Seed coating with environmentally acceptable polymers as an alternative to fungicide treatment of corn and soybeans

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$17,500 for year one
$17,500 for year two

Background and goals

In the United States alone, more than fifty-five million acres of crop land are planted annually with corn seed that has been treated with Captan® (Mercaptan, a powder fungicide). This means that more that 1,230,000 pounds of Captan® are applied to the soil each year.

Large-scale use of this fungicide (which has been banned in at least one European country) merits investigation into more environmentally benign alternatives. Captan® forms dust clouds when farmers open bags of seeds that have been treated with this powdery substance. And currently, all corn seed planted in Iowa is treated with Captan® to protect the emerging seedlings from soil-borne fungi. Seedlings are most vulnerable in late April or early May when soils are cold. Seeds planted later emerge quickly and thus avoid long periods in the soil when they are susceptible to attack by fungi. In this latter scenario, little protection from fungicides is needed.

This project evaluated degradable polymers, or plastic compounds, as environmentally acceptable alternatives to fungicide treatments of corn and soybeans. Such coatings have been used to reduce the moisture uptake of seeds stored at high humidity and thus hinder the decay caused by storage molds. In addition, many polymeric coatings exhibit potential as seed protectants in the soil environment. It is also possible that some polymer coatings may accelerate the rate of germination and growth to allow seedlings to escape the ravages of soil-borne organisms.

Investigators established the following objectives:

- to identify nontoxic, environmentally safe polymers that provide for the regulation or delay of moisture uptake by corn and soybean seeds;
- to apply coatings that will provide protection to the seed under unfavorable conditions, yet allow germination to proceed when conditions are satisfactory; and
- to determine whether coated seeds can produce healthy stands of seedlings similar to those obtained by Captan® seed treatment.

Approach and methods

The primary objective for the first year of the project was to screen traditional pharmaceutical coatings for their possible usefulness as seed coatings. The Seed Science Center at ISU provided soybean and corn seed, including both dent and sweet-corn cultivars, to the Pharmaceutical Services Unit at the U of I, where seeds were coated and returned. The investigators initially tested soybeans as a model system because of their sensitivity to soil-borne organisms and their normally rapid rate of water uptake. During this part of the project, investigators considered the use of polymers that predictably delayed germination until seedbed conditions were conducive to germination and growth. They also identified polymers that accelerate germination and growth without promoting soil-borne organisms.

Within the first eight months of the project, investigators attempted to coat both dent and sweet corn. Because the seedcoat characteristics of both seed types are different from the soybean seed, many of the coating materials that were successfully applied to soybeans could not be readily applied to corn. As these trials continued into 1990, the investigators made sufficient progress in coating the corn seed to conduct a major field emergence trial using both soybeans and the two types of corn.

In 1990, following the initial tests with a limited number of coatings in 1989, the soybean seed was coated with 20 candidate polymers or polymeric systems (see Fig. 1) in a Wurster Column® fluidized-bed film coater. Although investigators produced the coatings according to manufacturers' recommendations, they varied the coating levels to investigate a range of seed responses. Once coated, the seeds were returned to the Seed Science Center for laboratory and field testing. Warm germination tests were conducted on a special substrate at 25° C (77° F) with enough light provided to allow chlorophyll production by the seedlings. This substrate provided adequate moisture, allowed routine evaluation of the seedling development, and left the planted seed undisturbed. The frequency with which investigators monitored germination depended on the experiment.

Investigators also tested seeds under cold germination conditions on the substrate by placing the seedling trays at 10° C (50° F) for seven days before placing them in the 25° C chamber for the remainder of the growth period. Upon removing seedlings from the cold chamber, investigators evaluated them periodically during exposure to the warmer temperature. For the field emergence trials, conducted at the ISU Experiment Station's Agronomy and Agricultural lingineering Research Center, seeds were prepackaged in the laboratory into four-row plots. They were planted by a machine specially modified for these small plots. Two trials took place in 1989, one in 1990, and one in 1991. Investigators counted seedling emergence daily until counts remained the same for three or more days. They used a randomized block design with a minimum of four replications.

Fig. 1. Coating materiais evaluated during 1990 and 1991 on both soybeans and corn.

1990	1991
Aquacoat	Captan
Captan	Chitosan
Eudragit	Daran 8600
Ethyl cellulose	Klucel
Hydroxyethyl cellulose	Hydroxymethyl cellulose
Hydroxymethyl cellulose	Colorcon F
Carboxymethyl acetate	Colorcon X
Carboxymethyl acetate butyrate	Surelease
Klucel	Wilbur Ellis Film Coat
Cellulose acetate	Sacrust
Methylvinyl acetate	Sepiret
Polyvinylpyrrolidone	
Chitosan	
Cellulose triacetate	
Mobilcer	
Maltrin	
Sacrust	
Sepiret	
Wilbur Ellis Film Coat	
Zein	

Findings

Most of the polymer materials tested seem to have little if any effect on water uptake, or imbibition. Two substances substantially delayed the imbibition rate of the soybeans under laboratory conditions when applied at the 10% rate; however, only one of these two depressed the germination rate after either seven or ten days. At the 5% level, no dramatic effects were observed, perhaps because of inadequate coverage. The field-tested seeds were planted into reduced tillage seedbeds, which resulted in generally low emergence, although the polymers tested in 1989 showed some interesting treatment differences (see Fig. 2). The Aquacoat at 10% reduced emergence substantially compared to the control, while hydroxypropyl methylcellulose at 10% and the Zein-coated material increased emergence compared with the uncoated control. This increased (longer) emergence rate persisted throughout the trials.

Ethylcellulose applied in an organic solvent dramatically reduced the rate of water uptake in the laboratory. The emergence delays were strongly related to the uptake delays, yet the resulting seedlings appeared to be relatively normal. The field emergence of the same seed was delayed longer than expected from the earlier laboratory tests. The timing of the delays was generally the same as that in the laboratory; unfortunately, the field trial was terminated because of very low air and soil temperatures.

Materials that provided substantial germination delays were cellulose triacetate and cellulose acetate-butyrate. In both, delays were related to the amount of the material applied. The surviving seedlings generally appeared to be normal, and the final germination was very similar to the uncoated control. The degree of delay can be regulated to a limited extent by varying the coating thickness. However, the delay is not sufficiently uniform, nor are the seedlings that develop free from physiological lesions. The Sepiret coating, on the other hand, resulted in a more rapid, more uniform water uptake rate and a faster initial germination. This strategy may provide an alternative approach to improving the field stand establishment and potentially reducing the need for traditional fungicide application.

After unsatisfactory initial attempts to apply the same coatings to both dent and sweet corn, investigators tried a pan-coating system instead of the fluidized bed. Because the seed coat characteristics of corn are very different from soybean, the polymer application problems were not unexpected. In spring 1990, they evaluated both delay and germination acceleration treatments on both corn genotypes and soybeans. Following the successful field test, they extended their evaluation in laboratory tests to the physiological and pathological impacts of delayed water uptake and the acceleration of water uptake on seedling performance. Additional coating materials were investigated by using the modified test as an evaluation system and a modified fluidized-bed application system.

In the 1990 field emergence trials, several polymers applied to dent corn performed nearly as well as the Captan®-treated seed under very stressful field conditions. Rains of at least 0.75 inch occurred no more than three days apart during the first 20 days after planting. Seedbeds were nearly saturated, resulting in almost no emergence in the soybean plots. The corn plots emerged at a much higher rate, but few seedlings were present prior to 16 days after planting. In general, the polymers did not

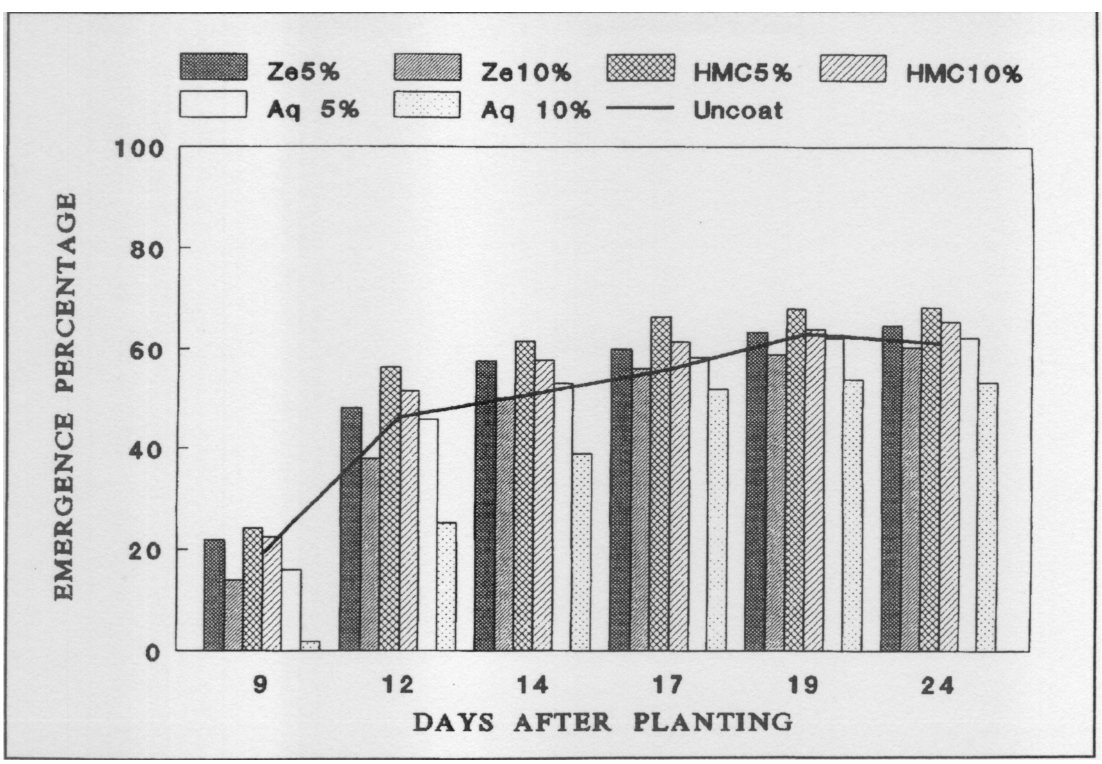

Fig. 2. Effect of coating material on rate of field emergence of soybeans planted May 11, 1989. Zein = Ze; Aquacoat = Aq; and hydroxymethyl cellulose = HMC.

improve emergence of either soybeans or sweet corn. Rankings of the field emergence differed considerably from those of the laboratory tests. The extended cold test appears to offer potential as a screening technique to identify materials that may be beneficial under extremely stressful conditions.

Implications

Despite the logistical challenges of a collaborative project between laboratories located 150 miles apart, investigators made significant progress. They identified environmentally acceptable polymeric seed coatings that resulted in field performance similar to traditional fungicides; they also identified some testing and regulatory labeling challenges that accompany coated seed that performs well in the field but poorly in standard tests. In addition, they developed a laboratory-scale, fluidized-bed coating unit capable of coating several different species.

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Although a polymer to replace currently used fungicides has yet to be identified, this project clearly demonstrated that field performance similar to traditional pesticide-treated seed can be obtained with conventional polymers. It also represented the initiation of a seed coating research program within the Seed Science Center that is now recognized nationally as the leading program of its kind within the public sector.

This project has since attracted additional grant funds from the Iowa Department of Economic Development, Northrup King Seeds, the Independent Professional Seed Association, and Crop Genetics International. The program has been described in several seed trade publications for its leadership role in this important research area. Ultimately, these researchers hope that plastic-coated seeds will eliminate the fungicide dust clouds to which farmers are currently exposed when they open bags of seeds.