SEED COATING AS A MEANS OF IMPROVING CROP PRODUCTION

Frederic E Porter, PhD

In 1905, Aristotle Rey patented a scheme for coating cereal grains with fertilizer bound to the seeds with glue. His process never found acceptance and its description remained hidden in the patent files. Others re-invented seed coating and by 1958, there were some 35 U. S. patents describing seed coating methods and coated seed products. Except for vegetable and flower seeds pelleted for precision planting, there was no substantial quantity of coated seed in commerce.

In 1958, New Zealand workers began to report their experiments with lime coated legume seeds. They began with the idea that the individual farmer could coat his own seeds at planting time and their process was developed with this goal. They mixed 100 pounds of legume seed with a pint of binder made with water and one of the water soluble gums. Their mixer was a concrete mixer. When the seed mass was doughy, they added 30 pounds of lime and allowed the mass to break up into individually coated seeds. They continued mixing to firm up the particles and then sifted the material to remove lumps. After a brief period of tempering, they planted their product from the air, usually on broken and inaccessible pasturelands common to New Zealand.

The New Zealanders created some impressive successes and their work attracted attention. Other investigators copied and modified the original coating procedures. Today there is a great body of reports on coated seed performance.

The list of potential benefits from coating is long and impressive. Coated seeds sprout quicker and establish seedling populations more effectively. Nodule bacteria perform better in coated seeds. Coatings provide protection from birds, vermin, insects and disease organisms. They allow incorporation of growth factors, fertilizer, micronutrients, pesticides and other supportive materials. And to this list, one can add the ill-defined benefits that have been observed but not fully explained. If one could accept all of these reports at face value, he would conclude that seed coating offers a potential solution to every problem faced by the farmer.

I am personally convinced that the reports, astonishing as they are, reflect real observations made by capable people. Unfortunately, some of the reported benefits cannot be reproduced consistently in commercial farming operations. None can be produced invariably. The list of real benefits is, therefore, reduced to contain only those benefits that occur with enough frequency to justify commercial coating. In the final analysis, coating must be justified in terms of the cost-benefit experience of the commercial farmer.

In 1959, Northrup King began study of seed coating methods. The New Zealand system is essentially a batch process that is not readily converted to continuous flow. Production equipment is expensive and labor requirements are large. The organic gums are not outstanding adhesives in their dry state; coatings made with these binders depend in part on work hardening of the coat and this consideration extends processing times. Our conclusion was that a new adhesive system was required.

In 1974, we obtained a patent covering a new and radically different coating process A prepolymer in solvent is applied to seeds. A curing agent is then applied to begin chemical change in the prepolymer. The seeds become sticky and will accept and hold pulverized solids that are applied. As the reaction goes to completion, the seeds are covered with a porous coating of solids and adhesive, bound to the seed in an insoluble mass. Coating can be accomplished continuously at any desired rate. Production of our NOCULIMED Seed takes place at a rate of 20,000 pounds of raw seed, input, per hour. Coated seed is packaged directly from the coater.

In the course of development studies, this basic system was used to bind various materials to many different kinds of seed. We have coated corn, sorghum, alfalfa, clover, orchard grass, soybean, sugar beet and wheat. In terms of coating integrity, we can apply many different kinds of pulverized solids to seeds.

In general, insoluble materials are without harmful effects. Application of fermentable materials results in accelerated fungus growth; chemical poisoning of seedlings may result. Soluble salts appear to interfere with germination through osmotic effects; delays in emergence typically result in reduced stand. Urea, soluble nitrates, and pulverized phosphate salts have the latter effect.

Once a coating method was developed, we began study of the effects of coating on seed performance. Figure 1 shows results from a germination study made to establish effects of adhesive application levels on germination values.

The coating materials have no effect on speed of germination nor do they affect ultimate germination levels, even when applied in substantial excess. The coating has no water demand in itself; water simply moves through the coating into the seed.

FIGURE GERMINATION VALUES FOR ALFALFA SEEDS COATED WITH LIME AND POLYURETHANE ADHESIVE

ADHESIVE APPLIED	GERMINATED SEEDS	% GERMINATION
12 oz/cwt seed	45.6 ± 3.4	
24 oz/cwt seed	45.0 ± 3.4	90.0
48 oz/cwt seed	47.6 ± 2.7	
CONTROL, NOT COATED	45.6 ± 3.4	

Data based on 5 replicate plantings of 50 seeds each
Lime was pulverized $CaCO_3$ applied at 20 lb/cwt seed

Plantability studies were made of coated seeds in a test stand fabricated from parts obtained from John Deere. In commercial machinery, the seed settings are made on a notched gate with each notch representing 1/16 inch of exposure of the fluted metering roll. With 25.3 RPM at the metering roll and a gate set in the 5th notch, the equipment would plant about 10 lbs. of uncoated alfalfa seed/acre. Planting speed is specified at 5 MPH.

Flow of seed through metering systems of the type commonly used will be affected by particle size, particle uniformity, particle smoothness, gate opening and driving speed. The speed of metering roll rotation is established by a chain drive powered from the planter wheels. The farmer can adjust planting rates by adjusting gate opening. If his seeding rate exceeds the capacity of the metering roll, he may change sprockets and achieve a 4-fold increase in seed flow. Uniformity of seed flow through the metering rolls is critical to uniform planting.

Figure 2 summarizes typical results from a plantability test on lime coated seed.

FIGURE 2 FLOW OF NOCULIMED ALFALFA SEED THROUGH A JOHN DEERE PLANTER

GATE OPENING	GRAMS OF SEED DELIVERED IN 15 SECONDS		
	UNCOATED ALFALFA	COATED ALFALFA	
		PRODUCT	ACTUAL SEED
22/16ths	35.36 ± 2.61 g	36.30 ± 2.61 g	31.58 g
16/16ths	27.22 ± 1.29 g	26.10 ± .31 g	22.71 g
12/16ths	18.70 ± 0.61 g	17.92 ± 0.41 g	16.27 g
8/16ths	9.96 ± 2.25 g	9.66 ± 0.51 g	8.40 g
7/16ths	10.32 ± 0.95 g	8.36 ± 2.15 g	7.27 g
6/16ths	7.50 ± 0.39 g	5.94 ± 0.08 g	5.17 g
5/16ths	5.90 ± 0.17 g	4.40 ± 0.06 g	3.83 g
4/16ths	0.70 ± 0.44 g	0.40 ± 0.14 g	0.35 g

The data of Figure 2 illustrate two points. First, a farmer must open his seeder gate when he plants coated seeds if he wants to maintain actual seeding rate and second, flow of coated seeds is as uniform as flow for uncoated seeds. I might note in passing that alfalfa seed lots vary greatly in seed count/pound (about 218,000 to 254,000 seeds/pound) and in bulk density. Implement settings are based on average values and the prudent farmer will check actual delivery of seed prior to planting.

Development of a mechanically sound plantable coated seed once seemed to be the difficult part of our research project. But with the completion of the mechanical development, it became clear that the formulation of a useful coating composition was the difficult part of the project. Let me comment on a few coating applications we have defined and proved under conditions of practical use. We have patented a coated seed product for use in regulating emergence of corn in seed production fields. We pellet the corn and then apply a moisture barrier that delays water uptake by the coated seed. This coating system allows us to plant male and female parents of different maturities on the same day. By imposing a controlled delay on the early parent, we insure male and female plants will flower at the same time. We eliminate our need for split plantings in seed production fields.

Figure 3 presents germination data and data on silking of female with pollen shed by male. Work on this application began in 1968; the principle was placed in use in production fields in 1976. The concept has application in commercial seed corn for purposes of insuring adequate distribution of pollen in commercial farm fields.

A second application is an anti-erosion coat applied to turfgrass seeds. There are many overseeding operations in which seed movement creates difficulties. We have pelleted seeds with a water-activated adhesive. When these seeds are broadcast and moistened, they cement themselves to the surfaces and resist forces such as sheet erosion and mower lift. Figure 4 shows a test plot in which freshly planted turfgrass seed was flooded after planting. The clean boundaries of the plot on inclined soil illustrate the efficacy of the anti-erosion coat.

In a third application, coated seeds are agglomerated during coating. The product is a pellet containing several seeds. In the normal course of events, people are far more interested in singulation than in agglomeration. But the seeds in agglomerates appear to sprout more rapidly than singulated seeds and tend to establish more quickly. This principle has not been applied commercially although its value has been demonstrated in the field. We believe the idea will find its ultimate use in pasture plantings, soil bank plantings and the like. In hay fields, the effect is unlikely to be of commercial importance.

Because forage legumes are important in our business, because lime coating has proven value in acid soils, and because 75% of our forage seeds are planted in acid soils, we chose lime coating as our principal coating venture. Let me offer a brief overview of our work with this product. Our product is called NOCULIMED Seed. It is inoculated and lime coated forage legume seed.

In the testing of such products for inoculation efficacy, pairs of seeds are planted in sand within glass test tubes. After about 3 weeks of growth, the plants are washed out of the sand and evaluated. Figure 5 shows data from a representative test in which inoculated seed lots were tested in both lime coated and uncoated versions. All seeds received identical rhizobial counts.

FIGURE 5. GROWTH OF ALFALFA SEEDLINGS FROM COATED AND UNCOATED INOCULATED SEEDS

INOCULANT	MEAN PLANT HEIGHT AFTER 21 DAYS	
	NOCULIMED SEED	UNCOATED SEED
	94.1	54.3
2	105.6	
3	133.1	
4	76.6	
5	106.5	
	93.6	
	120.8	
8	107.5	
9	42.0	
10	73.5	51.3
MEAN	95.33	64.12
CONTROL, NOT COATED OR INOCULATED		

Comparable results were obtained in pot tests from the growth chamber. Data are summarized in Figure 6. In this trial, seedlings were cut and allowed to grow back again The second harvest is reported. Coated seeds gave plants producing more stems/crown and more leaves/plant. They also gave a higher yield by about 6%. Plants from coated seeds developed heavier roots and larger crowns. The increase in root reserves appears to favor re-growth, making benefits of lime coating persistent.

FIGURE 6. CHARACTERIZATION OF SECOND CUTTING FORAGE OF PLANTS GROWN FROM LIME COATED AND UNCOATED ALFALFA SEEDS

ATTRIBUTE	RAW SEED	NOCULIMED SEED
Plant count/pot		
Stems/plant	7.5	10.7
Mean Stem height (cm)	18.7	13.9
Green wgt/plant (mg)	450	480
Leaf count/plant	55	76

Soil was pH 6.5 measured with glass electrode

Figure 7 summarizes a similar comparison made of field grown plants. The soil was pH 6.5, the growth period was 30 days from planting. The differences predicted from both tube and pot tests were observed in these tests. The gain in plant tissue was about 16%. As the crop develops, one would expect the differences to shrink without disappearing.

Similar gains in forage production were seen in farm fields from Oregon to West Virginia and from Canada south to Missouri. Of some 150 farmers interviewed, about half reported visible improvement in their crop from the NOCULIMED Seed in comparison plantings. In several cases, NOCULIMED Seed produced effective stands on problem fields Some farmers reported better survival of plants as well.

FIGURE 7. WEIGHTS OF ALFALFA SEEDLINGS PRODUCED FROM COATED AND UNCOATED SEEDS IN THE FIRST 30 DAYS

SEED LOT	AVERAGE SEEDLING WEIGHTS		GAIN
	NOT COATED	COATED	%
	610 mg	720 mg	18.0
	580 mg	620 mg	
3	540 mg	640 mg	18.5
	650 mg	660 mg	
	430 mg	484 mg	
6	309 mg	363 mg	
	384 mg	545 mg	

Figure 8 shows a comparison planting made by a farmer in Oregon. The field is shown about 7 days after the hay was harvested. The difference in regrowth is evident. We attribute this difference to the improved food reserves in the larger roots of plants from NOCULIMED Seed.

We have coupled our lime coating process with the new techniques of chemical renovation of pastures on farms across the midwest. Figure 9 shows one of the fields where we worked. The field contained soil at pH 6.0 and had no legume component in the sward at planting. Forage production from the improved area was greatly increased.

The cost-benefit ratio for participating farmers was substantial. The most commonly reported yield increase was about 10%. With normal hay production of 2.5 T/acre and current hay prices of $75/T, farmers increased return by about $18/acre. Increased seed cost associated with coated seed use was well below $1.00/acre.

Lime coatings would seem to be of limited value to farmers in the major alfalfa producing areas of California. On alkaline soils, elemental sulfur would seem a better choice of coating solid. Gypsum could also be useful. Perhaps an inert solid might be incorporated to provide a mechanical barrier between seed and soil.

We have done work with sulfur-coated wheat seed in the Yuma, Arizona area. Results of a replicated field trial are summarized in Figure 10. Coating improved yield. Treatment differences for Produra were statistically significant; those for Cajeme were not. The test was variable; the coefficients of variation exceeded 20%.

Results such as these are interesting, but they require confirmation. Test plantings of coated wheat are growing across the winter wheat belt at this time.

At this point, we have some convictions as to the value of coated seeds. We think coated seeds will find their place in commercial farming and will return substantial benefit over cost to farmers. But we are convinced that top yields will still depend on conventional practices. A farmer must plant high quality seed of improved varieties. He must prepare his land and sow seed properly in a well-prepared seedbed. He must control weeds and pests. He must harvest his crop so as to transfer yield from the field to the hopper or barn. We do not think coating techniques will compensate for defects in farm practice.

But, given sound farm practices, we expect seed coatings to improve crop performance. Some types of coatings are already established as valuable to the farmer. We expect additional coatings to prove their value in seasons to come.

FIGURE 10. Yields of Cajeme and Produra Wheat from coated and uncoated seeds.

	CAJEME	PRODURA
NOT COATED	97.5 bu/acre	107.08 bu/acre
GYPSUM	111.27	104.51
GYPSUM/PHOSPHATE	103.70	115.26
ELEMENTAL SURFUR	111.89	109.63

Differences for Produra met tests of statistical significance; those for Cajeme did not.

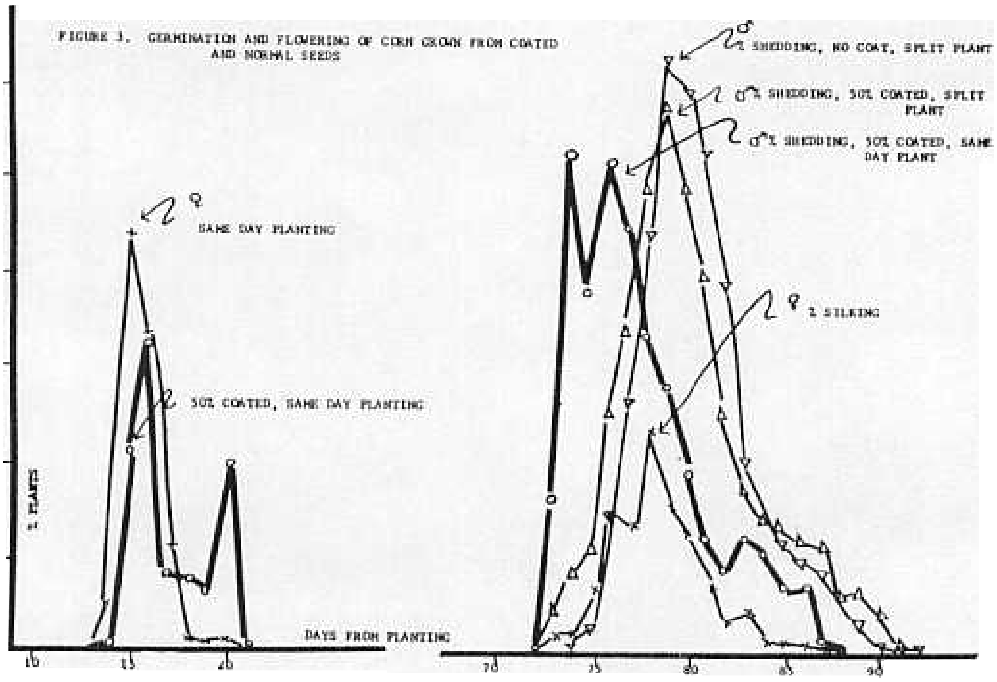
FIGURE 3. GERMINATION AND FLOWERING OF CORN GROWN FROM COATED AND NORMAL SEEDS
♂ % SHEDDING, NO COAT, SPLIT PLANT
♂ % SHEDDING, 50% COATED, SPLIT PLANT
♂ % SHEDDING, 50% COATED, SAME DAY PLANT
♀ SAME DAY PLANTING
♀ % SILKING
50% COATED, SAME DAY PLANTING
% PLANTS
DAYS FROM PLANTING
60
50
40
30
20
10
10
15
20
70
75
80
85
90

FIGURE 4