Polymer Seed Coatings: Sufficient Risk Reduction for Early Plant Corn?

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TRADITIONAL RISKS OF EARLY PLANTING OF UNCOATED CORN SEED

Most producers are reluctant to plant corn early even when soil conditions are sufficiently dry to achieve a suitable seedbed. Their fears of ultra-early planting include (a) the risk associated with corn emergence before a late killing spring frost, (b) the risk of a significant reduction in plant population due to pests and other factors, (c) the risk of excessive variability in emergence and development of adjacent plants, and (d) the consequent (or possibly unrelated) risk of lower corn yields than could be achieved by delaying corn planting until the optimum planting dates for a particular region.

In west-central Indiana, for instance, corn producers generally accept that April 15-30 is the optimum range for planting full season hybrids, and would be extremely reluctant to plant corn before April 1 even if soil conditions were dry in March. Not being able to take advantage of these early planting “windows” has the disadvantages that (a) corn producers need substantial planting equipment to accomplish corn planting within a narrow time frame, (b) that excessive precipitation during the optimum planting period will force planting to be delayed well past the optimum date (as occurred in the wet spring of 1996), and (c) that many corn producers are reluctant to adopt no-till corn production because soils may be wetter longer than they are with conventional tillage practices.

Uneven emergence of plants within rows may be one of the biggest risk factors of early planting be-
cause corn emergence tends to be less uniform when soil temperatures at seed depth are low. Intensive research on delayed emergence effects on corn grain was conducted in Illinois and Wisconsin (Nafziger et al. 1991). This research was conducted with two hybrids, various planting dates within the row, and various planting dates for adjacent rows. Emergence delays due to delayed planting intervals of approximately 10 to 25 days resulted in yield reductions of from 6 to 22% compared to a full stand of normal emergence (based on common planting dates from April 30 to May 15). Agronomists have not looked closely at corn emergence uniformity with ultra-early planting dates; however, if seeds did not begin germination until soil temperatures were above a critical temperature one might expect more uniformity.

POLYMER SEED COATINGS

Landec Ag of Monticello, IN, works extensively with patented polymers (Stewart, 1992; Stewart et al., 2001) that regulate seed germination based on controlling when seeds imbibe water. The temperature-activated seed coatings are based on C-12 to C-25 side-chained polymers varying in number and length of the monomer side chains. Varying the monomer side chain length enables the preparation of different melting point temperatures (in a range from 0 to 100°C) where the polymer coating can reversibly undergo a crystalline to amorphous phase change. The latter phase change permits coatings which were previously impermeable to water to become permeable to water. Seeds subsequently begin germination as they imbibe water. The reported accuracy of the “temperature switch” for a particular polymer coating is from 1 to 3°C.

Thus far, the majority of the commercial evaluation of the polymer coatings has been for production of hybrid seed corn. Coatings may, for instance, be applied to the male inbred parent seed to achieve synchrony in flowering with the adjacent rows of female inbred seed. Traditionally, synchrony was often achieved by planting male inbred seed several days or weeks later than the female inbred seed. In 2001, there are over 30 seed corn companies utilizing these acrylic polymers on male parent seed in seed production fields. There has been less commercial use of this polymer for planting of hybrid corn seed in commercial fields. However, Landec Ag representatives indicated that pre-commercial, on-farm tests (both replicated and non-replicated) were conducted on over 3000 acres in approximately 15 mid-western states in 2001 (Balachander, personal communication).
The potential for utilization of these polymers on hybrid corn production is huge (on an acreage basis, at least) if these polymers can be proven to improve corn plant populations and grain yield when corn is planted 2 to 3 weeks before the optimum planting period in a region. The key concern for corn producers is whether the polymer-coated seed will reduce the traditional risks sufficiently.

RECENT FIELD INVESTIGATIONS

Replicated research trials involving experimental polymers for hybrid corn seed with multiple planting dates have been conducted in Indiana and in Minnesota. Research the recently modified polymer-coated corn has only been underway at Purdue University for the past two years (2000-2001). In both years we attempted to plant 2-3 weeks before the beginning of the optimum period; both April and May temperature patterns were quite different in those years (Fig. 1). Similar research with multiple planting dates has also been underway by USDA-ARS staff at Morris, Minnesota (Gesch et al. 2001). In total, just 5 hybrids have been investigated in replicated trials at these locations. Thus, the results of these investigations should be considered as preliminary. Additional years, hybrids and locations are required to provide a fuller assessment of the reliability of early planting with polymer coatings.

Polymer coatings resulted in emergence delays for early, intermediate and late planting dates for Fielder’s Choice (FC) hybrids 9307 and 8509 in both 2000 (Fig. 2) and 2001 (Fig. 3). Emergence of the first

![Figure 2. Daily air growing degree days from April 1 to May 31 for the year 2000 and 2001.](image-url)
uncoated (UTC) corn seeds generally occurred 1 to 4 days before the coated seeds (coating treatments A, B, C or D), and the emergence period from initial to final emergence generally was more extended for coated treatments than for uncoated seeds. However, uncoated seeds resulted in less uniform emergence than coated treatments A and B for FC-8509 planted on March 28, 2000 (Fig. 2).

Weather conditions in April of 2001 were unusual in the sense that air temperatures were warm very early, but killing frosts (27-28°F) occurred on April 17 and 18. The result of the warm period in early April (Fig. 1) was that all coated and non-coated treatments began to emerge just 9 days after the April 2 planting date (Fig. 3). The mid-April frosts, however, reduced the stand of the uncoated seed treatment by 40% for FC-9307, and by 15% for FC-8509. Coated seed treat-

Figure 2. Cumulative emergence (living seedling) for three different planning dates, two hybrids (9307, 8509) and different coating treatments (UTC) control, coating A with 2% of seed weight, coating B with 3% of seed weight.
ments were less affected by frost since only 50% of the seedlings had emerged when freezing temperatures occurred.

The impacts of polymer seed coatings need to be evaluated in terms of average emergence delay (e.g. days from planting to 50% emergence), emergence uniformity (e.g. number of days from 10% to 90% emergence) in final populations, and in grain yield. Our results indicate that the average emergence delay of coated versus uncoated seeds ranged from 1 to 5 days, and only minor differences were apparent between the polymer coatings themselves (Table 1). Coating treatments resulted in additional days from 10 to 90% emergence for the early planting date in 2001, but not in 2000 (Table 1). Final plant populations were never lower with polymer-coated seeds than uncoated seeds in

![Graphs showing cumulative emergence](image)

Figure 3. Cumulative emergence (living seedling) for three different planning dates, two hybrids (9307, 8509) and different coating treatments (UTC) control, coating A with 2% of seed weight, coating B with 2.5% of seed weight.
FC-8509, and significantly higher plant populations occurred with coated seeds of both hybrids for the early planting date in 2001 (Table 2). Emergence uniformity is also a function of within row consistency in soil temperature at seeding depth, and achieving consistent depth at planting is at least as important with planting polymer-coated, as for uncoated, corn seed.

Table 1. Coating treatment effects on mean days to emergence, days from 10 to 90% emergence for different panting dates, and hybrids in years 2000 and 2001.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Planting Date</th>
<th>Planting Date</th>
<th>Planting Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>9307/UTC</td>
<td>28.8 c</td>
<td>17.09 b</td>
<td>10.1 b</td>
</tr>
<tr>
<td>9307/A</td>
<td>31.2 b</td>
<td>18.8 a</td>
<td>11.4 a</td>
</tr>
<tr>
<td>9307/B</td>
<td>33.6 a</td>
<td>19.5 a</td>
<td>11.5 a</td>
</tr>
<tr>
<td>8509/UTC</td>
<td>30.4 b</td>
<td>16.3 b</td>
<td>10.0 b</td>
</tr>
<tr>
<td>8509/A</td>
<td>30.8 ab</td>
<td>18.6 a</td>
<td>10.8 ab</td>
</tr>
<tr>
<td>8509/B</td>
<td>31.8 a</td>
<td>19.0 a</td>
<td>11.2 a</td>
</tr>
<tr>
<td>9307/UTC</td>
<td>11.3 b</td>
<td>10.5 b</td>
<td>8.4 c</td>
</tr>
<tr>
<td>9307/C</td>
<td>15.6 a</td>
<td>14.0 a</td>
<td>13.6 a</td>
</tr>
<tr>
<td>9307/D</td>
<td>15.7 a</td>
<td>13.3 a</td>
<td>10.4 b</td>
</tr>
<tr>
<td>8509/UTC</td>
<td>11.3 b</td>
<td>10.6 b</td>
<td>8.2 b</td>
</tr>
<tr>
<td>8509/D</td>
<td>15.1 a</td>
<td>13.4 a</td>
<td>10.3 a</td>
</tr>
</tbody>
</table>

Means separation within planting date and hybrid by Duncan range test, 5% level.

Treatment code: UTC, control, coating A, B, coating B, C, coating C, D, coating D.

The impact of hybrid on corn population responses to seed coatings is intriguing, as it suggests that hybrids varying in their tolerance to seed and seedling stresses might respond quite differently to the polymer coatings. Hicks et al. (1996) also observed that plant populations of only 3 of 6 hybrids were increased with earlier versions of the polymer coatings than those used in our more recent trials. In addition, the differential population response to polymer coatings on alternate planting dates for F.C. 9307 (Table 2) suggests that polymer seed coatings for early planting situations might be most appropriate for hybrids with good early vigor.

**GRAIN YIELD**

In the Indiana experiences to date, polymer-coated treatments generally did not increase yield, relative to uncoated seed, within a planting date (Fig. 4). However, yields with FC-9307 were 21% higher with
coatings than without for the earliest planting date in 2001. Similarly, Rush et al. (2001) observed corn yield gains of up to 22% with coated corn seed with a March 29, 2000 planting date because of improved corn plant populations with coated seed (Table 3). Potential yield gains with seed coatings relative to uncoated seeds for early planting situations may be hybrid dependent; polymer coating benefits will tend to be most obvious when stand reductions are more likely (whether because of hybrid or environmental factors). Earlier research with temperature responsive seed coatings in 1995 and 1996 also indicated that germination of sensitive hybrids are more likely to be improved with seed coatings (Hicks et al., 1996).

Another method to evaluate the yield potential of polymer-coated seeds is to examine yields of coated seeds planted 2 to 3 weeks before the optimum planting period relative to yields of uncoated seeds planted during the optimum period. Farmers would be more confident in utilizing polymer-coated seeds if they were assured that yields associated with 2-3 week earlier planting would be at least equal to those of planting during the optimum period. Current yield models suggest that corn yields are 5% lower with early versus optimum period planting when populations are similar, and up to 20% lower with early versus optimum planting when populations are reduced from 30,000 to 15,000 plants/acre (Nafziger et al. 1996). The present investigations suggest that coated corn planted in late March or early April yields as much or more than corn planted in mid-April to early May (Fig. 4). The only exception to that trend was with FC-9307 planted on
April 2, 2001; in that case coated corn averaged 12% lower than uncoated corn planted April 19. However, FC-9307 was more negatively affected by the frost in 2001 than FC-8509, and corn plant populations for FC-9307 were 4200 to 5200 plants per acre lower with the first planting date even in the coated treatments (Table 2). Thus, one might conclude that polymer coated corn planted early is more likely to achieve yields equal or superior to uncoated corn seeds planted in the optimum period when the hybrids have good early vigor and when final plant populations are not unduly lowered by early stress conditions.

Figure 4. Grain yield for three different planting dates, two hybrids (9307, 8509), and different coating treatments (UTC: control, A: coating A, B: coating B, C: coating C, D: coating D)
Means separation within planting date and hybrid by Duncan range test, 5% level.

Table 3. Polymer coating effects on plant populations and yields in a conventional tillage trial in Morris, Minnesota planted March 29, 2000. (Source: Gesch et al., 2001)

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Coating Treatment</th>
<th>Plant Population (1000 acre(^{-1}))</th>
<th>Yields (bu acre(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC-9198</td>
<td>Uncoated</td>
<td>22.5</td>
<td>128 (sd. 11)</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>25.5</td>
<td>134 (sd. 13)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>27.8</td>
<td>132 (sd. 8)</td>
</tr>
<tr>
<td>FC-8195</td>
<td>Uncoated</td>
<td>15.0</td>
<td>124 (sd. 9.6)</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>26.7</td>
<td>152 (sd. 9.6)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>27.0</td>
<td>137 (sd. 6.4)</td>
</tr>
</tbody>
</table>
PRODUCER PROFILE

Corn producers most likely to benefit from polymer-coated seed are those who encounter difficulty in consistently completing corn planting during the optimum period in their environment. Specific comments about possible factors affecting grower interest are as follows:

1. No-till corn farmers may benefit more than conventional tillage farmers simply because their soils may dry slower in spring (particularly in fine-textured soils with high or uneven residue cover).
2. Farmers who expect to expand their corn acreage without changing their planting equipment might also be more interested in polymer-coated seed than farmers with sufficient labor and equipment availability to plant all of their acreage during the optimum period.
3. Corn farmers with land (owned or rented) that has variable drainage might be better able to take advantage of those years in which the fields are sufficiently dry enough to plant in March, but when soil temperature and the calendar indicate it is too risky to plant uncoated seed. Fields with poor drainage might be considered as potential areas for planting polymer-coated seed since the yield penalty associated with delayed planting after the optimum period in wet (or even normal) springs may result in substantially higher costs than the additional cost of seed coatings.
4. Corn farmers in the middle of the Corn Belt region might benefit more from this technology simply because there is more likelihood of dry field conditions occurring in March or early April than is the case in the northern edge of the Corn Belt.

SUMMARY

Few replicated studies with multiple planting dates have compared polymer-coated versus uncoated hybrid corn seed. More research is required to ascertain the benefits of polymer coatings and to investigate the hybrid interactions with specific coatings. Our preliminary conclusions are:

1. The initial results confirm that temperature-sensitive polymer coatings do indeed delay emergence and result in higher plant populations when cool (and/or wet) soil conditions and post-emergence frosts compromise corn stand establishment of uncoated seed in early planting situations.
2. Corn population gains for polymer-coated seed versus uncoated seed was more apparent in certain hybrids than in other hybrids. Hybrid selection was also a factor in whether polymer coatings extended the emergence period, or resulted in a similar emergence variability, relative to that occurring with uncoated seed, in early planting situations. Corn hybrids with good seedling vigor would seem to be the best candidates for polymer coatings, because final corn yields with coated seed planted early are more likely to equal or exceed those of uncoated seeds planted during the optimum period.

3. Polymer seed coatings did not negatively affect the yield of corn planted in mid-April to early May. Farmers should thus be able to utilize the polymer-coated seed even if wet soil conditions prevent them from planting before the optimum planting period.

4. More investigations of polymer coating effects on emergence uniformity within corn rows are required before concerns about extended emergence time frames can be allayed. Consistent seeding depth is essential.

5. These polymer seed coatings show good potential for extending the corn planting period in spring by at least an additional 2 weeks. Corn farmers with variable-drained fields, no-till planting systems and equipment or labor limitations during the optimum planting season may be the ones who would benefit the most from this advanced technology.

6. While there is little doubt that these temperature-sensitive polymers will reduce the plant establishment and yield risks associated with very early planting in spring, it is too early to conclude if the risk reduction is sufficient to warrant widespread use of this technology.

ACKNOWLEDGMENTS

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REFERENCES


