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Stand Establishment Variability in Corn

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A wise agriculturalist once told me that "the sins of planting will haunt you all season." By that he meant that mistakes made during the planting operation are usually permanent, unless you decide to replant the field at a later date. Uneven stand establishment can reduce the yield potential of a field before the plants have hardly begun to grow.

A stand of young corn can be a beautiful sight from the pickup window, and at 50 miles an hour the uniformity of that stand usually looks acceptable. But, a closer look sometimes points out stand problems; like tall corn-short corn, long gaps within the row, and groups of crowded plants. Stand establishment uniformity is thus composed of both emergence uniformity and within-row spacing uniformity.

How important is it for producers to establish as uniform a stand of corn as they possibly can? What effect does uneven plant spacing or uneven seedling emergence have on grain yield? What causes variability in stand establishment? How can stand establishment variability be prevented?

Read on for some answers...

Plant Spacing Variability

Modern corn planters have the capability to singulate kernels and place them very uniformly in the seed furrow. In practice, however, spacing between plants within rows often turns out to be quite uneven. Variability of plant-to-plant spacing usually consists of high percentages of crowded plants (doubles, triples, or worse); often accompanied by long skips within the row.

If seed placement uniformity is irregular, then some plants find themselves on a crowded part of the dance floor and others end up as lonely wallflowers. While it's true that the plants next to a gap may compensate and produce a larger ear, they generally cannot make up for those crowded plants which are competing for sunlight, water, and nutrients.
Measuring Plant Spacing Variability (PSV)

Before the effects of PSV on yield can be presented, I must first try to explain how PSV is measured in the field. It's actually pretty simple. First you must measure as many actual plant-to-plant spacings as you think it takes to adequately represent the PSV situation in your field. Typically, I measure plant spacings at two or three locations throughout a field. Within each location, I measure all of the plant-to-plant spacings (inches between plants) that occur in 25 feet of row and repeat this for each row of the planter unit.

The PSV for each row can then be quantified by calculating what is called the standard deviation of the plant-to-plant spacings. The standard deviation of a group of plant spacing measurements describes how far on either side of the average were the majority of the measurements found. The standard deviation is calculated in the same units of measure as the plant spacings. As a corn producer, you should strive for a low standard deviation of plant-to-plant spacing.

Two fields of corn can have identical plant populations, but vary dramatically for plant spacing uniformity. As an example, consider two fields of corn in Wells Co., Indiana that I surveyed in 1987 (Fig. 1). The plant populations in the two fields were identical (approximately 24,000 plants per acre), so that the average plant-to-plant spacing in each field was 8.7 inches. But, the uniformity of plant spacing in one field was more uniform than the other.

The graph illustrates that more crowded plants (double seed drops) and larger gaps occurred in the more variable field, even though the plant population was identical to the more uniform field. The standard deviation of plant-to-plant spacing for the more uniform field was 3.5 inches, while the standard deviation for the more variable field was 6.8 inches. This means that for the more uniform field, the majority of plant spacings that I measured fell within 3.5 inches of the average spacing of 8.7 inches (i.e., between about 5 and 12 inches). For the more variable field, the majority of the plant spacings that I measured fell within 6.8 inches of the average spacing of 8.7 inches (i.e., between about 2 and 16 inches).

The standard deviation calculation is a common statistical measure of the spread or variation of a group of individual measurements. It can be calculated by hand, using formulas available in any standard statistics reference, but is better suited to the use of statistical calculators or computer spreadsheets.

1 For the sake of brevity and because I am a lazy typist, I will use the acronym 'PSV' for Plant Spacing Variability throughout the rest of the text. For those of you who hate acronyms, I apologize.
2 There is nothing magical about using 25 feet of row. I just happen to use a 25 ft. surveyor's rod with large easy to read numbers that I don't have to bend over to read while I walk down the row.
3 Most computer spreadsheet programs can calculate the standard deviation of a group of values (i.e., a given range of data cells) with the use of a built-in mathematical function. For example, in Microsoft Excel the formula would be: =STDEV (cell range)
Effect of Uneven Plant Spacing on Yield

I've measured plant spacing variability in 77 commercial fields during the past several years. Standard deviations have ranged from as low as 2 inches to as great as 8.5 inches (see Fig. 2). The graph indicates a large proportion (76%) of the sampled fields were within the 3- to 5-inch standard deviation categories, what I would consider to be only moderately variable. However, many of the fields that I have sampled have tended to be farmed by 'good' managers and the data may thus be skewed toward the uniform side of the graph.

I have also conducted field studies on the effect of PSV on grain yield across Indiana since 1987. My field research indicates that approximately 2.5 bushels per acre are lost for every 1 inch increase in the standard deviation of the plant-to-plant spacings (see Table 1). These results mean, for example, that the fields that fall into the 5-inch standard deviation category (12% of the fields sampled) likely yielded 5 bushels per acre less than those fields in the 3-inch standard deviation category (10% of fields sampled.) If the uniformity could be improved to a standard deviation of 2 inches, the potential yield gain would then be about 7.5 bushels per acre. Potential yield gains for fields worse than a 5-inch standard deviation (16% of the fields in my survey) would be even greater.
Fig. 2. Range of plant spacing variabilities observed in commercial corn fields in Indiana. Data from 77 fields sampled from 1987-93. R. Nielsen, J. Cardinal, and M. Fain, Agronomy Dept., Purdue Univ.

**Causes of Plant Spacing Variability**

Plant spacing variability is typically related to misadjusted or malfunctioning planter mechanisms. With Deere-type planters, double or triple seed drops may occur from worn finger-pickup mechanisms, mis-adjusted finger tension, worn knockoff brushes, or from driving too fast. Aged seed conveyor belts may not deliver kernels properly to the seed chute. Mis-adjusted air pressure, leaks in the system, worn knockoff brushes, or wrong disc sizes may result in uneven seed drop with air planters.

Don’t forget that small gaps will always occur due to the fact that less than 100 percent of the kernels planted actually germinate. Warm germination percentage of seed corn typically ranges from 90 to 95 percent, thus perfect final stands are rare. Keep in mind that stand reductions caused by weather- or pest-related damage may also result in unevenly spaced plant survivors within the rows. Perhaps replant decisions should take this additional yield loss into considerations.

**Tips for Preventing Plant Spacing Variability**

Adjustment instructions and servicing schedules provided in the planter owners manual should be read and followed religiously during the off-season as well as during the planting season. Here are a few pointers:

1) With plate-type planters, match the seed grade with the correct planter plate,
2) Planters with finger pick-ups should be checked for wear on the back plate and brush, use a feeler gauge to check tension on the fingers, then tighten them correctly,
3) Check for wear on double-disc openers and seed tubes,
4) Make sure the sprocket settings on the planter transmission are correct,
5) Check for worn chains, stiff chain links, and improper tire pressure,
6) Lubricate all chains and grease fittings,
7) Make sure seed drop tubes are clean and clear of any obstructions,
8) Clean seed tube sensors if you have a planter monitor,
9) Make sure coulters and disc openers are aligned properly, and
10) With air planters, match the air pressure to the weight of the seed being planted.

Plant Emergence Variability

Are you bothered by late sleepers in your corn field? You know, those deadbeat kernels that refuse to germinate at the same time as the rest and, subsequently, emerge later than the rest? Actually, it’s not uncommon to find some degree of delayed emergence in your fields every year. What you want to avoid, though, is ending up with large proportions of a field made up of these lazy, good-for-nothing late emergers.

Effect of Late Emergers on Yield.

My university counterparts in Illinois and Wisconsin recently reported (Carter & Nafziger, 1989; Nafziger et al., 1991) on a joint field experiment designed to determine the effect of delayed emergence on corn grain yield. They evaluated differing lengths of delays, different patterns and proportions of delayed and normal plants, and two hybrids differing in ear-size flexibility.

Emergence delays of about 10 days scattered throughout the field reduced yield 6 to 9% compared to full stands of normal emergence. Emergence delays of about 21 days reduced yield 10 to 22 percent compared to a full stand of normal emergence, depending on the proportion of delayed emergers to normal emergers.

Causes of Delayed Emergence

The primary causes of delayed seedling emergence in corn include 1) soil moisture variability within the seed depth zone and 2) poor seed to soil contact due to cloddy soils, inability of no-till coulters to slice cleanly through surface residues, worn disc openers, and misadjusted closing wheels. Other causes include soil temperature variability within the seed zone, soil crusting prior to emergence, occurrence of certain types of herbicide injury, and variable insect and/or soil-borne disease pressure.

Tips for Preventing Delayed Emergence

Remember your goal in planting corn should be to achieve rapid uniform kernel germination and seedling emergence. Time spent before and during planting to ensure uniform stand establishment is time well spent.
Table 1. Yield loss due to plant spacing variability in corn. 1987-92.

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Harvested Population</th>
<th>Yield Level (bu./ac.)</th>
<th>Rate of Yield Loss (bu/in. of Std. Dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>Westcentral</td>
<td>28,500 ppa</td>
<td>200</td>
<td>-3.7</td>
</tr>
<tr>
<td>1987</td>
<td>Southcentral</td>
<td>26,000 ppa</td>
<td>145</td>
<td>-4.5</td>
</tr>
<tr>
<td>1990</td>
<td>Eastcentral</td>
<td>24,500 ppa</td>
<td>125</td>
<td>-2.0</td>
</tr>
<tr>
<td>1991</td>
<td>Northeast</td>
<td>27,500 ppa</td>
<td>150</td>
<td>-2.3</td>
</tr>
<tr>
<td>1992</td>
<td>Northeast</td>
<td>27,000 ppa</td>
<td>165</td>
<td>-2.7</td>
</tr>
<tr>
<td>1992</td>
<td>Northwest</td>
<td>26,000 ppa</td>
<td>150</td>
<td>-1.4</td>
</tr>
<tr>
<td>1992</td>
<td>Southeast</td>
<td>26,000 ppa</td>
<td>185</td>
<td>-1.2</td>
</tr>
</tbody>
</table>

Average = -2.5


Determining the correct seeding depth may be one of the biggest decisions a corn grower makes in the field during planting. Notice I said "in the field" and "during planting." Your seeding depth decision should be made in the field, not in the shop or from last year’s records. The correct seeding depth for any given field should be based on its current soil moisture conditions and the 5 to 10-day weather forecast.

For example, if the soil is dry down to 1.5 inches and the short-term forecast calls for continued dry weather, don’t hesitate to plant at 2 or 2.5 inches. Corn can easily emerge from these depths, even deeper if necessary. In this example, your risk of germination problems is greater for shallow planting than for deeper planting. Germination may be uneven at shallower depths if some seeds encounter sufficient moisture and others don’t. On the other hand, if rain is forecast in the next several days, then plant at 1 to 1.5 inches to avoid potential surface soil crusting problems.

While you’re at it, make sure that the depth control settings on your planter are accurate. Check the manual’s theoretical depth with actual depth for the settings you commonly use. Remember, too, that actual depth will likely change as soil conditions change. Check it every time you pull into a new field or start a new day. If your planter has rocker arm assemblies to "smooth" the effects of surface rocks on depth, make sure the assemblies are well lubricated and are operating as they should.
Inspect the condition of the double-disc openers before planting. As each disc wears, its diameter decreases and the two discs slowly "move" apart where they meet at the bottom. Such worn disc openers may slice a "W" shaped seed furrow rather than a "V" shaped one. The closing wheels may not be able to adequately firm a "W" shaped furrow, leaving pockets of air around or near the seed. Remember, you want good seed-to-soil contact, not good seed-to-air contact!

Coulter down-pressure and depth for no-till planting should be adjusted for each field’s soil and residue situation. Make sure the coulters slice cleanly through the residue, rather than pinning residue inside the seed furrow. Remember, you want good seed-to-soil contact, not good seed-to-residue contact!

If your single coulters just can’t cut through residue no matter what you do, then maybe it’s time to consider one of the many types of planter attachments that move, sweep, brush, incorporate, or otherwise manage residue. It’s my contention that the primary value of these zone preparation gadgets lies mainly in their potential for moving the residue away from the planter units so that the units can do what they were built to do; that is to open the furrow, drop the seed, and firm soil (not residue) around the seed for optimum germination and emergence conditions.

Adjust the tension of the closing wheels according to the soil conditions you will be planting in. Make sure the seed furrow is being closed and firmed adequately. On the other hand, be aware that too much tension on the closing wheels may lead to troubles in itself. For example, too much tension on true-V press wheels in loose soil may decrease the uniformity of seeding depth by occasionally squeezing kernels upward.

Finally, if you are practicing reduced tillage and especially if you are planting on the early side, be conscious of soil temperature variability. Temperatures under heavy residue areas may be several degrees lower than more bare areas in the field. While corn will germinate at soil temperatures of 45 to 50 degrees F, minor drops in temperature below this range may significantly decrease the uniformity of germination. If crop residues are not spread evenly throughout the field, avoid planting until average soil temperatures are closer to 55 or 60 degrees.

References
