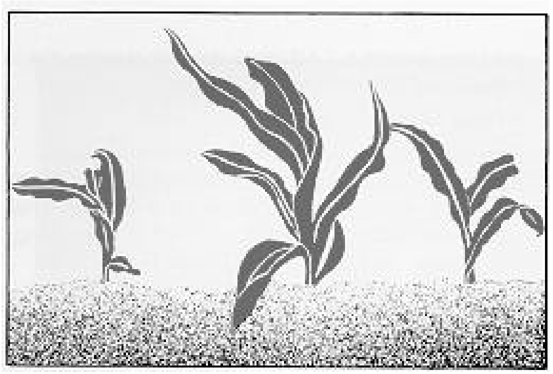

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Uneven Emergence in Corn

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If soil conditions are not ideal at planting, corn may emerge unevenly. You might eventually get a full stand, but plants will emerge at different times. This publication discusses why corn emerges unevenly, describes a study that measured how much uneven emergence reduces corn yields, provides some management recommendations for what to do with uneven emerging stands, and gives suggestions for obtaining uniform emergence.

Why Corn Emerges Unevenly

The most common reason for uneven corn emergence is dry soil at or shortly after planting. Moisture at seed depth may be adequate for seed germination and emergence in some areas, but not in others. Soil moisture in the seed zone within a field can differ because of variations in soil type and topography, or from uneven distribution of moist and dry soils caused by secondary tillage. Cloddy seedbeds caused by working the ground too wet, can mean poor contact between seed and soil, allowing some seeds to absorb enough moisture to germinate while others are too dry. In many cases, some seeds originally placed in dry soil don't germinate and emerge until after rainfall. This produces a mixture of larger and smaller plants, with plant size differences depending on time from planting to rainfall. Emergence time may vary between parts of fields, from one row to the next, or from one plant to the next.

Uneven soil temperature is another cause of uneven corn emergence. Seed-depth soil temperatures can vary if crop residues from reduced tillage systems aren't distributed evenly, if seed depths vary, and if soil within fields varies in type and topography. Corn may also emerge unevenly because of variable soil crusting, herbicide injury or because of insects or diseases.

Finally, uneven corn emergence occurs when corn growers, with stand loss or uneven stands, replant by "filling in" the existing stand, rather than tearing up the field and starting over.

How Uneven Emergence Affects Grain Yield

Competition from larger, early-emerging plants will decrease the yield of smaller, late-emerging plants. The authors designed a research project to measure this effect and help answer these questions:

" What is the yield loss for various patterns of uneven emergence?

" Should you replant stands with unevenly emerging plants'?

" What are the benefits of "filling-in" a poor stand compared to tearing up the field and starting over?

" Should you protect late-emerging plants during cultivation, or are these late plants just "weeds"?

To answer these questions, the researchers established corn plant stands with different plant sizes within the same or adjacent rows, using two corn hybrids in seven environments in Illinois and Wisconsin. According to the company which provided the seed, one of the hybrids was less able to expand ear size ("fixed-ear type") than the other hybrid ("flex-ear type") at low plant densities.

The stands shown in Table 1 include the following planting patterns:

a)Full stands of 26,000 plants/a with even emergence but early, medium, and late planting dates.
b)Full stands of 26,000 plants/a with various combinations of uneven emergence across-row or within-row with 1/4, 1/2, and 3/4 delayed plants.
c)Reduced stands with 1/4, 1/2, and 3/4 stand loss.

To imitate emergence delays, corn was planted either 1 1/2 (m) or 3 weeks (L) after the optimum, early date (E) (see Table 1). To evaluate the effect of uneven across-row emergence, rows were alternately planted early and delayed. This produced 1/2 early and 1/2 delayed emergence within the stand. To assess *within-row* emergence, four repeating patterns of in-row planting time were used for each of the two delayed plantings. These patterns produced 1/4, 1/2 (both every other plant and every other set of three plants delayed), and 3/4 delayed plants within the stand. Figures 1 through 3 show the relative height and growth stage of early plants in contrast to seedlings delayed in planting by 1 1/2 and 3 weeks.

For reduced stands, researchers used the same repeating patterns for the delayed plantings, but planted nothing, producing stand losses of 1/4, 1/2, and 3/4 (Table 1).

Grain yield and growth responses were similar for the seven environments and for the two corn hybrids. The results presented in Tables 1 and 2 are discussed below.

Within-Row Uneven Emergence

1 1/2 Week Delay

When the planting delay was 1 1/2 weeks, mixed early and delayed plantings within a row decreased yield by 6-9% (Table 1). This was nearly the same yield loss as with a 1 1/2-week delay in planting the entire stand (5% yield loss) (Table 1).

3-Week Delay

When the planting delay was 3 weeks, mixed early and delayed plantings within a row decreased yield by about 10% when 1/4 of the plants were delayed. This was similar to the 12% yield loss for delayed planting of the entire stand by 3 weeks (Table 1). Yield loss was 20-22% when 1/2 or 3/4 of the plants were late. This loss was more than 10% greater than for 3-week late planting of the entire stand (Table 1).

Across-Row Uneven Emergence

1 1/2- Week Delay

Compared to timely, early planting, alternating rows of corn planted on time and delayed by 1 1/2 weeks gave about the same yield loss (6%) as when planting

Table 1. How uneven emergence affects corn grain yield. Grain yields are shown as percentages of the maximum yield of 187 bu/a obtained with even emergence of a full stand (26,000 plants/a) with early planting. Yields are averages of studies with two corn hybrids in seven environments in Illinois and Wisconsin.

E = Early planting (approx. May 1) L=Planting 3 weeks after early planting

m = Planting 1 1/2 weeks after early planting x =missing plant

	Planting time and row pattern	Proportion of delayed plants	Grain yield as % of maximum
Full stand even emergence	E	none	100
	M	all	95
	L	all	88
Full stand uneven emergence alternate row pattern	E and m	1/2	94
	E and L	1/2	85
Full stand uneven emergence within-row pattern	EEEm	1/4	94
	Em	1/2	91
	EEEmmm	1/2	93
	mmmE	3/4	93
	EEEL	1/4	90
	EL	1/2	79
	EEELLL	1/2	80
	LLLE	3/4	78
Reduced stand plants missing		Proportion of missing plants	
	EEEx	1/4	90
	Ex	1/2	71
	EEExxx	1/2	69
	xxxE	3/4	49

Table 2. Grain yield contributions of early and delayed plants in within-row mixtures (Yields are averages of studies in seven environments in Illinois and Wisconsin.)

E = Early planting (approx. May 1)
m = Planting 1 1/2 weeks after early planting
L = Planting 3 weeks after early planting

1 1/2-Week planting delay

Within-row plant delayed pattern	Proportion of early plants	%of Total grain Yield contributed by: delayed plants	plant plants
EEEm	1/4	85	15
Em	1/2	61	39
EEEmmm	1/2	59	41
mmmE	3/4	31	69

3-Week planting delay

Within-row delayed pattern	Proportion of yield early plants	%of total grain contributed by delayed plants	plants
EEEL	1/4	96	4
EL	1/2	82	18
EEELLL	1/2	74	26
LLLE	3/4	42	58

of the entire stand was delayed 1 1/2 weeks (5% yield loss) (Table 1).

3-Week Delay

When the planting delay was about three weeks, alternating rows of timely and delayed emergence caused about the same yield loss (15%) as when planting the entire stand 3 weeks late (12% yield loss) (Table 1).

Yield Contribution from Delayed Plants

Delayed plants contributed to total grain yield for all within-row uneven emergence patterns (Table 2). For example, the yield contribution from 3-week late plants in the same row as early plants (see various EL and LE combinations in Table 2) ranged from practically none when only 1/4 of the plants were late, to over 50% of the total yield when 3/4 of the plants were late (Table 2).

Stand Loss

Losses of 1/4, 1/2, and 3/4 of the stand decreased grain yields 10, 30, and 51 %, respectively (see Table 1 - Reduced stand). You can assess the benefit of late-emerging plants within a stand by comparing yield percentages of uneven emergence vs. stand loss (Table 1), and by observing yield contributions of early vs. delayed plants (Table 2). For example, when 1/4 of the plants were planted 3 weeks late (EEEL in Table 1), yields were 90% of maximum - the same yield obtained without the late plants (1/4 plants missing - see EEEx in Table 1). This indicates that the presence of late plants did not help or hurt overall yields. However, when 1/2 of the plants were planted 3 weeks late (see EL and EEELLL in Table 1), yields were about 80% of maximum - 10% higher than the yield without the late-emergers (1/2 plants missing see Ex and EEExxx in Table 1).

Recommendations

The first step in using the recommendations below is to determine the general pattern of non-uniform emergence. This will vary both from field to field and within parts of fields. Thus, you can change management for particular fields or parts of fields depending on the most prevalent emergence pattern.

Should You Protect Late-Emerging Plants During Row Cultivation?

- If late-emerging plants are within 1 1/2 to 2 weeks of those emerging early, avoid burying them during cultivation.

- Protect plants emerging 3 weeks late if 1/2 or more of the plants in the stand are late-emergers.

- If less than 1/4 of the stand is emerging 3 weeks late or later, it probably won't pay to encourage their survival. Yields will be about the same whether or not these delayed plants are buried.

Should You Replant Stands With Uneven Emergence?

- If unevenness is mostly row-to-row, replanting will probably not increase yield.

- If the delay in emergence is less than 2 weeks, replanting will increase yields less than 5%, regardless of the pattern of unevenness.

- If 1/2 or more of the plants in the stand emerge 3 weeks late or later, then replanting may increase yields up to 10%. To decide whether to replant in this situation, estimate both the expected economic return of the increased yield compared to your replanting costs and the risk of emergence problems with the replanted stand.

Should You Fill-in A Poor Stand?

When replanting a poor stand (3/4 stand loss or greater), you can either tear up the stand and replant the whole field, or fill-in the existing stand and create uneven emergence.

- If you replant within 2 weeks of planting the original stand, filling-in the existing stand may be an option. Yields will be similar to those from a uniform-emerging, replanted stand, if you can get relatively uniform plant spacing within the row between old and new plants. However, within two weeks of planting, it may be too early to determine what the final stand will be.
- If you replant 3 weeks after the initial planting, yield potential is about 10% greater if you tear up the field and start over with an even-emerging stand. Balance this possible yield increase against the additional cost of tillage, seed, pesticide and dryer fuel.

Other Considerations

- It may be useful to evaluate non-uniform emergence by comparing growth stage differences between early and delayed emerging plants rather than time differences. The 1 1/2 and 3-week planting delays described in this bulletin resulted in similar time delays in emergence. However, emergence delays may vary with different environments and the actual time delays may not be known. You can use Figures 1 through 3 to help relate growth-stage and appearance differences between uneven emerging plants to the time delays described in this bulletin. For example, at emergence of plants delayed in planting by 1 1/2 weeks, there were 4 to 5 visible leaves on early plants (Fig. 1). When plants delayed 3 weeks in planting emerged, there were 7 to 9 visible leaves on early plants (Fig. 2).
- If plant-to-plant competition is low, late-emerging plants will yield more. For example, at plant densities under 20,000 plants/a, late-emerging plants will probably contribute more to yield than the proportions shown in Table 2.
- In this study, the uneven emerging stands yielded less primarily because of direct competition of

Figure 1. Early Plants and Plants delayed in planting by 1 1/2 weeks.

Figure 2. Early plants delayed in planting by 3 weeks.

Figure 3. Early plants mixed with 3-week delayed plants later in the season.

plants of two different ages next to one another. Older plants generally have an advantage in obtaining light, water, and nutrients. In some cases, late-emerging plants could be more vulnerable to silk clipping by corn rootworm beetles. Beetles may attack fresh silks of late silking plants, cutting the silks as soon as they emerge, preventing pollination and reducing kernel set.

- Late-emerging plants had higher grain moisture content at harvest. This could result in grain with varying moisture levels, which would increase kernel damage and drying costs. They also often had smaller stems, weaker stalks and fewer brace roots, so they lodged more. Also, at harvest it's difficult to adjust combines for the variable ear sizes between early and late plants. These problems would be minimal with a 1 1/2-week delay, but could be serious with a 3-week delay.

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Avoiding Uneven Emergence

Corn sometimes emerges unevenly because of environmental factors that corn growers can't control. Nevertheless, the following management practices can help you avoid uneven stands:

- Avoid excessive tillage trips which dry or compact the seedbed.
- Remember that tilling when soils are too wet can produce cloddy soils, a major cause of uneven stands.
- Dig up some seeds during planting to monitor seed placement. If contact between seed and soil is poor or seeding depth isn't uniform, adjust seed openers and/or presswheel tension. Secondary tillage operations may need to be changed to improve soil conditions for more uniform planting.
- If you are using a tillage system that retains substantial crop residue on the soil at planting, adjust tillage and planting equipment so residue cover over the row area is uniform after planting.
- Follow recommended herbicide application guidelines to avoid injuring corn.
- After planting, closely monitor corn emergence and use a rotary hoe it a soil crust is keeping corn from emerging uniformly.

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