# Chapter 5

# GENERAL DISCUSSION

## 5.1 Effect of Boron on Seed Number and Fruit size

The present study showed that with increasing B application, number of seeds fruit$^{-1}$ and fruit size increased. Effect of B deficiency on reduction of seed number was also observed in other crops (Gupta, 1993; Noppakoonwang, 1991). Both maximum seed number fruit$^{-1}$ (11.5) and fruit size were obtained in B80. Williams (1977) confirmed that 11 seeds fruit$^{-1}$ in Delicious apple were required for maximum fruit size.

That fruit size increased with increasing seed number may be attributed to the fact that apple belongs to pome fruit which forms fruit from a receptacle. Growth of the receptacle requires endogenous hormone induction and stimulation (Yang, 1993). Developing seed of apple produce endogenous hormone such as cytokinins, gibberellins and auxin (Hoad, 1978; Luckwill, 1953). Cytokinins promote cell division whereas auxins and gibberellins promote cell elongation in young fruit of apple (Chen, 1969; Letham, 1963).

Therefore, it may be concluded that the apart from promoting vegetative growth, B supply may have indirect increase in fruit size through increasing number of seed. Thus, if small apple fruit have seed number fruit$^{-1}$ lower than 11, small fruit size may be caused by B deficiency.

**5.2 Effect of Boron on Fruit Yield and Its Quality**

Wang (1992) established the criteria for ascertaining high fruit quality in apples in China. The highest rank of Golden Delicious apple quality was given to fruit with a diameter > 75 mm, firmness > 11 kg $cm^{-2}$, soluble solids > 12%, and a sugar:acidity ratio ranging from 29 to 40. In this study, only B80 and B160 tree had fruit diameters >75 mm, B0, B40 and B80 trees fruit had a firmness > 11 kg $cm^{-2}$, all treatments produced fruit with soluble solids > 12 % and B0, B40 and B80 trees fruit had a sugar:acidity ratio within 29 to 40. Thus, all high quality criteria were satisfied only in fruit from B80 trees having mean leaf B concentration of 21.5 mg B $kg^{-1}$ dry wt at harvest.

High B fruit reached maturity earlier since fruit color developed faster and firmness decreased faster compared with low B fruit (Tables 4.4 and 4.5; Bramlage and Thompson, 1962; Bramlage and Thompson, 1963; Bramlage and Weis, 1991; Yogaratnam and Johnson, 1982). Thus, in part the high yield and fruit quality in high B fruit in the present experiment may be due to late harvest suggesting that B may have indirectly increased yield and yield quality through earlier fruit maturity.

However, the present experiment results suggested that B also directly increased yield and fruit quality and its direct effect dominated its indirect effect through earlier maturity. This may be explained by the fact that 50% of fruit skin in B0 and B40; B40 and B80 became yellow at the same time but yield in B40 and B80 trees were higher than those in B0 and B 40, respectively (Table 4.4). In addition, diameter, length, weight and total sugar of fruit in B80 trees were higher than those in B40 respectively. (Tables 4.3, 4.4 and 4.5). By contrast, although fruit in B80 reached maturity 5 days after that in B160, there was no difference of their yield, weight and total sugar of fruit. This suggests that harvesting time had little or no effect on yield and some fruit quality. However, firmness in high B fruit generally lower than those in low B fruit (Table 4.5) suggesting that firmness decreased with fruit development so that high B fruit should be harvested earlier.

Above explanation suggested that B directly increased yield and some fruit quality such as total sugar, size and weight of fruit but B indirectly decreased fruit firmness through its earlier maturity.

The small fruit size and low weight due to B deficiency in the present experiment may be attributed to the fact that B deficiency decreased cell division, cell enlargement of fruit and vegetative growth at early reproductive stage. At 4W, fruit length and shoot length in B0 and B40 trees were already reduced (Tables 4.1 and 4.3). Frank (1986) suggested that a rapid phase of cell division occurs in the first few weeks after pollination and ceases abruptly within 30-40 days after full bloom. The subsequent fruit growth occurs mainly due to cell expansion. Kouchi (1977) and Lovatt *et al* (1981) suggested that B deficiency decrease cell division and enlargement. In addition, decreasing shoot growth due to B deficiency at early reproductive stage may have led to decreasing photosynthate for fruit development later. The limiting photosynthate decreased fruit weight in B0 trees in spite of low photosynthate requirement due to low fruit number tree$^{-1}$ (Table 4.4).

Thus, if fruit in B0 and B40 trees had been harvested 5 days later, size and weight of fruit would have increased by little or not at all since fruit size was already limited at the early fruit development and photosynthate was limited at the late fruit development. However, fruit should not be harvested after 5 days after ripening since its firmness will decrease below criteria of high quality fruit as it was seen in B160 tree harvested 10 days after ripening. In order to obtain high fruit quality in B160 trees, fruit should have been harvested 5 days earlier to increase their firmness.

High total sugar due to B application have been observed in many crop such as sugar beet (Shkolnik, 1984) and radish (Shelp, *et al*, 1987). It has been found that high fruit B concentration had high sugar in *Malus* species (Brown and Hu, 1996).

### 5.3 Selection of Plant Part for Diagnosis of Boron Deficiency in Fruit

Fruit B concentration should not be used to access B status in apple fruit since it is likely to vary with fruit weight and fruit weight is controlled by many factors affecting vegetative growth including insect, disease, solar radiation, temperature, water supply and nutrient application. In the present experiment, the limiting factors for fruit development is B deficiency. Consequently, B supply increased fruit weight through promoting vegetative growth to provide photosynthate for late fruit development. Thus, B content in fruit did not directly increased fruit weight but increasing fruit weight decreased B concentration in fruit.

The above discussion may explain why the calibration curve for diagnosis of B deficiency based on fruit B concentration had poorer ability to identify deficient and adequate B levels than that based on fruit core B concentration (Figure 4.6).

Changing of fruit weight may have little or no effect on fruit core B concentration since relatively high concentration of B accumulated in fruit core (Figure 4.3) and fruit core weight comprised only a small proportion of apple fruit. Thus, calibration curve can be obtained by correlation of fruit core B concentration with yield or total sugar (Figure 4.7). In addition, calibration curve also can be obtained by correlation of leaf B concentration with yield and total sugar (Figure 4.8).

Compared with fruit core, sampling and preparation of leaves for B analysis are easier and quicker. Thus, in the field, leaf B concentration should be preferred to be used for diagnosis of B deficiency in apple. However, fruit core can be used for diagnosis of B status in apple fruit especially in the market where leaves are not available.