc in the fruitlets was increased by the bloom and cell division applications (Table 12). The highest concentration was found in the fruit that was treated at all development stages; this fruit contained three times the concentration of zinc found in the untreated controls. This treatment reduced calcium concentration compared to all the other treatments.

At harvest, fruit samples were taken for mineral analysis and determination of fruit quality after storage. Leaf samples were taken in August for mineral analysis.

Conclusions

- Application of zinc and boron had no negative effect on fruit quality ex-store compared to untreated controls.
- Fruit set was generally unaffected by application of boron.
- Zinc application at bloom reduced fruit set.
- Application of boron at cell division increased concentration of boron in fruitlets.
- Application of zinc at bloom and cell division increased concentration of zinc in fruitlets.
- Application of boron had no influence on harvest yield and grade out.
- Application of zinc at bloom reduced harvest yield and grade out of Class I 80-100 mm fruit whereas application at cell division increased harvest yield and grade out of Class 1 80-100 mm fruit compared to untreated controls.

Table 1. Application of boron and zinc treatments

Boron (2 ml Bortrac/litre)

*Rate litre/tree	Rate l/ha	Date of application	Treatment
-	-	-	No Application
1	800	8/10/98	Post harvest
0.9	720	15/10/98	
1.2	960	26/04/99	Bloom
1	800	29/04/99	
1	800	06/05/99	
1	800	27/05/99	Cell division
0.7	560	07/06/99	
0.7	560	10/06/99	
1	800	08/10/98	All
0.9	720	15/10/98	
1.2	960	26/04/99	
1	800	29/04/99	
1	800	06/05/99	
1	800	27/05/99	
0.7	560	07/06/99	
0.7	560	10/06/99	

Zinc (Zinc heptasulphate 4.4 g/litre)

*Rate litre/tree	Rate l/ha	Date of application	Treatment
-	-	-	No Application
1	800	08/10/98	Post harvest
0.9	720	15/10/98	
1.2	960	26/04/99	Bloom
1	800	29/04/99	
1.1	880	06/05/99	
1.1	880	27/05/99	Cell division
0.8	640	07/06/99	
0.7	560	10/06/99	
1	800	08/10/98	All
0.9	720	15/10/98	
1.2	960	26/04/99	
1	800	29/04/99	
1.1	880	06/05/99	
1.1	880	27/05/99	
0.8	640	07/06/99	
0.7	560	10/06/99	

*Tree sprayed to run off

Table 2. The effect of zinc and boron applications on storage disorders in Bramley/M.9apple trees fruit harvested on 17 September 1998 after removal from CA storage (4ºC, 9% $C0_2$, 12% 0_2) 21 June 1999

Zinc application Growth stage	Firmness out of store (N)	Rots %	External Corking %	Total internal Corking %	Corking index 1-100 (100=severe)	Core flush %	Skin colour L	Skin colour a	Skin colour b
No application	58.4	6	20	15	8	10	58.0	-12.4	26.6
Post-harvest	59.8	1	11	8	4	11	57.7	-12.4	27.1
Bloom	57.9	2	25	24	12	10	57.5	-12.5	27.0
Cell division	59.2	2	21	15	8	22	57.9	-12.5	27.1
All	59.2	4	17	13	7	9	57.3	-12.5	26.9
Significance	ns	ns	ns	*	ns	ns	ns	ns	ns

* statistically significant (<5%)
ns not statistically significant (>10%)

Boron application Growth stage	Firmness out of store (N)	Rots %	Corking %	Corking index 1-100 (100=severe)	Core flush %
No application	61.0	4	26	14	12
Post-harvest	59.2	3	37	20	17
Bloom	60.9	2	21	11	15
Cell division	62.8	3	24	11	12
All	61.5	2	21	10	17
Significance	(*)	ns	ns	ns	ns

(*) statistically significant (<10%)
* statistically significant (<5%)
ns not statistically significant (>10%)

Table 3. The effect of post-harvest boron application on numbers of floral buds per tree

19/4/99

Growth stage	Axillary	Spur	Terminal	Total
No application	1	26	39	65
Post-harvest	4	22	48	73
Significance	ns	ns	ns	ns

ns not statistically significant (>10%)

Table 4. The effect of timing of boron application on initial fruit set per tree 11/6/99

Growth stage	Axillary	Spur	Terminal	Total
No application	2	15	41	57
Post-harvest	6	16	42	64
Bloom	6	8	38	52
Cell division	3	15	52	69
All	0	7	30	37
Significance	(*)	(*)	ns	*

(*) statistically significant (<10%)
 * statistically significant (<5%)
ns not statistically significant (>10%)

Table 5. The effect of time of application of boron on the concentration of boron and calcium in flower receptacles of Bramley/M.9 apple trees on 17/5/99

Growth stage	Boron µg/g dry weight	Calcium mg/g dry weight
No application	53	3.0
Post-harvest	58	3.1
Bloom	121	3.0
All	129	3.0
Significance	*	ns

* statistically significant (<5%)
ns not statistically significant (>10%)

Table 6. The effect of time of application of boron on the concentration of boron and calcium in fruitlets of Bramley/M.9 apple trees on 5/7/99

Growth stage	Boron µg/100 g fresh weight	Calcium mg/100 g fresh weight
No application	258	6.9
Post-harvest	293	6.1
Bloom	327	6.0
Cell division	495	6.4
All	680	6.5
Significance	*	ns

* statistically significant (<5%)
ns not statistically significant (>10%)

Table 7. The effect of time of application of boron on yield and grade out of Bramley/M.9 trees at harvest 1/9/99

Growth stage	Total yield/tree (kg)	Total number of apples/tree	Wt. Class I 80-110 mm (kg)	% Class I 80-110 mm	Wt. Class II 90-120mm (kg)	% Class II 90-120 mm
No application	17.17	48	7.33	42	0.45	3
Post-harvest	18.96	56	8.41	46	0.93	6
Bloom	15.90	64	7.87	49	0.20	1
Cell division	19.97	54	7.83	42	0.49	3
All	12.83	36	5.87	44	0.53	7
Significance	ns	ns	ns	ns	ns	*

* statistically significant (<5%)
ns not statistically significant (>10%)

Table 8. The effect of timing of zinc application on numbers of floral buds per tree 19/4/99

Growth stage	Axillary	Spur	Terminal	Total
No application	1	21	42	64
Post-harvest	1	19	36	56
Significance	ns	ns	ns	ns

ns not statistically significant (>10%)

Table 9. The effect of timing of zinc application on initial fruit set per tree 11/6/99

Growth stage	Axillary	Spur	Terminal	Total
No application	0	11	37	48
Post-harvest	1	10	32	42
Bloom	1	7	30	37
Cell division	1	16	41	57
All	1	13	24	37
Significance	ns	ns	(*)	(*)

(*) statistically significant (<10%)
ns not statistically significant (>10%)

Table 10. The effect of time of application of zinc on yield and grade out of Bramley/M.9 trees at harvest 1/9/99

Growth stage	Total yield/tree (kg)	Total number of apples/tree	Wt. Class I 80-110mm (kg)	% Class I 80-110 mm	Wt. Class II 90-120mm (kg)	% Class II 90-120 mm
No application	15.69	41	5.11	33	7.47	48
Post-harvest	13.23	35	4.95	38	5.67	43
Bloom	11.48	31	4.03	35	5.32	47
Cell division	18.24	52	8.44	44	6.80	41
All	10.83	35	4.15	40	3.16	28
Significance	*	*	*	ns	*	*

* statistically significant (<5%)
ns not statistically significant (>10%)

Table 11. The effect of time of application of zinc on the concentration of zinc and calcium in flower receptacles of Bramley/M.9 apple trees on 17/5/99

Growth stage	Zinc µg/g dry weight	Calcium mg/g dry weight
No application	44	2.8
Post-harvest	44	3.0
Bloom	57	2.6
All	62	2.6
Significance	*	(*)

(*) statistically significant (<10%)
ns not statistically significant (>10%)

Table12. The effect of time of application of zinc on the concentration of zinc and calcium in fruitlets of Bramley/M.9 apple trees on 5/7/99

Growth stage	Zinc µg/100g fresh weight	Calcium mg/100g fresh weight
No application	52	6.2
Post-harvest	54	5.4
Bloom	83	6.2
Cell Division	110	6.6
All	151	4.9
Significance	*	*

* statistically significant (<5%)
ns not statistically significant (>10%)