# Site-Specific Management Guidelines

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SSMG-37

# Estimating Corn Yield Losses from Unevenly Spaced Planting


## Summary

- Agronomists and corn growers have long assumed that evenly spaced stands of corn have a greater yield potential than unevenly spaced stands.
- The uniformity of spacing between plants can easily be determined by using a commonly used statistic, standard deviation (SD). This statistic is available within most spreadsheets.
- By measuring the SD of plant uniformity, yield loss due to non-uniform plant spacing can be estimated using the following equation: Yield loss = (present plant spacing SD –2.0) X (4 bu/A/in. of SD improvement)
- This guide discusses how to measure stand variability and develops criteria for determining if recalibration of planter meters is needed.


## Introduction

Does an evenly spaced corn stand have greater yield potential than an unevenly spaced stand (**Figure 1**)? Many times when plants are unevenly spaced, one plant does not produce grain and will actually act like a weed, drawing nutrients and moisture from the other plant. Under these conditions, yield can be reduced.

**Figure 1. The corn plants shown above are unevenly spaced.**

The accuracy of planting can vary from perfect to very poor. Many agronomists believe that importance of a uniform stand increases with row width.

A split-planter study by Pioneer Hi-Bred (Doerge and Hall, 2000) showed an average yield improvement of 4.2 bu/A due to planter calibration. At some locations, the advantage for calibration exceeded 20 bu/A. In a research study conducted by Purdue University, yield losses in the range of 7 to 15 bu/A were observed in uneven stands (Nielsen, 1997). Clearly, fine-tuning planters to achieve the best possible stands should be the goal of every producer. Of all production variables that affect farm profitability, planter condition is one of the most controllable.

## Measuring Plant Spacing Uniformity: Use the Standard Deviation

### Standard deviation defined

The SD of the distance between plants within a row is a good measure of the spacing uniformity of a stand. Standard deviation is defined as:

$$\text{Standard deviation} = \sqrt{\sum_{i=1}^{n} \frac{(x_i - \bar{x})^2}{n-1}}$$

where;

$\bar{X}$ = the average distance between all pairs of adjacent plants

$X_i$ = an observation of the distance between two adjacent plants.

i = a counter

n = the number of pairs of adjacent plants

In a perfectly planted cornfield where all the plants

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were 7 in. apart, the average spacing would be 7 in. and the SD would be zero. If half of the spacings were 6 in. and half were 8 in., the average spacing would still be 7 in. but the SD would be 1 in. An extreme example with 50 percent of the plant spacings at 2 in. and 50 percent at 12 in. would again result in an average spacing of 7 in. but the SD would be 5 in., and so on. Most spreadsheets have an internal function that easily calculates SD.

## Collecting plant spacing measurements

Lay a 20 ft. (or more) tape measure next to the row of plants to be evaluated (**Figure 2**).

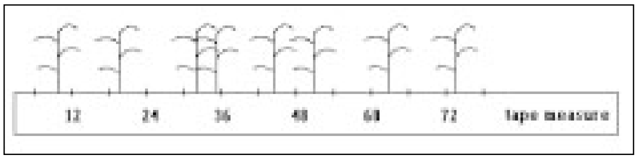


**Figure 2. Tape measure placed next to a corn row. (All calculations in this guideline are based on inches. If centimeters are used, estimated yield losses will be incorrect.)**

Record the location within the row in inches of each plant of corn. A field notes book works but our preference is to use a voice activated micro tape recorder. In **Figure 2,** the first plant is located at about 9 in., the second at 20 in., the third at 32 in., and so on to 240 in. (20 ft). Repeat the measurement of within row plant spacing at four or more randomly selected areas in a field. Collecting plant spacing data from more areas or for longer lengths of row improves the reliability of the estimation values. Different field areas planted by different planters may have different degrees of planting accuracy. Pay particular attention to rows that are abnormally erratic.

## Calculating plant spacing results

From your notebook or tape recorder, type the numbers into a spreadsheet in column A as shown in **Figure 3a**. Have the spreadsheet calculate the distance between each plant with the equations shown in column B (**Figure 3b**). **Figure 3a** is an example of how Excel spreadsheet equations are used to easily calculate the average plant spacing, the standard deviation, and the plant population **Figure 3a** shows the values that will appear on the spreadsheet after the equations shown in **Figure 3b** are entered into the computer. If you have more or less measurements than 10, changes must be made to the spreadsheet. For example, if 15 measurements are collected, the formula locations will shift downwards. Data will be entered in cells A2 to A17. The formula for the average and SD will be entered in B18 and B19. The formulas will be changed to reflect more measurements, i.e., formula in B18 will be

"=AVERAGE(B2:B17)"

and in B19 will be

"=STDEV(B2:B17)".

Also, note that the row width was entered in cell C1. This will be used to calculate plant population.

| | A | B | C |
|---|---|---|---|
| | Measured location of each corn plant | Spacing between each pair of plants measured | |
| 1 | 0 | | 30 |
| 2 | 2 | 2 | |
| 3 | 17 | 15 | |
| 4 | 33 | 16 | |
| 5 | 38 | 5 | |
| 6 | 39 | 1 | |
| 7 | 44 | 5 | |
| 8 | 52 | 8 | |
| 9 | 55 | 3 | |
| 10 | 60 | 5 | |
| 11 | 68 | 8 | |
| 12 | Average | 6.8 | |
| 13 | Standard deviation | 5.116422 | |
| 14 | Estimated yield loss bu/A | 12.465688 | |
| 15 | Plants/A | 30748.24 | |

**Figure 3a. Example spreadsheet for calculating plant spacing uniformity. This example uses Excel.**

| | A | B | C |
|---|---|---|---|
| | | The equations used in column B | |
| 1 | | | (enter row spacing inches) |
| 2 | | =A2-A1 | |
| 3 | | =A3-A2 | |
| 4 | | =A4-A3 | |
| 5 | | =A5-A4 | |
| 6 | | =A6-A5 | |
| 7 | | =A7-A6 | |
| 8 | | =A8-A7 | |
| 9 | | =A9-A8 | |
| 10 | | =A10-A9 | |
| 11 | | =A11-A10 | |
| 12 | | =AVERAGE(B2:B11) | |
| 13 | | =STDEV(B2:B11) | |
| 14 | | =(B13-2)*4 | |
| 15 | | =(1/(C1*B12))*144*43560 | |

**Figure 3b. Example spreadsheet showing equations used for calculating plant spacing uniformity. This example uses Excel.**

## Interpreting plant spacing results

Field researchers have conducted many experiments to measure the yield loss associated with increasing levels of the SD in plant spacing. Results of these studies have been inconsistent. Some studies have shown little or no response (Erbach et al., 1972) while others indicate yield losses as high as 4.5 bu/A for every inch of increased SD (Krall, et al., 1977).

An extensive plant spacing study was conducted in 10 states and two provinces in the Corn Belt of North America (Doerge and Hall, 2000). In this work, 96 farmers each had half of the meters (planter units) on their planters calibrated using the MeterMax* System. The other half of their planter was not calibrated. Doerge and Hall (2000) showed that:

- The metering performance of planters in operation on farms varies from very good to quite poor.
- A standard deviation of 2 in. is the best spacing uniformity that a commercial farmer can typically expect to obtain under normal production planting conditions.
- The ability to improve a planter meter performance was dependent on the initial planter performance. If the planter is planting stands with a standard deviation of 2 in. or less, then it is unlikely that calibration of the planter meter will improve the planter's performance.
- Importance of stand uniformity increases with row width.

Doerge and Hall (2000) developed a relationship between improvement in SD (as a result of meter calibration) and yield advantage. With this relationship, expected increases from planter calibration can be calculated. From their work, (http://www.pioneer.com/usa/technology/metermax.htm), we conclude that the expected yield loss due to non-uniform plant spacing is approximately 4 bu/in. of improvement. The following equation (which uses the calculated SD from cell B13, **Figure 3b**) is used to determine the potential increase in yield from planter calibration (cell B14 in **Figure 3b**).

Your calculated SD

$$\left(\frac{\frac{\text{4 bu loss}}{\text{A}}}{\text{in. of SD}}\right) \times \left(\text{5.12 - 2 in. SD}\right) = \frac{\text{12.5 bu loss}}{\text{A}}$$

From these calculations, a plant spacing SD of 5.12 in. will result in an estimated yield loss of 12.5 bu/A when compared to a calibrated planter (SD = 2).

Where is the threshold of concern? Doerge and Hall (2000) found that if the SD is greater than 3, then the planter needs calibration, and if the SD is less than 3, then calibration is not needed. In their study, yield increases resulting from the calibration of planter meters was profitable 83 percent of the time.

A well-tuned planter operating at a reasonable speed minimizes the SD of within-row plant spacing. Planting at high speeds with a poorly maintained planter would frequently result in a large number of doubles (two-plant hills) and skips (missing plants). Doubles can result in barren stalks, which should be considered as just another weed. Likewise, skips result in a significant loss of yield potential for the field. In most cases, planter calibration will result in relatively modest yield increases. However, planter operation is usually quite consistent, and even a slight yield advantage due to planter calibration will usually be realized over all of the acres planted.

With essentially no additional work, plant population (plants/acre) can be calculated from the data that you have already collected. Plant population is calculated using the following equation (cell B15, **Figure 3b**).

$$\text{Plant Population (plants/A)} = \frac{1}{\text{average spacing within row} \times \text{row width spacing}} \times \frac{144\ \text{in.}^2}{\text{ft.}^2} \times \frac{43{,}560\ \text{ft.}^2}{\text{A}}$$

Your average from cell B12

Your row spacing from cell C1

Note that the row width must be entered in cell C1 of **Figure 3a** for the plant population calculation to function. ■

## References


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