SEED COATING METHODS AND PURPOSES: A STATUS REPORT

F. E. Porter and J. M. Scott

Seed coating is an old art dating back at least to 1866 and the patent issued to Blessing. Blessing proposed to improve plantability of cottonseed by slicking down the lint carried by these seeds with a paste of wheat flour. Since then, the literature of seed coating has exploded. Methods, products, and performance information are now published in the patent literature, in the popular press, and in technical journals.

Seed coating art covers a broad array of methods and purposes. In a simple case such as fungicide treatment of seeds, a minority of solid is applied, perhaps as little as 6 oz/cwt of seed. At the other end of the spectrum is the precision sized petunia seed in which coating increases particle weight by a factor of 200. In this case, one pound of seed may be increased to 200 pounds of product. In between these extremes lie the seeds coated for other purposes. The purposes are as varied as the methods and formulations.

This paper deals with methods of coating in broad terms. It lists some representative purposes of seed coatings, discusses adhesive systems, methods of application, and observations made on coated seed performance. It then discusses some of the Northrup King coating arts with reference to production, performance and cost. The final section discusses the potential role of coated seeds in commercial agriculture.

A brief list of references is furnished with major emphasis on the patent literature. The list is necessarily selective and offered to illustrate the range of methods and opportunities in the field.

The Coating Arts

Table 1 illustrates some of the variety of methods and purposes found in the seed coating literature. Figure 1 shows some of the products that have been offered, at least for farmer testing. Some of these are commercially available today.

Seed coating has its roots in pharmaceutical pill coating. Those with serious interest in seed coating will do well to consult a good

1/Northrup-King Co., Minneapolis, Minnesota.
Table 1. Published methods of seed coating for various purposes.

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Seed Kinds</th>
<th>Adhesive</th>
<th>Typical Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Precision sizing</td>
<td>Vegetables, flowers, sugar beets</td>
<td>Colloids 1/</td>
<td>Clay, ash, talc, vermiculite</td>
</tr>
<tr>
<td>B. Stand establishment</td>
<td>Legumes, grasses</td>
<td>Colloids, polymers</td>
<td>Calcium carbonate, gypsum</td>
</tr>
<tr>
<td>C. Inhibition of herbicides</td>
<td>Grasses, any seed</td>
<td>Waterproof resins, colloids</td>
<td>Active carbon, specific inhibitors</td>
</tr>
<tr>
<td>D. Germination delay</td>
<td>Any seed, corn, rape</td>
<td>Waterproof resins</td>
<td>Cured resin</td>
</tr>
<tr>
<td>E. Pest control</td>
<td>Any seed</td>
<td>Colloids</td>
<td>Pesticides and repellants</td>
</tr>
<tr>
<td>F. Adhesion (to sowing surface)</td>
<td>Grasses</td>
<td>Resins</td>
<td>Colloids</td>
</tr>
<tr>
<td>G. Micronutrients</td>
<td>Any seed</td>
<td>Colloids</td>
<td>Fertilizers</td>
</tr>
<tr>
<td>H. Promote water accumulation</td>
<td>Any seed</td>
<td>Colloids, resins</td>
<td>Starch-graft polymers</td>
</tr>
</tbody>
</table>

1/ Colloids include animal glues, natural gums, modified celluloses, etc.
text on pill coating for specific information on the coater's art. In general, seeds are mixed with an adhesive so that every seed is covered. The coating solids are then added. Each seed in the doughy moist mass will assume its own coating and the particles tend to singulate. The coating is then cured. The coated seed are then screened to remove lumps and fines and is ready for packing.

The keys to success include selection of an appropriate adhesive system, selection of a solids formulation of appropriate grind, selection of an appropriate mixing intensity, and selection of a workable balance among seeds, adhesive, working method, drying time, and working time. Seed coating as traditionally practiced is an art and not a science. Specific details of the art are typically held as trade secrets but general descriptions are public information.

The Rotating Drum

Most of the seed coating patents describe preparation of coated seeds in a rotating drum. The drum might be a simple concrete mixer or an elegant device with automatic controls and complex accessory devices. Adhesives are typically chosen to be soluble or dispersible in water. Starches, natural gums, sugars, animal glues, plant mucilages are commonly used. These are dispersed in water to give a sprayable fluid.

If one is pelleting to size, he will place a batch of seeds in the rotating drum and commence rotation. He will then apply a fine mist of adhesive to the mixing seeds and allow mixing to continue until each seed bears a thin film of adhesive. He will then add sufficient solids to cover each seed without excess. Continued rotation under ventilation dries the coated seed. The process is repeated again and again until particles are of the desired size and shape. During the operation, the coating work-harden. A final application of a binding agent will impart a smooth finish to the particles. Wax, lacquers, shellacs and similar materials may be used in this final coat.

The same general method can be used to produce coated seeds if particle size is not particularly important. In the lime coating of alfalfa, for example, the adhesive is made more viscous. The total requirement is applied to seeds at one time and the seeds form a wet doughy mass. The total solids application is made in one step. As much as 30 lb/cwt of seed is applied. The seeds take on individual coats and the coating work-harden with continued rolling.

Figure 2 shows a typical rotating drum for particle coating. The equipment produces batches with an upper limit of perhaps 1300 lb of seed/batch. The drum of this capacity will cost about $25,000. Additional accessories and product handling devices can increase the cost to a total of $50-100,000, depending on available equipment in the coater's plant. Process time/batch will vary from perhaps 2 hours up to 8 hours, depending on operations.
The charge for coating varies with operations. In the case of precision pelleting of petunia, 1 pound of seed will be increased to 200 lb of product at an approximate cost of $1.00/lb, product basis. Precision sized sugar beet seed increased 6-fold in weight will cost about 35¢/lb, product basis.

Continuous Flow Paddle Mill

Northrup King Co. examined the commercial problems of seed coating and concluded that the rotating drum imposed unacceptable production rate limits and production costs for seed coating. The early stages of our research program dealt first with alternate adhesives and finally with alternative methods of assembly. In one current version, the adhesive is a special organic prepolymer that reacts with moisture to form a sticky intermediate product that cures into an insoluble but porous coating. The seed coating could then be handled on a continuous basis in a paddle mill.

Figure 3 shows a coating mill used by Northrup King. The coater is a paddle mill. Raw seed is metered into the mill and sprayed with the organic prepolymer. Each seed takes on a film of this material. A small amount of water is sprayed into the working mass. The water spreads from seed to seed, activating the prepolymer and creating the sticky intermediate product. Pulverized solids are then metered into the working mass. Each seed assumes its own coat and the prepolymer continues to cure. Finished coated seed particles are discharged from the mill. The apparatus is ventilated to remove solvent and water. Coated seeds can be packaged directly from the mill. The production rate is 20,000 pounds of seed, input/hour. The seed is expanded to 24,000 pounds of product. Cost is about 8¢/lb, product basis.

The same equipment can be used for coating different kinds of seed with various materials, all under continuous flow conditions.

Product Performance

Precision Pelleted Seeds

Northrup King does not produce precision pelleted seeds but has examined them. Buyers of some types of seeds may have Northrup King seed items pelleted by a firm specializing in the art. The custom pelleters are highly successful in producing particles of the desired size. But the performance of these products can be imperfect. In the case of sugar beet seed, for example, growers have reported poor stands or erratic emergence. The problems are associated with dry soils, excessive depth of planting and flooded soils. Precision pelleted seeds appear more demanding of their environment.
Figure 1. Examples of coated seed.

Figure 2. Diagram of rotating drum device for pelleting seed.
Figure 3. Paddle mill used in continuous flow coating of seeds at Northrup-King Co.
Precision pelleted seeds are commonly used to improve efficiency of seed use, to allow precise seed placement and to reduce labor used in weeding, thinning, blocking and harvesting. Growers also expect to have a greater yield of marketable produce. Their hopes flow from undisturbed growth of precision planted seedlings, more uniform emergence and more uniform development. These hopes may or may not be realized.

Precision sizing and planting offers opportunities for better crop production but these are limited by variability in commercial seeds. Commercial seed lots are characterized by variations in size, shape, emergence, speed, and that understood but ill-defined property called vigor. Until methods are found to separate lots into sublots of greater uniformity, the true potential of precision planting will not be realized.

Coating to Aid Establishment

There is substantial information on the use of coated seeds to establish forage legumes on acid soils. The early work on this idea was done in New Zealand. The idea was moved around the world and has now been studied in many different places. In the United States, the Washington, Idaho, California and Hawaii experiment stations have endorsed the practice. Wisconsin, Michigan, and Nebraska have reported lime coating to be without benefit in station trials. About half of the farmers who have planted lime coated legume seed offered by Northrup King have observed improvement in crop performance. Typical yield increases run from 5-10%. Protein increases are commonly reported. Establishment of legumes on problem fields is also a common report. When NOCULIMED seed was used in chemical improvement of pastures, lime coated seeds have performed very well indeed. More recently, these products are finding use on disturbed soils of the spoil banks of middle-American coal fields.

Figure 4 shows an alfalfa field planted with NOCULIMED alfalfa and seed of the same lot without coating. Benefits included thicker stand, greater yield and quicker recovery after cutting. The field is shown as it recovered following cutting.

Figure 5 shows a comparison of plants from coated and market red clover. Plants from coated seeds establish crowns earlier, develop more leaves and a thicker root. They have storage reserves for prompt recovery after cutting.

Figure 6 shows a Wisconsin pasture during improvement planting in 1975. Figure 7 shows forage production in the third year after seeding. This field had been free of legumes for many years. The farmer converted the field from a marginal grazing pasture to a source of stored feed.
Experiences of the types shown here testify that lime coating can bring about a profitable increase in crop performance.

Inhibition of Herbicides

In some seasons, herbicide residues from earlier plantings persist and damage the new crop. A soybean crop following corn may exhibit atrazine damage under some climatic conditions. Improper use of herbicides can also create problems both in the crop for which weed control was applied and the succeeding crop. Seed coatings can be applied to take up or inactivate herbicide in the seed zone of the field. Activated carbon has been used for the purpose. There are indications that lime coatings can have this effect. The coating art for herbicide inactivation is not well defined or developed. It seems clear, however, that a combination of protected seed and non-persistent herbicide could have economic value, especially to producers of vegetable crops. A new combination of herbicide for soil application coupled with seed treated with a specific inactivator will be test marketed in the next two years by Ciba Geigy.

Delay Germination

Producers of hybrid corn seed commonly produce hybrid seed from two parental lines of different maturities. One parent, the maternal line, produces the actual seeds. The other, the paternal line, provides pollen needed for seed production. Since these two lines flower at different dates, a method is necessary to adjust the flowering period of one line. Most commonly the pollen line matures early and so must be planted later than the maternal line. Traditionally, a production field is planted with the maternal line with rows left open for later planting of the male parent. The farmer requires a special fee for double planting. Weather can interfere with the second planting. The practice creates special risks for the seedsman and grower alike.

Northrup King developed a coating process through which the germination of a seed can be delayed. Very simply, the seed is coated to slow movement of soil moisture into the seed. Germination is delayed as is subsequent flowering. Through adjustment of the coating process, one can impose a predictable delay on seed germination and on flowering period. There is the additional benefit that one can produce a blend of seeds coated to impose different delays. This practice allows extension of the period of pollen availability by creating non-uniformity where substantial uniformity originally existed.

Figure 8 shows seedling corn plants grown from coated and normal seeds.

The coating process for seed germination delay is the product of 10 years of laboratory investigation and field testing. Coated seeds have
Figure 4. Alfalfa field recovering after hay harvest. Right, planting of uncoated seed; left, planting of lime coated seed.

Figure 5. Plants of medium red clover from non-coated and "NOCULIMED" seed.
Figures 6 and 7. Top: Sod seeding of pasture (Wisconsin) with lime coated legume seed. Bottom: Forage production in third year after seeding.
Figure 8. Rate of germination and emergence of corn seed without coating (right) and with "waterproofing" coating to delay germination (right).
been used in commercial seed production for the past 3 years. Accumulated research and commercial data support these conclusions. First, one can impose predictable delays up to about 150 Heat Units without substantial loss of stand. At greater delays, stand losses can exceed 25%. The process is most useful when applied to the male parent seed. Second, the redistribution of pollen over a broader period leads to yield increase of about 5%, average. Third, pollen availability over a longer period tends to result in the increased production of medium flat kernel grades. These grades are most wanted by seed buyers. Fourth, coated seed allows convenient interseeding of male between normally spaced rows of female corn. Rows will be parallel and cultivation risks to the crop are reduced. This practice of interseeding improves yield/female acre and also improves yield/field acre. The interseeding contrasts with traditional planting methods where seeds are planted in 4 row frames of female adjacent to 2 row frames of male plants. In this traditional practice, only two-thirds of the field produces seed; one third produces only pollen.

Germination delay coatings have been shown effective with sunflower, sorghum, wheat, radish, snap bean and many other crops. While the concept was developed to meet a need of the seed producer, it has application for the canner who must stagger plantings to regulate flow of produce to packing plants. It has potential application in double cropping practices. It has potential application in establishing vegetation on construction sites where seeding must be completed to satisfy contract rather than to exploit appropriate seasonal weather for establishment.

Delay germination coatings have also been explored by Schreiber and others as a means of extending the growing season. Their concept was to coat seeds so as to delay germination and then plant a spring crop in the fall. The concept appears workable with wheat and triticale in Manitoba. These crops will tolerate some cold stress without stand loss. The concept failed when applied to rape seed. Premature emergence and other factors caused stand loss to low temperatures.

**Anti-Erosion Coating**

Northrup King has developed a coating process through which a water-softening adhesive is bound to seeds. When such seeds are broadcast and moistened, they bind themselves to the surface on which they fall. They resist movement. This kind of product has been used on winter golf greens where seed movement can produce ridges, clumps and other defects in the playing surface. It has been tested on slopes subject to sheet erosion.

**Micronutrient Coatings**

Coated seeds have been prepared with micronutrient coatings to correct crop deficiencies. Deficiencies of sulfur, iron, zinc,
molybdenum, manganese copper and other micronutrients exist as commerical problems; seed coating provides a means of applying small amounts of corrective material/acre. The development of economic quantities of metal chelates provide special opportunities in that the chelate stabilizes the nutrient in an available form and also limits its application to the actual root zone of the establishing plant.

Georgia Pacific Corporation in cooperation with university personnel from different states has been exploring the commercial application of metal chelates for deficiency correction. Their programs include broadcast, in furrow, foliar and seed coating applications. Each method offers potential advantages; each presents some problems. Metal chelates can be applied to seeds through any of the coating processes mentioned here. In the case of rice, zinc coated seeds will provide the zinc needed to support the growth of the crop. In the case of sorghum, zinc chelate coating improved yields by 27%. Foliar treatment involving 5 applications of ferrous sulfate increased yield by 40%. The pelleted seeds carried 20 grams of iron/acre (on 5 lb of seed) and the foliar spray applied about 172 grams of iron/acre in each of 5 foliar applications. The seed application of chelated iron can be increased substantially without affecting seed germinability or vigor. The preliminary conclusion is that seed coating can replace several foliar applications of iron for sorghum grown in iron-deficient soils. Similarly, seed coatings containing chelated zinc appear to correct deficiency when rice is grown under conditions of inadequate zinc availability. Field trials on a substantial scale are in preparation.

**Fertilizers**

It seems unlikely that macronutrients can ever be applied in quantity to sustain a crop grown from fertilizer-coated seeds. Additions of available nitrogen tend to accentuate damping off and seedling diseases. Additions of available phosphorus also tend to reduce stands. At best, seed coating can provide a low level of starter fertilizer at some risk in stand reduction.

**Promote Water Accumulation**

Starch graft polymers have the capacity to imbibe water to very high levels and to release this water to seeds. Academic studies of the benefits of starch graft polymers have been disappointing in results. But there is a reasonable body of reports from farmer trials that suggest the "Super Slurper" can be very useful. Most of these reports are from irrigated farms and from farms where double cropping operations are under way. The water collecting action of these remarkable compounds seems to aid establishment of seedlings from seeds broadcast into standing crops.
Herbicide Applications

We have mentioned the use of safeners to protect seeds from soil-applied herbicides. Recently, research workers have begun exploring the use of seeds as carriers for herbicides. Dr. Jean Dawson of the University of Washington, Prosser has begun to develop this concept. Beginning with band application of herbicide, he moved on to granulated herbicide mixed with seeds and then to direct application of herbicide to seeds. He used lime coated alfalfa and applied Eptam. He also examined herbicide-treated field beans in Costa Rica. In the case of alfalfa, weed control from seed-carried herbicide extended from 4-8 cm from the treated crop seed. Each seed carried herbicide to control weeds in a little less than a square inch. Damage to the alfalfa seedling was reported to be transient and minor. With high costs of agricultural chemicals, the economies of seed application truly are appealing.

We have not really presented a complete description of the seed coater's arts and dreams. We have offered a broad view with brief comments on specific examples. Variations on the themes mentioned here are being proposed. The field is really changing constantly.

Let us now offer a brief statement designed to put coating into perspective. You will understand this is our perspective; others may well hold other views.

Perspectives

Seed coating ideas have been advanced, tested and exploited for many years. Most coating ideas have been abandoned. Those that survived exist as specialty products making up a minority of the seed supply. Some ideas appear destined to remain as possibilities that never receive their test in commercial markets.

Traditional methods of coating add substantial cost to the product. Cost has been a limiting factor in acceptance of coated seeds. On a seed weight basis, costs range from 10¢/lb of seed coated with lime in the NOCULIMED Process to perhaps $200/lb for the precision pelleted flower seeds created by the various custom pelleting firms for their customers. Since alternate solutions to problems solved through coating are available, coated seed acceptance depends heavily on the values a seed buyer associates with coated seeds. The values assigned by seed users to the benefits of coated seeds also loom large.

In the case of bedding plant growers, high priced small seeds such as petunia can be sown in mixture with a carrier into seed flats. Seedlings can be transplanted. If a grower is unable or unwilling to organize an appropriate seasonal labor force, pelleted seed will assume a high value in his operations. Precision pelleted flower seeds have
been produced on a substantial scale for many years. It is impossible to establish market share for pelleted flower or vegetable seeds. These products are surely a minor part of total trade in terms of either dollar value or pounds of seed affected.

In the case of sugar beet seeds, consumption has changed abruptly from time to time. In some areas, precision pelleted seed dominates the beet seed market but in other locales there is virtually no demand. Use is limited by cost and by the sensitivity of the pelleted seeds to adverse conditions. Pelleting alters the moisture up-take of beet seeds and germination can be both slow and erratic in dry soils. Similarly, the pellet coating can affect gas exchange in wet soils with resulting problems of stand. Precision pelleted beet seeds have generated complaints from some growers. While pelleted beet seeds dominates the European market, it has lost market share in the United State recently.

Other pelleted and coated seed products are in their early stages of market development. There is a continuing market for lime coated forage seeds. These products are a small element in the total market but are substantial factors in some local areas. Cost is a factor in slowing acceptance. Planting equipment must be adjusted for the larger seed size. Failure of a farmer to adjust his equipment often leads to a complaint of poor plantability. Performance as measured by yield responses has been good. These products will grow in commercial importance.

Micronutrient seed coatings on sorghum, and rice have been examined at the experimental level with success. Zinc chelates have been used successfully for in-furrow broadcast and aerial applications on rice land. Rice seeds will tolerate economic levels of zinc chelate. The rice seed market is confined to a few regional markets sharing common problems. The probability is that zinc chelate coatings will find their place in the rice seed markets.

On the whole, seed coatings appear to have substantial commercial value to some seed users. In time, they will find their own places in the seed market. Coatings cannot replace sound crop growing practices. They cannot compensate for poor seed quality. They typically are applied for a specific purpose and will not be universally useful in all locations. But taking all of the facts relating to crop production into account, one must conclude that coated seeds have a place in American agriculture. Increases in coated seed product production are expected.

We will close with this thought. Our social and technical climates have changed over the past decade or so. We are working toward the elimination of risks of all kinds. We have changed our ideas of liabilities and of where risks lie. Farmers are faced with rising costs of land, equipment, labor, and supplies. They are also faced with crop and livestock prices that seem excessively low. Despite world feed and
forage shortages, this country lives with market-depressing surpluses. These factors, more than coated seed benefits, appear destined to control the rate of development of the coated seed market. On balance, the social and economic factors promise to slow commercialization of seed coating technologies.

References


