**APRC Project Report**

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| **Project SP113** | Apple nutrition |
| **Contractor:** | Horticulture Research International – East Malling |
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This project is re-evaluating the guidelines for the optimum use of boron and zinc foliar sprays. Two new and separate experiments were conducted from autumn 1997 to harvest 1998. 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/M9 planted in 1990 at 3 m x 5 m spacing.

Treatments consisted of a control with 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.

**Boron experiment**

Background

The major role of boron in fruit trees involves fruit set and flowers contain high concentrations of boron. The boron in the flower is mainly transported from reserves in the wood during development of the flower. Boron sprays applied in the autumn are therefore considered to be the most effective in increasing boron boron content of flowers. The boron remobilised and transported into the flowers is from the adjacent branches and not from the root. The concentration of boron in flowers may vary from year to year due to temperature differences, bloom density and growing conditions of the previous year. Drought reduces boron concentration in the tree. The concentration of boron in leaves is not always a good guide for the influence on fruit set as supplementary boron has been shown to be beneficial even when leaf analysis has indicated adequate quantities. Boron increases pollen germination and pollen tube growth in vitro, but high boron content of buds does not enhance pollen tube growth in vitro. No evidence shows that increased fruit set is caused by better pollen germination or pollen tube growth. Boron may enhance cell division or nucleic acid synthesis in the developing fruit, which may influence fruit set. Furthermore, any enhancement of cell division has important implications for fruit quality as an increase in number of cells in apples, linked to increases in dry matter concentration improves fruit texture and firmness.

Results

The effectiveness of applications at different stages of growth on increasing the concentration of boron in the receptacles of the flower was investigated. The receptacle contains the carpel that surrounds the ovule. The ovule develops into the fruit after fertilisation with pollen. Therefore changes in the concentration of these tissues are most likely to influence fruit set and quality. Flowers were taken from all the trees at full bloom (18/5/98) and the petals removed to leave the receptacle. Post-harvest application of boron was effective in significantly increasing the concentration of boron in the receptacles by 37% (Table 2). Calcium concentration was also slightly increased applications of boron although this effect was not statistically significant. The number of fruit that set per 100 flowers was consistently increased by application of boron (Table 3), but this effect was not statistically significant. Therefore lower concentration found in the trees that had received no foliar application of boron was sufficient to provide good fruit set. Boron application at any growth stage had no effect on the total number of spur and terminal floral buds and initial fruit set in these positions compared to untreated trees (Table 4). The mean yields and number of fruit per tree at harvest were not statistically significantly different (Table 5). The fruit was graded manually into class 1 and class 2 in size ranges <80, 80-90, 90-100, 100-110, >110 mm. A summary is presented in Table 5. The mean proportions and weights of Class 1 fruit 80-110 mm and Class 2 fruit 90-110 mm were not statistically significantly different between treatments. Therefore, it may be concluded that boron application at any stage of growth did not influence blossom quality, harvest yield and grade out.

Preliminary investigations using leaf washing and marker techniques have indicated that the boron was absorbed quickly by the leaves – a high proportion within 24 hr of application. The sprays were applied on dry days and therefore it is unlikely that lack of responses in fruit set and yield were due to non-absorption because the foliar applications were washed off by rainfall. However, the absorption of boron by leaves will be more fully investigated next year. The influence of boron application on leaf and fruit mineral concentrations and storage quality will be presented in the next report.

**Zinc Experiment**

Background

Apple is more susceptible to zinc deficiency than many other deciduous species. Deficiency causes reduced shoot extension and in extreme cases tip death. Zinc is closely associated with the production of auxin, the primary growth hormone and enzymes that control protein synthesis, fruit set and ripening. Zinc also has been implicated in increasing dry matter concentration, sugar and acid content and cracking of fruit.

Results

Post-harvest application of zinc was ineffective in raising the concentration of zinc in the receptacles of the flowers, but application during bloom significantly increased concentration by 7% (Table 6). This confirms recent work from elsewhere that has shown that zinc is immobile and after uptake, it remains in the leaves and is not easily transported to storage organs. Zinc had no effect on the number of floral buds that developed (Table 7), but initial fruit numbers per tree were significantly reduced by 17% by application after petal fall during the period of cell division (Table 8). This effect was particularly marked where zinc also had been applied previously at other stages of growth and fruit numbers per tree were reduced by 32%. The number of flowers that set fruit was unaffected by application of zinc (Table 8), therefore the reduction of fruit numbers was due to increased abscission of fruit caused by the late application of zinc. The reduction in the number of fruit that remained on the tree resulted in fewer fruit at harvest and lower harvest yields than non-sprayed trees or trees sprayed post-harvest or at bloom with zinc (Table 9). The grade out of fruit reflected fruit yield at harvest because the proportion of fruit within particular size grades remained approximately the same. The weight of class 1 fruit 80-110 mm was greatest for trees that received no zinc application or for which zinc was applied before the cell division stage.

Preliminary investigations using leaf washing and marker techniques have indicated that the zinc was absorbed more slowly than boron by the leaves. Therefore loss due to wash off by rain is more likely. The absorption of zinc by leaves will be more fully investigated next year. The influence of zinc application on leaf and fruit mineral concentrations and storage quality will be presented in the next report.

Table 1 Application of Boron and Zinc treatments

| Nutrient | Rate litre/tree | Date of application | Treatment |
|---|---|---|---|
| Boron (Bortrac) | 1.8 | 14/10/97 | Post-harvest |
| 2 ml Bortrac/ litre | 1.6 | 22/10/97 | |
| | 1.6 | 3/11/97 | |
| | 1.0 | 8/4/98 | Bloom |
| | 1.5 | 23/4/98 | |
| | 1.5 | 8/5/98 | |
| | 1.5 | 21/5/98 | Cell division |
| | 1.4 | 8/6/98 | |
| | 1.5 | 12/6/98 | |
| | Applied all above dates at same rates | | All |
| | No application of boron | | No application |
| Zinc | Rate | Date of | Treatment |
| (Zinc heptasulphate) | litre/tree | application | |
| 1g Zinc/ litre | 1.6 | 23/10/97 | Post-harvest |
| | 1.6 | 3/11/97 | |
| | 1.0 | 8/4/98 | Bloom |
| | 1.6 | 24/4/98 | |
| | 1.8 | 8/5/98 | |
| | 1.6 | 21/5/98 | Cell division |
| | 1.6 | 8/6/98 | |
| | 1.5 | 12/6/98 | |
| | Applied all above dates at same rates | | All |
| | No application of zinc | | No application |

Table 2 The effect of time of application of boron on the concentration of boron and calcium in flower receptacles of Bramley/M9 apple trees in 1998

| Growth stage | Boron mg/g dry matter | Calcium mg/g |
|---|---|---|
| No application | 75 | 2.5 |
| Post-harvest (1997) | 103 | 2.8 |
| Bloom | 87 | 2.7 |
| All | 109 | 2.8 |
| LSD | 20.8 | 0.24 |
| Significance | * | ns |

* statistically significant
ns not statistically significant

Table 3 The effect of boron application on number of fruit set per 100 flowers

| Growth Stage | |
|---|---|
| No application | 49 |
| Post-harvest (1997) | 59 |
| Bloom | 53 |
| Cell division | 54 |
| All | 59 |
| LSD | |
| Significance level | ns |

ns not statistically significant

Table 4 The effect of boron application on number of floral buds and initial fruit set per tree

| Growth stage | Spur | Terminal | Total | Initial Set |
|---|---|---|---|---|
| No application | 86 | 109 | 194 | 221 |
| Post-harvest (1997) | 84 | 107 | 191 | 213 |
| Bloom | 71 | 101 | 172 | 230 |
| Cell division | - | - | 204 | 235 |
| All | 73 | 107 | 180 | 201 |
| LSD (5%) | 31 | 21 | 44 | 57 |
| Significance level | ns | ns | ns | ns |

ns not statistically significant

Table 5 The effect of time of application of boron on yield and grade out of Bramley/M9 trees at harvest

| 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 90-120 mm (kg) | % Class II 90-120 mm |
|---|---|---|---|---|---|---|
| No application | 54 | 228 | 38 | 70 | 4 | 9 |
| Post-harvest (1997) | 46 | 200 | 32 | 70 | 3 | 6 |
| Bloom | 46 | 189 | 34 | 73 | 3 | 7 |
| Cell division | 50 | 215 | 36 | 72 | 3 | 6 |
| All | 44 | 179 | 33 | 74 | 3 | 8 |
| LSD (5%) | 10.6 | 55.1 | 8.4 | 9.5 | 2.2 | 5.1 |
| Significance level | ns | ns | ns | ns | ns | ns |

ns not statistically significant

Table 6 The effect of time of application of zinc on the concentration in flower receptacles of Bramley/M9 apple trees in 1998

| Growth stage | Zinc mg/g dry matter | Calcium mg/g |
|---|---|---|
| No application | 42 | |
| Post-harvest (1997) | 42 | |
| Bloom | 45 | |
| All | 46 | |
| LSD | 2.9 | |
| Significance | ** | |

** highly statistically significant

Table 7 The effect of zinc application on number of floral buds and initial fruit set per tree

| Growth stage | Spur | Terminal | Total | Initial Set |
|---|---|---|---|---|
| No application | 130 | 83 | 213 | 223 |
| Post-harvest (1997) | 180 | 82 | 263 | 252 |
| Bloom | 162 | 92 | 254 | 251 |
| Cell division | | | | 185 |
| All | 160 | 97 | 258 | 152 |
| LSD (5%) | 59 | 19 | 59 | 56 |
| Significance level | ns | ns | ns | ** |

ns not statistically significant
** highly statistically significant

Table 8 The effect of zinc application on number of fruit set per 100 flowers

| Growth Stage | |
|---|---|
| No application | 50 |
| Post-harvest (1997) | 50 |
| Bloom | 47 |
| Cell division | 52 |
| All | 43 |
| LSD | |
| Significance level | ns |

ns not statistically significant

Table 9 The effect of time of application of zinc on yield and grade out of Bramley/M9 trees at harvest

| 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 90-120 mm (kg) | % Class II 90-120 mm |
|---|---|---|---|---|---|---|
| No application | 50 | 178 | 37 | 75 | 4 | 6 |
| Post-harvest (1997) | 56 | 248 | 41 | 74 | 3 | 4 |
| Bloom | 53 | 214 | 38 | 72 | 4 | 6 |
| Cell division | 38 | 169 | 28 | 72 | 2 | 3 |
| All | 41 | 178 | 37 | 70 | 2 | 5 |
| LSD (5%) | 8.6 | 49.7 | 6.6 | 7.9 | 2.2 | 4.9 |
| Significance level | *** | * | *** | ns | ns | ns |

* statistically significant
** highly statistically significant
*** very highly statistically significant