INSIGHTS
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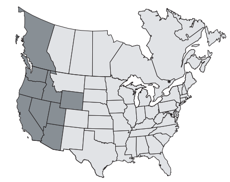

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Taking Statistics to the Field

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THE VERY IDEA of statistics seems to frighten many people. While the math can sometimes be intimidating, the general concepts of statistics are used in everyday decisions. For example, will I need my umbrella today? When do I need to fill up my gas tank? Who will win the big game? Or, will my crop respond to additions of fertilizer? Understanding a few basic concepts will help you make decisions and get the most from your nutrient additions.

Mean and Median

Most everyone is familiar with the concept of the mean value, generally called the average. This is useful if the measurements are "normally distributed", meaning that half of the observations are greater than the average and half are less than the average. For example, if you have an "average" yield, then half of your fellow growers had a greater yield than you and half had a smaller yield than you.

Sometimes measurements and observations are not uniformly distributed. When this occurs, it is helpful to take a median measurement. For example, suppose the incomes of 11 people were averaged together. If 10 of the people were agronomists and one was a billionaire, their average income would make it appear as if they were all millionaires. However, using the median value, the salaries would be ranked in order from low to high and the middle salary (agronomist number 6) selected as the median—a much more representative number!

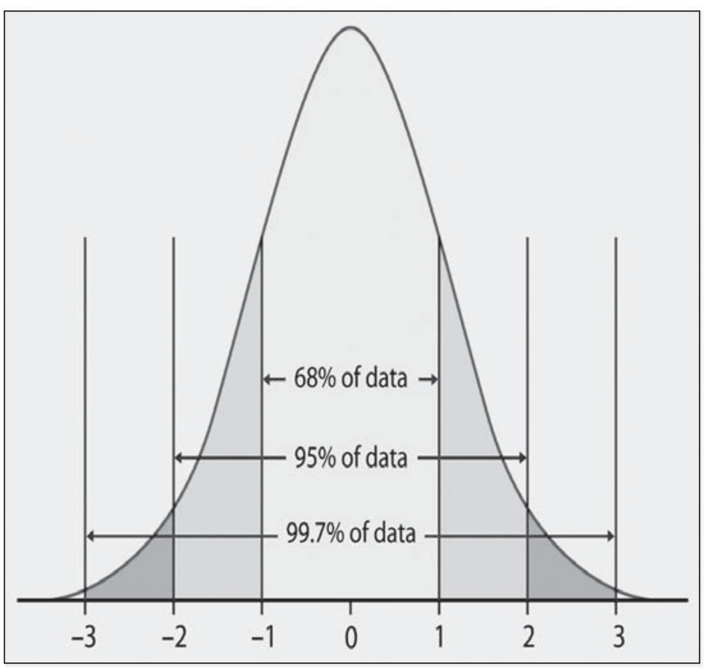

Figure 1. The distribution of samples around the mean of zero. One standard deviation greater or less than the mean accounts for 68% of the samples, two standard deviations around the mean account for 95% of the samples, while three standard deviations account for 99.7% of the data.

Standard Deviation and Variation

The standard deviation is a calculation that tells you how close all the measurements are to the overall mean. When the measurements are close together, the standard deviation is small. When the measurements are widely spread around the same mean, then the standard deviation is large. Calculating the standard deviation is not complicated with the help of a computer, but not simple to do with a pencil alone.

By graphing it out, the concept of standard deviation is not difficult to understand. One standard deviation in either direction from the mean accounts for 68% of the measurements. Two standard deviations from the mean account for about 95% of the observations, while three standard deviations represent about 99% of the measurements (**Figure 1**).

Since the standard deviation of two different groups of measurements (for example, comparing seeds per pod with apples per tree) cannot be directly compared, dividing the standard deviation by the mean value puts the variation on the same footing. This provides a measure called the coefficient of variation (CV), often expressed as a percentage by multiplying the CV by 100. A high CV indicates large variability in the measured data.

Abbreviations and notes: P = phosphorus; K = potassium; ppm = parts per million.

Applying Statistics to Soil and Tissue Analysis

• Soil

Every agronomist knows that there is usually considerable variability in the nutrient content of soils and crops within a field. For example, a study in Oklahoma measured soil P concentrations in 10 ft. increments across a 500 ft. line (**Figure 2**). The mean value of the 50 samples was 47 ppm P, with a standard deviation of 14 (and a CV of 30%).

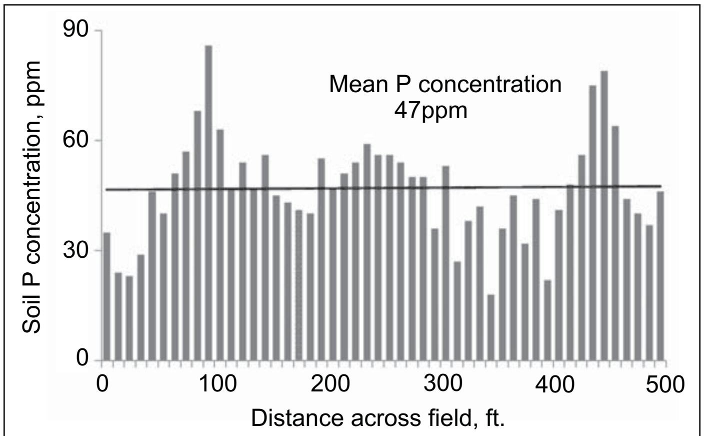

Figure 2. Soil P concentration in 50 soil samples taken across a field near Stillwater, Oklahoma (extracted with Mehlich-3 solution)[1].

While knowing that the mean P concentration across the field was 47 ppm, the other statistics are useful too. For example, the mean alone does not reflect that 21 locations across the field were over the average of 47 ppm or the 25 locations were under the average.

Suppose that the grower in this example was trying to achieve a soil P concentration of 47 ppm in the field. On average, the field has already reached that point, but over half of the sites are actually below this value.

Let's see what would happen if the grower wanted to make sure that 99% of the locations in the field were above the critical value of 47 (or three standard deviations). Using the average of 47 ppm plus 42 (3 x standard deviation of 14) equals 89 ppm of soil P. Remember that achieving this soil concentration may not be economically, agronomically, or environmentally desirable, but it will keep 99% of the soil sampling locations above the critical value.

• Tissue

Leaves from a California almond orchard were sampled across the field in 50 tree rows and analyzed for nutrients (**Figure 3**). The average of the leaf samples was 2.05% K, with a standard deviation of 0.27. The grower far exceeded the University of California–Davis recommendation of 1.4% K in this orchard, but has done it with careful reasoning. In this orchard, all but one row of trees now meets or exceeds the 1.4% K recommendation. If the grower had fertilized to a field average of 1.4% leaf K, half of the trees would fall below this recommendation and nut production would likely be limited. Instead, the grower has increased the average leaf K to over 2% to make sure that very few trees contain less than the recommended concentration and potentially suffer yield losses.

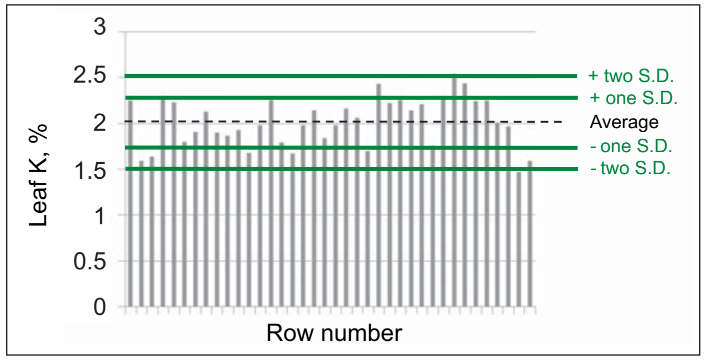

Figure 3. Leaf K concentrations from 50 rows of almonds in Yuba County, California. The average K concentration and the two standard deviations are shown. Data source: F. Niederholzer, Univ. of Calif. Cooperative Extension

The decision to exceed the "average" tissue concentrations in favor of boosting all of the trees above the critical limit will depend on several factors. Certainly the economic return from the additional yield from the fertilizer investment needs to be carefully considered. Nutrients such as K have no adverse environmental impact from heavy application rates. However, the environmental considerations from additional N application will demand additional management to avoid undesirable losses.

When multiple soil or plant tissue samples are combined before sending them to the lab, it is not possible to get additional statistics beyond the mean. However, laboratory analytical expenses are lessened when multiple samples are combined in order to pay for fewer analyses. The decision to combine multiple samples or to analyze more individual samples depends on the objectives.

Statistics may seem to be an unnecessary bother on the farm, but these two examples illustrate how keeping careful track of soil and tissue analysis can aid in making meaningful management decisions. Use all of the tools available to intensify yields to their highest sustainable level. Consider the variability in your fields that may be holding back the "average" yields and how the great advancements in precise use of fertilizers can help you move to the next level by applying just what your crop needs. ■

[1]Source: http://soil4213.okstate.edu/2006/PrecisionManagement_2006.ppt

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