REFINING STONE FRUIT DEFICIENCY AND SUFFICIENCY NUTRIENT LEVELS

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Introduction

The standard procedure for determining nutritional status of stone fruit trees was established many years ago. It involves taking a sample of mature leaves in June or July and analyzing for all macro and micro nutrients. Tables have been published indicating sufficiency ranges and deficiency thresholds (and sometimes toxicity levels) for each element. These tables were developed from leaves showing deficiency symptoms, from hydroponic experiments with small seedlings and from surveys of healthy and deficient orchards. For some nutrients, there has not been enough experience with deficiencies in the field to establish a threshold. Generally, these studies have not related the nutrient status of the tree to the different components of yield or fruit quality except in a qualitative way.

Over the past 5 years we have developed a system for studying the nutrition of mature peach and nectarine trees in the field. We planted trees in 60 large sand tanks and have been differentially fertilizing them in order to obtain widely varying nutrient contents. The full details of the treatments and results have been presented elsewhere (Johnson et al., 2003) and will not be reported here. For the purpose of this paper only the average fruit weight data from 2002 and 2003 on Zee Lady peach and Grand Pearl nectarine will be used. This information, together with a rather obscure method of analyzing nutritional data, will be presented as evidence for changing the currently established deficiency thresholds.

Boundary Line Analysis

In 1972, Webb proposed the use of a boundary line for many different types of biological data (Webb, 1972). He claimed for a given body of data where there is a cause and effect relationship between two variables, there exists a line at the edge of the data set representing the

best performance in the population. In other words, there is a theoretical maximum potential that can be achieved by the dependent variable at any given value of the independent variable. Recently, Schnug et al. (1996) applied this concept specifically to nutritional effects on yield of field crops. With enough data points, a clear boundary line emerges which indicates the loss of yield potential at deficient (and sometimes excess) nutrient levels. Schnug et al. (1995) have proposed a method for mathematically estimating this line. As we analyzed nutritional effects on fruit weight from our sand tank experiment, the data often appeared very scattered. However, it became clear that maximum fruit weight was never achieved at low levels of any given nutrient. We felt the boundary line approach as described above was a logical way to analyze these data sets. In order to maximize the number of data points, we combined all 60 peach and 60 nectarine trees from 2002 and 2003 to give 240 separate points. Since there were differences in absolute fruit weight between years and varieties, we expressed the data on a relative fruit weight basis, where the largest fruit from a given data set was given a value of 1.

Fruit Weight Analysis

For some of the nutrients, an obvious boundary line could be drawn where relative fruit weight is plotted against the level of that nutrient in leaves. For example, boron probably illustrates this best (Fig. 1) and the relationship seems to remain the same between years and between varieties. This boundary line suggests maximum potential fruit weight is decreased at boron levels below about 25 to 27 ppm. Currently, the published deficiency threshold value for peaches and nectarines is 18 ppm (Johnson and Uriu, 1989).
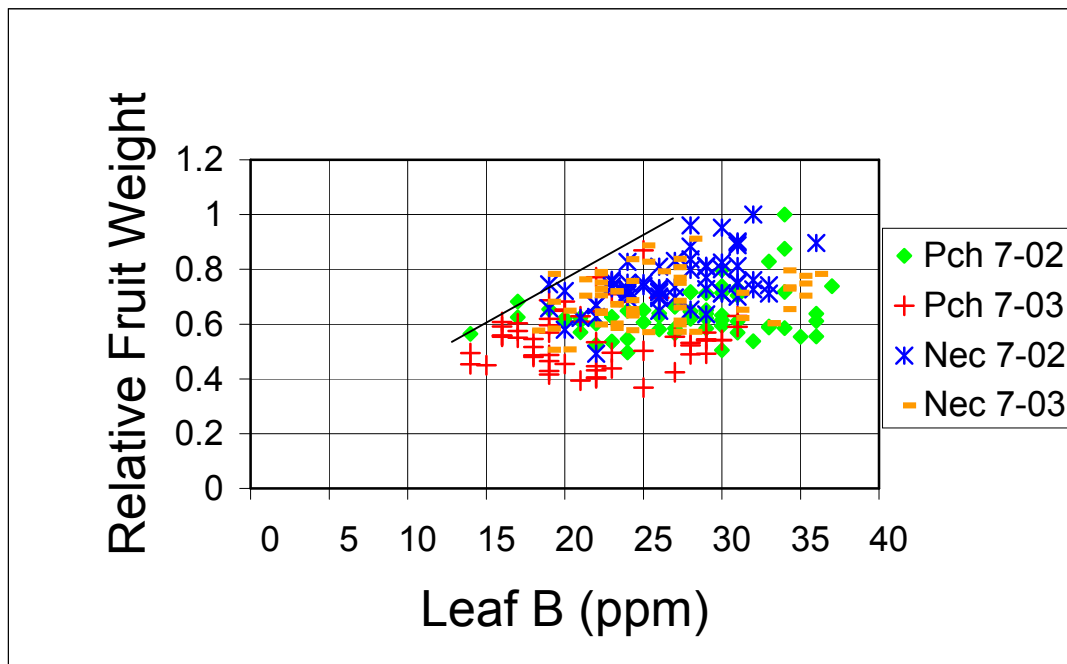

Fig. 1.   The relationship between relative fruit weight and July leaf boron content for Zee Lady peach and Grand Pearl nectarine in 2002 and 2003. The boundary line was drawn by hand.

Several other nutrients also showed quite clear boundary lines. Applying the same approach as with boron, deficiency thresholds can be estimated as follows: Phosphorus – 0.12 % (no published value); Copper – 5 ppm (no published value); Zinc – 10 ppm (published value = 15 ppm). Trees with zinc levels below 10 ppm often showed mild deficiency symptoms early in the spring. Above this threshold, no symptoms were observed. The iron (Fe) data set also showed a distinct boundary line, but the nectarine line was offset from the peach. Perhaps different varieties have varying requirements for (or different sensitivities to) a given nutrient such as Fe, which would require the establishment of different thresholds. However, from a practical standpoint it would be difficult to develop these for the hundreds of varieties grown commercially. In addition, the difference between the nectarine and peach was not great. Therefore, taking the average of the nectarine and the peach, a threshold value of about 60 ppm (based on a May leaf sample) is obtained which is the currently published value.

The situation with the other nutrients is more uncertain. There were not a lot of trees with low magnesium (Mg), but those few trees suggested a clear boundary line decreasing below a value of about 0.4 to 0.5 %. The currently published value of 0.25 % is considerably lower than this, but until we have more data points to solidify the relationship, there is insufficient justification to change it. For calcium (Ca), there was clearly a loss of fruit size below 1.0%, but the scatter in the data made it difficult to know where to draw the boundary line. The deficiency threshold could be anywhere between 1.0 and 1.7%. Likewise, the situation with nitrogen (N) was also quite confusing. Clearly, N has a strong effect on fruit size and the plot of relative fruit weight vs leaf N supported the idea of a boundary line. However, the line appeared to shift from year to year and between the peach and nectarine. Therefore, it is impossible to determine if the currently published threshold of 2.3% needs to be modified. Finally, for potassium (K) and manganese (Mn), we have been unable to lower the leaf nutrient levels below currently published values, so no reevaluation can be done. Table 1 summarizes our proposed changes for each of these 10 nutrients.

Table 1. Currently published nutrient deficiency thresholds for peaches and nectarines (See Johnson & Uriu, 1989) and proposed changes based on boundary line analysis of sand tank fruit weight data.

Nutrient	Published Deficiency Threshold	Proposed Deficiency Threshold
N	2.3%	ID[y]
P	--	0.12%
K	1.0%	ID
Ca	--	ID
Mg	0.25%	ID
Fe	60[z]	60
Mn	20	ID
Zn	15	10
B	18	25
Cu	--	5

[z]Based on May leaf sample, rather than standard June-July period.
[y]ID – Insufficient data.

As we continue this experiment for several more years, we will be able to expand the data set, thus establishing clear-cut boundary lines for each nutrient. In addition, we plan to apply this same type of analysis to other parameters of productivity and fruit quality such as vegetative growth, fruit set, flower density, fruit sugar content and fruit defects. Hopefully, the end result will be clearly defined deficiency thresholds that will help stone fruit growers manage tree nutrition much more precisely.

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