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Drs. G. H. Neilsen, F. Kappel, P. Toivonen, and D. Neilsen

A Closer Look At P And Water Management On Productivity Of Apple And Sweet Cherry

Five-year study shows benefits of P fertigation on apple; research on sweet cherry in early stages.

Summary: *Cumulative yield over five years was increased by phosphorus (P) primarily as a result of an increase in annual apple number rather than average fruit size. In two of three measurement years, water core was decreased by P fertigation and in two years fruit browning was inhibited by P, implying a role for this nutrient in post-harvest, apple membrane stability. Research on sweet cherry is still in the early stages but increasing irrigation frequency to four times daily, relative to applying the same quantity of water every two days, increased tree (canopy) size by the end of the second growing season and improved tree response to mulch and P fertigation.*

Traditionally, P fertilization frequently has been ignored in nutrition programs for high value fruit crops because the amount of P required in mature apple orchards can be as low as 18 lbs/A (20 kg/ha) and relatively few responses to P fertilization have been documented. However, root density of crops such as apple is relatively low and responses to P fertilization have occurred under conditions where root length may be limiting, as when trees are newly planted or when replant disorders further inhibit root growth. Drip fertigation has improved the availability of P to trees by allowing mass flow delivery of high P concentration directly to the root surface rather than depending upon the slow movement of P via diffusion. Phosphorus fertigation can improve tree P nutrition and performance and has become a standard first-year recommendation for growers in southern interior British Columbia (B.C.). However, little is known about persistence of the effect if P is fertigated annually.

Similarly, little is known concerning the effect of P fertigation on other tree fruits such as sweet cherry, which has a shorter growing season and normally more vigorous root growth. The rapid expansion of the sweet cherry industry in B.C. and the Pacific

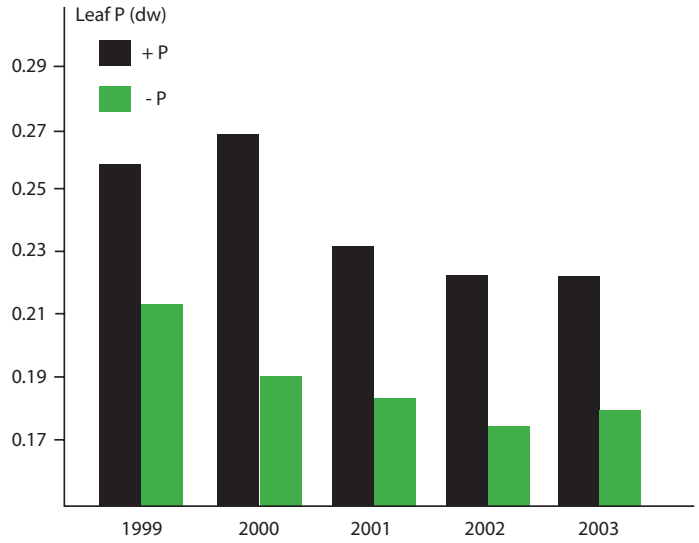

Figure 1. Midsummer leaf P concentration for all apple cultivars as affected by presence of P (+P) or absence of P (-P) fertigation near bloom,1999-2003.

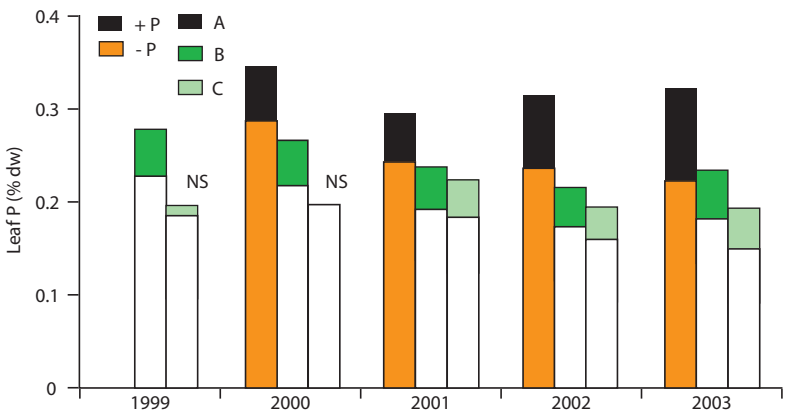

Figure 2. Leaf P concentration as increased by P fertigation at bloom throughout the growing season (times A, B, C) for 'Fuji' cultivar.

Northwest of North America, and increased interest in dwarfing sweet cherry rootstocks with a higher unit area yield potential have stimulated interest in strategies such as P fertigation, which could improve establishment and fruiting of sweet cherry.

For these reasons, P fertigation experiments were established on high-density apple and sweet cherry orchards in the semiarid fruit growing region of B.C.

Apple

P nutrition. Annual fertigation of a single-time application of ammonium polyphosphate near bloom, early in the growing season, consistently increased mid-terminal, mid-summer leaf P concentration of all apple cultivars in the first five growing seasons (Figure 1). Increases were particularly pronounced early in the growing season (four weeks post bloom, time A) each year as illustrated for the 'Fuji' cultivar (Figure 2). In the first two years (1999-2000), leaf P concentration was unaffected when measured twelve weeks post bloom (time C). However, subsequently increased leaf P concentration was apparent at time C. Concentration of P in harvested fruit was also nearly always increased by P fertigation. The single exception was fruit P values for 'Gala' apple in 2001, which, unlike the other five cultivars, were not significantly increased by P application.

Clearly, the single-time fertigated application of P strongly influenced P nutrition of both vegetative and reproductive tissue, indicating P applied by this method was readily available to all five apple cultivars tested. The mobility of a single-time large application of fertigated P has been measured previously in coarse-textured, sandy loam soils and attributed to the movement of P in mass flow with irrigation waters after saturation of reaction sites near the zone of P applications.

Yield. Both cumulative fruit number and per-tree yield over the first five harvests for all five apple cultivars were increased by P fertigation (Figure 3). There was no overall effect on apple fruit size. When considering yearly

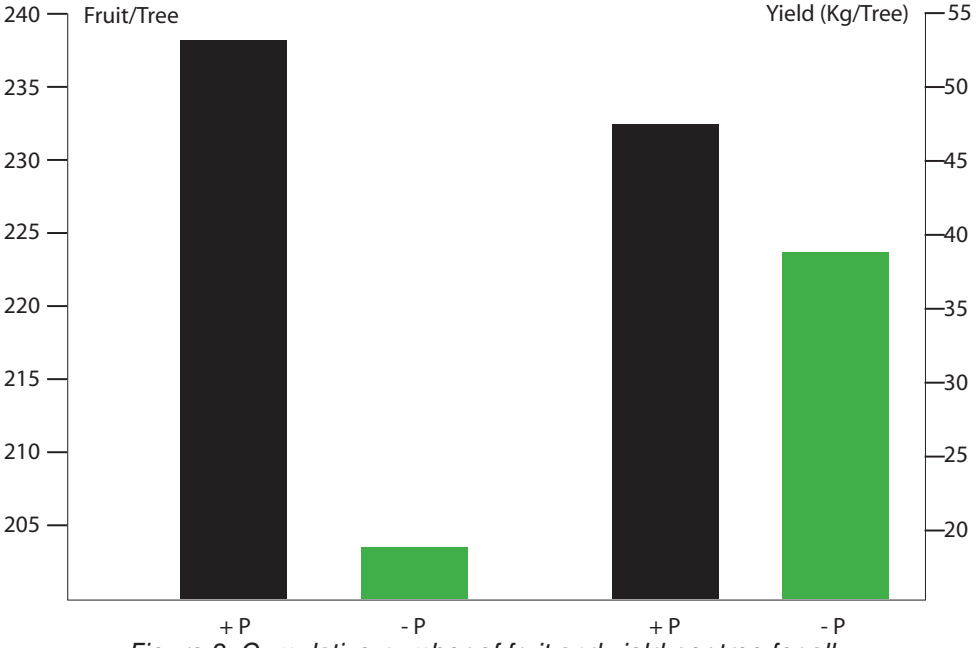

Figure 3. Cumulative number of fruit and yield per tree for all apple cultivars as affected by presence of P (+P) or absence of P (-P)fertigation near bloom, 1999-2003.

patterns, significantly increased annual yield was measured for all or some of the cultivars in three of the five years (data not shown). Similar increases were measured for number of fruit for two harvests and for fruit size only in the first year.

The benefits of P fertigation associated with increase per tree yield appear to result from an increase in fruit number rather than average fruit size. A stimulatory effect of P application on blossom formation has previously been observed. Yield response to P has not been widely reported for tree fruits although a multi-year effect of superphosphate application rate on tree growth, fruit set and yield has been observed in Australia. The results reported here would suggest that a single-time P application to trees receiving N and K fertigation will increase yield over the first five growing seasons.

Fruit quality. The fruit disorder called water core was reduced by P fertigation in two of three measurement years (2002-2003). In 2001, both cultivars that had the disorder ('Fuji' and 'Silken') had reduced incidence associated with elevated fruit P concentration. The same pattern was observed for P fertigated fruit over all cultivars in 2002 but significant effects were not observed in 2003. Occurrence of water core is of less practical significance for 'Fuji' since water core virtually disappears after cold air storage of this cultivar. Reduction of water core in 'Silken' is more useful since this yellow-skinned cultivar shows the disorder more readily. Regardless, the results imply that P has beneficial effects on fruit membrane stability.

P fertigation also inhibited browning of cut apple slices after one week of storage at 1°C in modified atmosphere packages in 2001 and 2002, the years when water core was reduced by P fertigation. The P treatment also decreased membrane leakage and increased antioxidant (water soluble and lipid soluble) contents for 'Fuji' after 90 days cold storage in 2002 (data not shown). Adequate fruit calcium concentrations long have been associated with optimizing fruit quality and minimizing fruit disorders. These data would suggest further research is justified to explore the relationship between fruit P concentration and fruit quality.

Cherry

Initial growth and yield. Both high frequency irrigation and application of a surface mulch increased stomatal conductance of sweet cherry leaves when periodically measured during July and August, the period of peak evapotranspiration. No stomatal conductance measurements were made on cherries receiving P fertigation. Trunk cross sectional area (TCSA) measurements by the end of the second growing season (November 2006) were affected by an interaction between irrigation frequency and soil management strategy. Application of the same amount of water four times daily (I-1), rather than every second day (I-2), increased TCSA (and tree canopy volume with which it is correlated), regardless of soil management strategy, even though the different irrigation treatments were only initiated in the second year (2006). The I-1 treatment was particularly effective with mulching and P fertigation, resulting in greatest growth. Irrigating at I-2 reduced growth of trees receiving P fertigation and mulched trees relative to control (no mulch, no P fertigation), implying more frequent irrigation is beneficial for early growth of trees in a mulched planting system. The number of fruit produced in the second growing season was very small but significantly increased at I-2 and for P fertigated and control soil management treatments relative to mulching.

Drip irrigation has improved the availability of P to trees.

In the first two establishment years of the cherry block, irrigation frequency had the largest effect on tree performance by improving tree water relations during the stressful mid-summer period so that stomates likely remained open longer, improving C assimilation by the plant. In turn, this developed large canopies and created conditions where further improvements in plant growth were possible for soil management treatments involving P fertigation and maintenance of a bark mulch.

Nutrition. Frequent irrigation increased leaf K concentration regardless of soil management strategy but did not significantly affect leaf P concentration. Leaf concentrations were increased by mulching and P fertigation. Leaf K concentration was highest under mulching and lowest for P fertigated treatments applied to 12 trees.

Dr. G. H. Neilsen is soil fertility and plant nutrition expert, Dr. Kappel is sweet cherry breeder, Dr. Toivonen is post-harvest/fruit quality specialist, and Dr. D. Neilsen is soil and water management scientist at the Pacific Agri-Food Centre, Agricultural Canada, Summerland, B.C.