# Using Dormant Shoots to Determine the Nutritional Status of Peach Trees

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**Keywords:** *Prunus persica*, nitrogen, phosphorus, zinc, boron, nutrient sampling

**Abstract**

**Nutrient analysis of leaf samples taken in mid summer has been as a standard practice for assessing the nutritional status of fruit trees throughout the world. This timing was originally proposed because most nutrient levels remain fairly stable for an extended period, thus creating a wide window for sampling. However, it is generally too late in the season to assist in making fertilization decisions regarding the crop for that year. Instead, orchard managers are much more interested in evaluating the condition of their trees early in the season when they can still influence parameters such as fruit set, shoot growth, fruit growth and fruit quality. Therefore, it would be very useful to be able to measure the nutritional status of fruit trees early in the spring and develop sufficiency ranges for each nutrient. Researchers have been able to do this with some success using flower and early leaf samples. The goal has been to evaluate the nutritional status of dormant shoots and relate it to various parameters of tree performance and productivity. The information was obtained from 60 'Zee Lady' peach trees and 60 'Grand Pearl' nectarine trees growing in large sand tanks since 2000. Applying fertilizer salts at differing rates has resulted in trees varying substantially in most nutrients. Many measures of tree performance have been taken including flower density, fruit set, early shoot growth, fruit size at thinning time, final fruit size, fruit quality and total vegetative growth. Visual ratings were also made of different leaf symptoms and levels of defoliation. Many of these parameters related well to nutrient levels measured in dormant shoots sampled in January or February of 2003 and 2004. Thus, good relationships have been obtained for nitrogen (N), phosphorus (P), boron (B) and zinc (Zn), and tentative deficiency thresholds have been proposed. Some of the other nutrients have not shown good relationships, mainly because distinct deficiency symptoms have not yet been induced. So far, this approach generally shows great promise as a tool to help peach growers fine tune the fertility program in their orchards.**

## INTRODUCTION

Having a reliable nutrient sampling method is the first step in a sound fertilizer management program for fruit trees. Without this procedure, unnecessary fertilizers may be applied, thus wasting resources and potentially contaminating soil and water or even causing toxicity in the trees. The standard technique that has been used for at least 50 years is a mid summer leaf sample (Batjer and Westwood, 1958). Researchers have found the concentration of most nutrients remains fairly stable for a period of several months during this time. Therefore, standard deficiency thresholds and sufficiency ranges have been established and widely tested on different cultivars and in different locations (Leece et al., 1971). Although it has been a very useful procedure in a fertility management program, it suffers from a problem of timing. Many processes affecting yield and fruit quality, such as flowering, fruit set, fruit cell division, fruit bud initiation and early shoot growth, occur in the early spring. If a nutrient is deficient and thus limiting to one or more of these processes, the mid summer leaf sample would be too late for any corrective measures in that season. An early season sampling procedure could potentially overcome this problem.

Researchers have recently reported some success with using other tissues such as flowers (Sanz and Montanes, 1995) or early leaf samples (Montanes and Sanz, 1994; Sanz et al., 1992) for nutrient analysis. For some corrective measures, this is still too late. It would be even more useful to take a dormant season sample so corrective treatments could be imposed at the beginning of bloom if necessary. Deciduous fruit trees recycle many of their nutrients from senescing leaves in the fall and depend on these stored nutrients for initial growth in the spring. Therefore, dormant tissues should reflect the relative abundance of nutrients and indicate whether they might be limiting for growth and other processes. Several studies have shown varying levels of nutrients in dormant shoots and roots (Cummings, 1973; Knowles et al., 1984). The authors of this report have analyzed nutrients in both dormant roots and shoots, but will focus on dormant shoots in this report for at least three reasons. First, shoots are much easier to collect and therefore more likely to be sampled by growers. Second, the concentration of nutrients in roots varies greatly with root diameter (Cummings and Xie, 1995) making it extremely difficult to take a standard sample. Third, for many of the nutrients, shoots tend to reflect the amount of fertilizer added better than the roots. This study is on peaches and nectarines, but the same principles (and maybe even some of the thresholds) should apply to other deciduous fruit crops as well.

## MATERIALS AND METHODS

The information for this study was gathered from 60 peach and 60 nectarine trees planted in large sand tanks in 2000. The polyethylene tanks (2.4 m x 3.4 m x 1.2 m deep) were placed in four trenches in the field, fifteen per trench. Sand was placed under each tank to provide a slight slope towards one end. At the lower end holes were drilled and a manifold system was installed to collect drainage water into a 200 L drum buried beside each tank. A 5 cm diameter pipe extends to the surface from each drum so drainage water can be pumped out. Once the tanks were in place they were filled with sand and the trench around the tanks was backfilled with native soil.

In mid February 2000, one tree each of Zee Lady peach, Fortune plum and Grand Pearl nectarine was planted in each tank. Trees were trained to a perpendicular V system with two 2.4 m bamboo poles per tree used to insure uniform tree shape. A low volume irrigation system was installed with 2 emitters per tank. From 2000 through 2002 emitters of equal volume were used in all the tanks. In 2003 and 2004, emitters with three different discharge rates were placed in the tanks depending on tree size. Generally, the trees have been over-irrigated by 10 to 20% to prevent water stress.

Initially, all trees were fertilized with N-containing-fertilizers to ensure good growth. Starting in 2001, combinations of fertilizer salts were applied to the different tanks in an effort to achieve the following treatments. Each treatment was replicated in four tanks. Treatment 1 – All nutrients; Treatment 2 – No nutrients; Treatment 3 – No N; Treatments 4 and 5 – No P; Treatments 6-7 – No K; Treatments 8-9 – No Ca; Treatment 10 – No S; Treatments 11-12 – No Mg; Treatments 13-15 – No micronutrients (B, Zn, Mn, Fe, Cu, Mo).

Each year from 2001 through 2004, measurements were made of flower density, fruit set, thinning fruit weight and number, yield, harvest fruit weight, fruit defects, fruit color, fruit soluble solids content and trunk cross sectional area growth. Leaf samples were also taken in April and July of each year from every tree. Samples were washed, oven dried at 65°C, ground and sent to the UC Analytical Lab for determination of N, P, K, S, Ca, Mg, B, Zn, Mn, Fe and Cu. Dormant shoot samples were collected in January or early February of 2003 and 2004 and analyzed for nutrients in the same manner. Although data has been collected for all three species, only the peach and nectarine data will be presented in this paper.

## RESULTS AND DISCUSSION

By 2004 evidence of N, P, B and Zn deficiency was observed in many of the peach and nectarine trees. These deficiencies were manifest in many different ways including leaf symptoms, reduced vegetative growth, smaller fruit size, fruit cracking, misshapen fruit, reduced fruit set and premature fruit drop and leaf senescence. Often these symptoms or defects were correlated with nutrient concentrations in the dormant shoots, thus allowing nutrient thresholds to be estimated for each. In the following discussion, each of these four nutrients will be discussed separately. Evidence of deficiency will be presented and a deficiency threshold in dormant shoots will be proposed.

### Nitrogen

Nitrogen deficiency was easy to impose on the peach and nectarine trees growing in sand culture. Typical symptoms of reduced shoot growth, yellow leaves, reddish stems, smaller fruit size, more highly colored fruit, advanced maturity and more smooth fruit finish (Johnson and Uriu, 1989) were all observed. July leaf concentrations as low as 1.61% in 2004 were measured (Table 1), indicating extreme deficiency. At the other extreme, leaf N concentrations over 4.0% were obtained from vigorously growing trees.

Despite these substantial differences in leaf values, the dormant shoot differences were not as great. Values ranged from 0.91 to 1.88% (Table 1) but often the N deficient trees were only slightly different from the high N trees. Combining both cultivars in both years, an average dormant shoot N value of 1.19% was obtained for the deficient trees. However, the well-fertilized control trees averaged just 1.28%. Even though the difference is small, a tentative deficiency threshold of 1.20% was set. Continued research will be needed to refine this value or perhaps come up with an alternative test. Other research studies suggest root N or certain N containing compounds such as arginine may be better indicators of tree N status (Taylor and van den Ende, 1969).

### Phosphorus

Phosphorus deficiency started showing up in a few peach trees in 2003 and was clearly evident in both peaches and nectarines in 2004. P concentration in leaf samples was as low as 0.06% by July of 2004 (Table 1). There were many different symptoms in the deficient trees including substantial reduction in both vegetative and fruit growth, fruit cracking (especially in nectarines), more flattened fruit (cheek to cheek) in peaches, preharvest fruit drop in peaches and premature defoliation in both peaches and nectarines. As these leaves senesced, they tended to have more red or purple coloration rather than the typical yellow or orange color of well-fertilized trees.

P concentrations in dormant shoots were slightly lower but generally quite similar to the levels found in July leaf samples (Table 1). Symptoms of deficiency tended to correlate well with the levels of P found in dormant shoots. For example, nectarine fruit cracking in 2004 was largely due to low P (deficient Zn also contributed – see Zinc discussion). Particularly severe cracking was found at P concentrations below 0.10% (Fig. 1). As long as dormant shoot P was maintained above 0.12% (and Zn was not deficient), fruit cracking was kept to a minimum. This threshold of 0.12% also applied to fruit cracking and premature drop in peaches, and early defoliation in both peaches and nectarines.

### Boron

Boron deficiency has been associated with low fruit set in a wide range of crop plants (Chaplin and Westwood, 1980; Nyomora et al., 1997; Shorrocks, 1997). Fruit set in the sand tank peach and nectarine trees varied considerably from tree to tree in both 2003 and 2004 (from 5 to 86%). Generally, this correlated best with tree B status, although other nutrients appear to have played a secondary role. Also, trees low in B had slightly smaller fruit size at harvest. There have been no other symptoms such as chlorotic leaves or fruit defects that would indicate a deficiency. In general, the trees testing deficient in B were healthy looking and vigorous, with normal appearing fruit.

July leaf B levels ranged from 14 to 36 ppm in the sand tank trees (Table 1). In general, the dormant shoots had concentrations about half of the summer leaf samples, ranging from 8 to 22. For both the peach and the nectarine, and in both years, a significant correlation was found between dormant shoot B concentrations and fruit set. Fig. 2 illustrates this relationship for Zee Lady peach in 2003. The correlation coefficient for Grand Pearl nectarine was not as large (but still statistically significant), probably because other nutrients contributed to the relationship. For both cultivars, fruit set was most drastically reduced when shoot B dropped below about 14 ppm.

**Zinc**

Zinc deficiency is a widespread disorder in California fruit trees (Johnson and Uriu, 1989). It has often been termed "little leaf" after one of its main symptoms. Other symptoms include wavy leaf margins and interveinal chlorosis. In the spring of 2004, about half the sand tank trees exhibited some degree of these deficiency symptoms. Four pomology experts independently rated the trees on a scale from 0 to 5, with 5 indicating severe symptoms. The average of these four scores was graphed against dormant shoot Zn concentration for that tree (Fig. 3). Although some trees with Zn values as low as 9 or 10 ppm showed no detectable deficiency symptoms, the majority of trees with these levels exhibited extreme deficiency. At concentrations above 20 ppm, there were no indications of deficiency in any trees.

Fruit cracking in Grand Pearl nectarine was also increased by low Zn. If the trees with low P (and thus severely cracked) are removed from the analysis, the remaining points show a significant relationship with dormant shoot Zn (Fig. 4). Once again a deficiency threshold of 20 ppm fits this data set. In contrast to the other three nutrients discussed so far, Zn levels in dormant shoots tend to be higher than July leaf concentrations (Table 1).

## CONCLUSIONS

Based on two years of data from peach and nectarine trees growing in sand tanks, dormant shoots appear to be a reliable tissue for determining the nutrient status of N, P, B and Zn. Deficiency thresholds have been proposed for these nutrients (Table 1) and will be evaluated in commercial orchards. Research will continue so that deficiency thresholds can be established for other nutrients and to improve testing for N.

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## Tables

Table 1. Range of N, P, B and Zn in July leaf samples and January shoot samples for Zee Lady peach and Grand Pearl nectarine in sand tank experiment for 2003 and 2004, and proposed deficiency threshold for dormant shoot samples.

| Element | Range in July leaf samples | | Range in January shoot samples | | Deficiency threshold[z] |
|---|---|---|---|---|---|
| | 2003 | 2004 | 2003 | 2004 | |
| Nitrogen (%) | 1.93-4.18 | 1.61-3.75 | 1.05-1.88 | 0.91-1.55 | 1.20 |
| Phosphorus (%) | 0.09-0.24 | 0.06-0.21 | 0.08-0.18 | 0.06-0.17 | 0.12 |
| Boron (ppm) | 14-36 | 19-36 | 9-22 | 8-18 | 14 |
| Zinc (ppm) | 5-18 | 5-28 | 9-47 | 8-39 | 20 |

[z] Levels proposed for dormant shoots.

## Figures

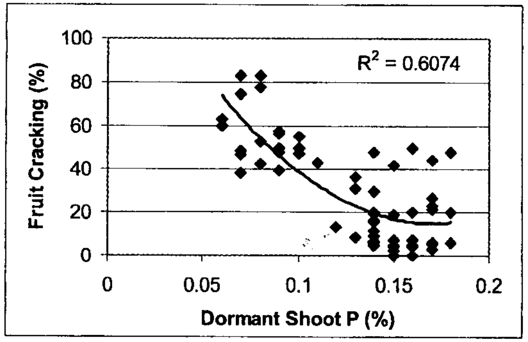



Fig. 1. Relationship between fruit cracking and dormant shoot P for Grand Pearl nectarine in 2004.

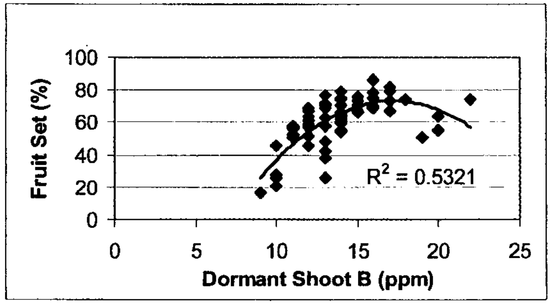



Fig. 2. Relationship between fruit set and dormant shoot B for Zee Lady peach in 2003.

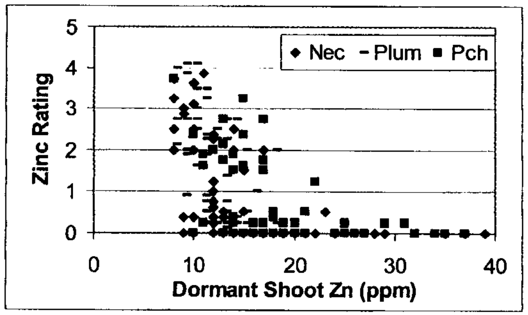



Fig. 3. Relationship between Zn deficiency rating (0 = none, 5 = severe) and dormant shoot Zn for Grand pearl nectarine, Fortune plum and Zee Lady peach in 2004.

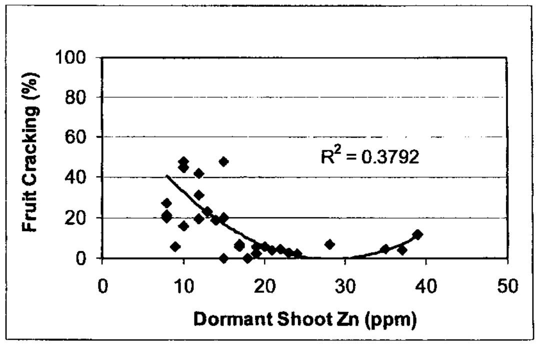
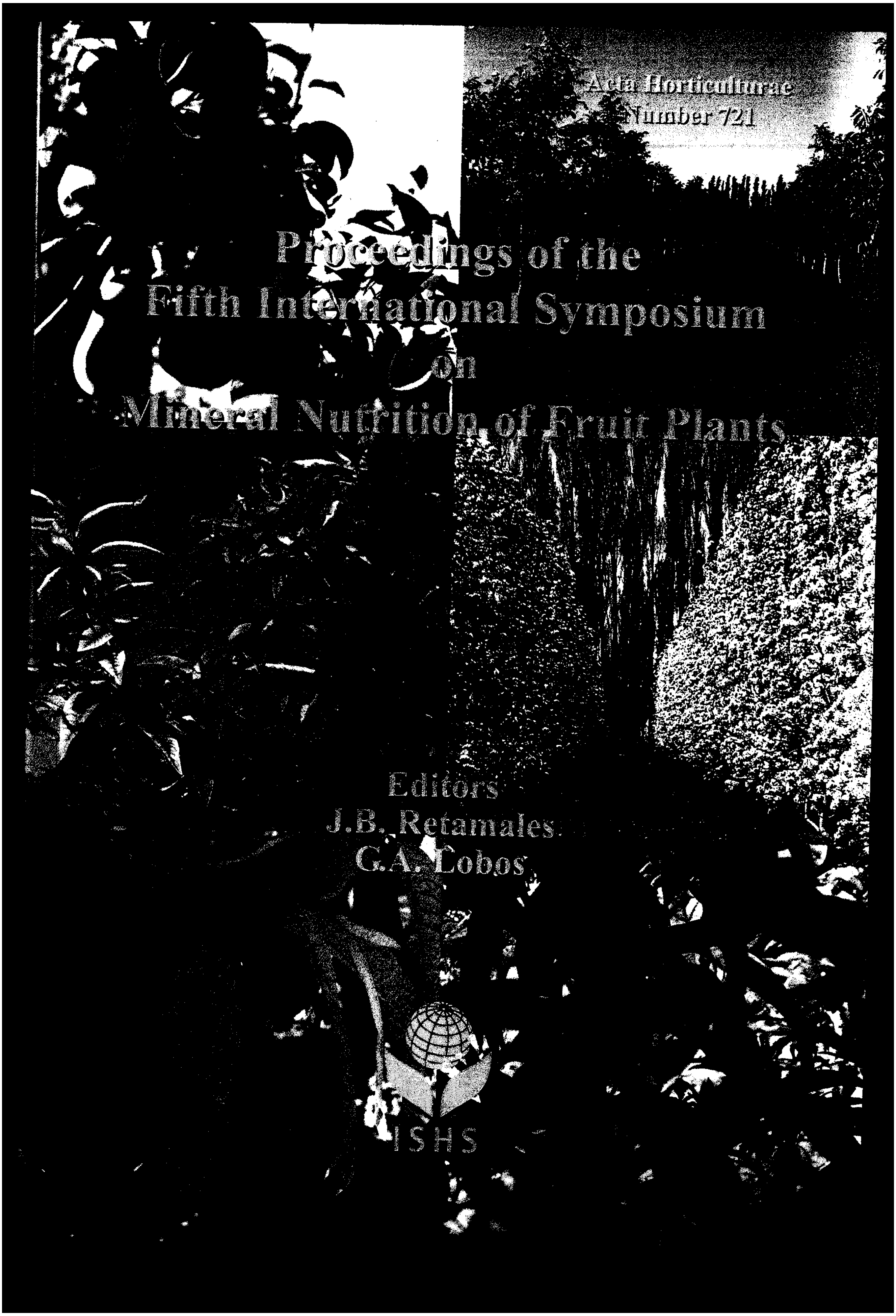



Fig. 4. Relationship between fruit cracking and dormant shoot Zn for Grand Pearl nectarine in 2004. All data points with shoot p≤0.0012 (see Fig. 1) removed from the analysis.



Acta Horticulturae
Number 721

# Proceedings of the Fifth International Symposium on Mineral Nutrition of Fruit Plants

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