

Dr. Patrick Brown

# Can Boron Correct Transient Nutrient Deficiencies?

Recent California experiments using foliar applications seem to indicate so. More research is needed.

**Summary:** *Over the past five years we have conducted considerable research into the unique effectiveness of targeted boron (B) fertilization and have observed that foliar B applications frequently increase fruit set and yield if applied during reproductive growth. Biochemical, isotopic, and molecular experimentation demonstrate that a transient B deficiency is common during reproductive growth and that B plays a unique but poorly understood role in reproduction. A transient nutrient deficiency is a short-term deficiency that occurs during a specific period of crop development, such as during flowering or seed fill.*

*Although this research on B clearly demonstrates that transient nutrient deficiencies occur and have important effects on tree yields, there is inadequate research to verify if transient deficiencies of other elements occur, or to determine if fluid fertilizers are the most efficient method of correction. Verifying the importance of transient deficiencies would provide a rationale for the use of fluid fertilizers in horticultural, field, and row crops. Such verification also represents a significant and important research challenge.*

**F**luid fertilizers are used in U.S. agriculture as both a replacement for solids and for their unique capacity to provide

nutrients quickly and effectively. The use of fluids often allows for highly localized and specifically tailored nutrient applications that are not as easily provided using solid or blended products. Very little research is available, however, that demonstrates the unique value of fluid fertilizers and the role they play in providing a balanced nutrient supply.

Although foliar fertilizers represent only a subset of all fluid fertilizers, recent advances in application of foliar fertilizers to provide balanced nutrition and resolve short-term nutrient deficiencies offer valuable lessons.

Foliar fertilizers have been used by fruit growers since the early 19<sup>th</sup> century and have become an important management practice in all well-managed orchards. Sup-

plying nutrients by foliar is expensive however, requiring careful consideration of both cost and relative benefit when compared with conventional soil applications.

Foliar application is well justified under soil conditions that limit nutrient solubility as a consequence of 1) unfavorable pH or chemical composition of the nutrient, 2) where there are excess soil concentrations of competing ions or 3) where there are unfavorable conditions for root growth and nutrient uptake. To this end a wide variety of chemical formulations are available to help supply nutrients that are made unavailable under certain soil conditions. Foliar fertilizers are also used frequently in the ornamental and turf industry where

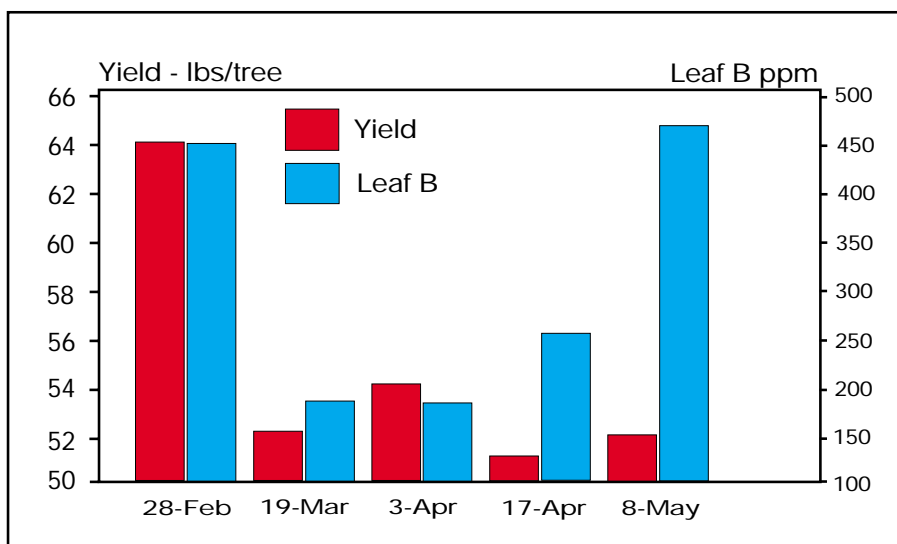


Figure 1. Effect of application date of foliar B (5 lbs Solubor/100 gal) on yield and leaf B in pistachio, Brown, U of Cal.

B gal/tree	Yield lbs in-shell splits/tree	B in ppm	
		Buds	Leaves (July)
<b>Foliar</b>			
0	19	35	170
2	22	37	185
5	26	39	171
10	21	41	210
<b>Soil</b>			
2	19	35	172
4	19	38	189
6	20	44	201
8	21	50	219

B applications. It can be seen that soil-applied B was most effective at raising tissue B levels. Plants supplied 6 or 10 oz *Solubor* in 1990 had tissue B concentrations (in 1992) higher than trees that received foliar applications alone. Nevertheless, trees that received foliar B showed a positive yield response while those receiving soil B did not. This indicates that adequate leaf B status does not ensure optimal tree productivity. Apparently foliar applications of B serve a unique role in enhancing pistachio fruit set.

Figure 1 demonstrates that the most effective time for application of foliar B was the late dormant spray (Feb 28—immediately pre-anthesis) in which a yield increase of as much as 20 percent over control trees was recorded. Later sprays effectively increased tissue B levels but did not increase fruit yield, even though all B sprayed trees yielded more than trees not receiving supplementation. The effectiveness of early but not late B sprays is evidence that B is critical for pollination or fertilization of pistachio flowers.

#### Olive response

Foliar B application immediately pre-anthesis significantly altered the ratio of perfect to imperfect flowers, increased

rapid re-greening of tissues is needed for aesthetic purposes.

A significant commercial justification for the use of foliar fertilizers is based upon the premise they offer specific advantages over soil fertilizers under certain conditions of high nutrient demand. Examples of conditions that prompt commercial use of foliar fertilizers include 1) periods of peak nutrient demand such as during rapid fruit growth when nutrient demand can exceed nutrient supply even in a well-fertilized soil or 2) occasions when localized within-plant demand exceeds the capacity for within-plant nutrient redistribution.

Although the use of foliar fertilizers to overcome soil physical and chemical properties is well defined and many examples of its implementation are available, use of foliar fertilizers to prevent or overcome transient deficiencies has received scant attention. In spite of this lack of sound experimentation it is the purported effectiveness of foliar fertilizers at preventing and correcting transient deficiencies that is the basis for the sales of many commercial foliar fertilizers.

What follows is experimental evidence supporting the occurrence of transient nutrient deficiencies and how they can be efficiently corrected by foliar fertilization. Also discussed are the broader implications of these results as a rationale for the use of foliar fertilizers.

#### Pistachio response

Table 1 compares the effectiveness of soil B applications with respect to foliar

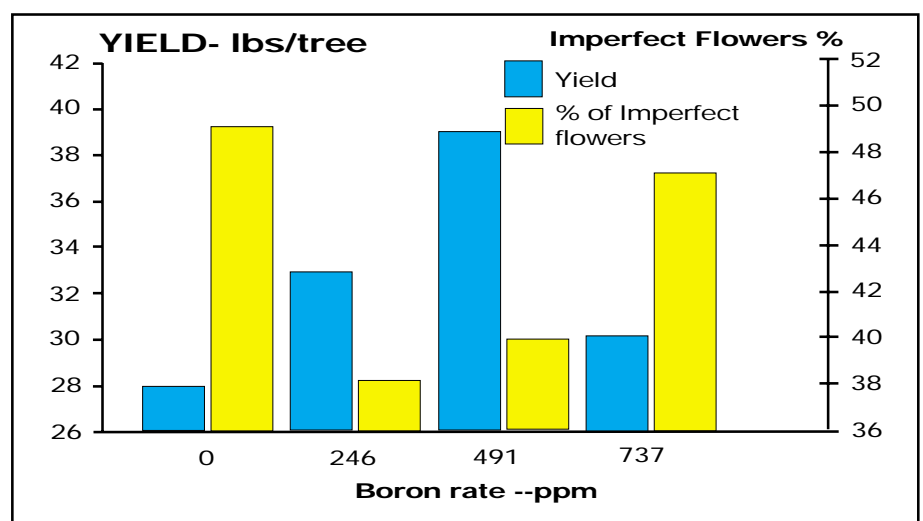


Figure 2. Influence of pre-anthesis foliar B on olive reproduction, Brown, U of Cal, 1999.

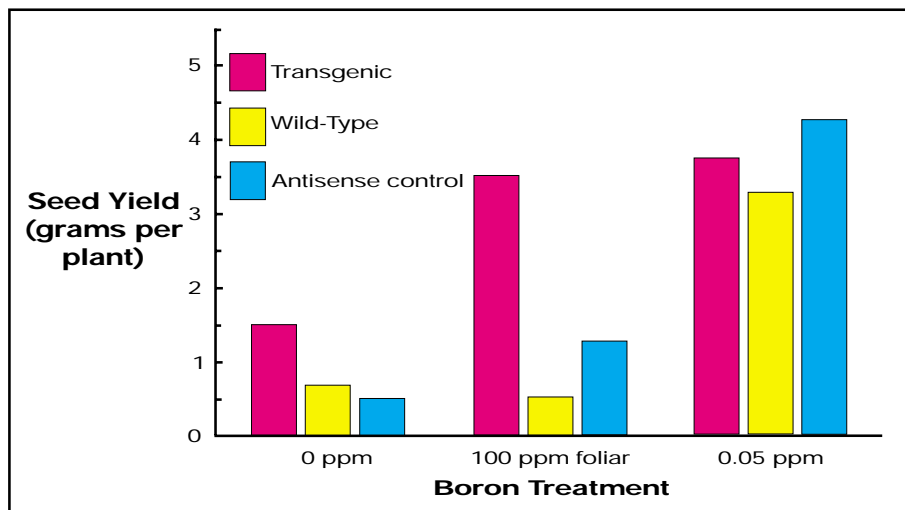


Figure 3. Seed yield of tobacco lines grown for 28 days with adequate B then transferred to growing medium that supplied either 0 ppm B, 0.05 ppm B to roots, or 100 ppm B spray applied to three mature leaves, Brown, U of Cal.

fruit set (results not shown), and increased final yield (Figure 2). Soil B status did not influence the response of plants to foliar B (results not shown).

#### Tobacco response

Following removal of B from the growth medium, significant flower abortion and subsequently reduced seed production occurred in both wild-type and antisense tobacco plants where a gene is put in backwards as an experimental control (in which B is immobile), demonstrating that a brief deficiency of B can have a profound effect on flowering (Figure 3). The application of foliar B had no beneficial effect on these plants.

Tobacco plants with the capacity to transport B in the phloem to flowers (transgenic) did not exhibit rapid flower abortion and in all cases produced significantly more seed than plants with limited phloem B mobility (Figure 3). With the application of foliar B, the transgenic tobacco equaled the performance of the control plants, showing that effective use of foliar fertilizers can entirely replace the need for soil B supply. Reduced seed set in the transgenic tobacco grown for an extended period in 0 ppm B is a consequence of the deple-

tion of all remobilizable B and the ultimate occurrence of B deficiency throughout the plant.

#### Conclusions

Each of these experiments demonstrates the potentially significant effect of short-term nutrient deficiencies and the role fluid fertilizers can play in maintaining a balanced nutrient supply.

The results of experimentation in both pistachio and in olive, as well as many other experiments, demonstrates that foliar B application can result in correction of an apparent deficiency that is not responsive to soil B application. This is most apparent in pistachio where foliar B fertilization applied pre-anthesis increases pollen germination, reduces blanking and non-splits (results not shown), and consequently increases yield. This stimulation occurs even in trees with summer B concentrations in excess of 150 ppm, indicating that there is a specific requirement for B in the developing flower. The most effective method to ensure adequate B for flowers is through foliar application. Soil applications of B are effective at raising leaf B levels but are not as effective as foliar sprays at increasing yield. Adequate leaf B levels are not a guarantee of opti-

mal yield.

The apparent superiority of foliar B can best be explained as a consequence of a transient inadequacy in B supply to the reproductive tissues from the soil. This may occur as a consequence of low root activity in cool soils, high B requirement in developing flowers, or low transport of B to the reproductive tissues. All of these explanations suggest that transient deficiencies of B can occur and they may not be efficiently corrected through soil fertilization. To our knowledge, this is the clearest example of a transient nutrient deficiency and a justification for application of foliar fertilizers.

The results here clearly demonstrate that transient nutrient deficiencies occur and can be important determinants of yield. The evidence also suggests that foliar fertilizers can, on occasions, be uniquely effective at correcting these deficiencies. Based upon these results, we conclude that transient deficiencies of nutrients may occur as a consequence of a combination of spatial and temporal variations in plant nutrient demand and supply, and will be influenced by the relative mobility of the nutrient in the plant.

From our extrapolations, we further conclude it is likely that fluid fertilizers represent a powerful technique to deliver nutrients in a balanced, effective, and efficient manner that minimizes periods of transient deficiencies.

Further research must be conducted to determine if transient deficiencies of other nutrients occur and if fluid fertilizers play a unique role in their correction.

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Dr. Brown is professor in the Department of Pomology at the University of California.