The Seed Treatment Toolbox

Investigating the options of seed coating and treatments and how they protect and enhance crop growth.

A report for

by Ashley Fraser

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Executive Summary

The global seed treatment market is the fastest-growing segment of the crop protection market. This market reached over US$2.25 billion by the end of 2010, and is expected to reach $3.43 billion by 2016, growing at a compound annual growth rate of 13.5 per cent from 2011 to 2016. (*Seed Treatment Market Trends and Global Forecasts (2011-16)*, 2012. This growth is due to the opportunity that seed treatments give the agricultural sector in improved occupational health and safety (OH&S), targeted insect and disease control, environmentally sustainable solutions, improved plant establishment and reduced plant stress.

The GRDC sponsored Nuffield Scholarship has allowed a comprehensive look at many different technologies from chemistry options to non-chemical solutions. The report investigates the physical process of coating and the techniques that are known to contribute to quality application. Much of the information contained in this report is from leading industry experts whom shared their knowledge and future directions of the seed treatment sector. The report intends to bridge the knowledge gaps between researches, technology providers, coating applicators, seed companies and farmers. The report highlights options from a seed treatment perspective that may be a possible solution to a given problem. The author found that establishment problems needed to be looked at from many angles including soil nutrition, moisture stress, bacterial, disease, insect attack; these are all issues that can be solved with the appropriate treatment.

The report examines the use of stimulus and trace element treatments. When the use of trace elements or stimulus products are required, we need to understand the seed interaction of these components in plant establishment. We need to better understand soil health and the interaction at the soil root interface, and to be able to understand and measure the many variables which contribute to plant establishment. With significant gains readily available by the use of stimulus products more research is needed to gain consistent measurable results.

The Australian seed industry is well serviced currently with appropriate machinery available, however, the machinery type and quality does vary which can have a significant impact on the final treated product. In Australia there is also a lack of skilled operators and appropriate training to allow personnel succession. This is an area that will need investment in the future if Australia is to maintain and keep pace with the growth in the seed treatment industry.

Contents

Foreword

I have spent the past 15 years working in the seed industry of which most has been in the processing area. My industry involvement now is as chairman of both the seed processors group and the south eastern region of the Australian Seed Federation. I was also appointed to the coated seed working group which overhauled the code of practice for labelling of coated seed. I was part of the initiative of the Australian Seeds Authority to establish a qualification My name is Ashley Fraser, I was awarded a Nuffield scholarship in 2012 sponsored by the GRDC, my topic was to look at "How seed coatings could protect and enhance crop growth". for the seed processing sector.

Four years ago Baker Seed Co expanded our coating capabilities with new machines which allowed allow us to offer the latest in coating technology and to service this sector as a truly independent service provider. Typically, these machines have only been available through proprietary seed companies with many of the innovations observed still company secrets. It did limit the scope of the report.

The turning point for me with what could be achieved with seed coatings was when we were approached by a local grower who had significant emergence issues with his canola crop. He was only able to get 30-40% of his crop to emerge. After investigating this across our region, a 50% strike rate seemed to be normal and was regarded as typical emergence. The grower was convinced that this was a result of fertiliser toxicity and not just nitrogen burn, so this led to some experimentation with different seed coatings to see if we could make a difference. As ammonium based fertilisers change from ammonium to ammonia to nitrite to nitrate, the fertiliser converts to a form in which the plant can use it. This reaction appeared to happen over the first 12-48 hours after sowing depending on the moisture availability at the time. During this reaction the fertiliser produces a toxin which is acidic and has a high salt index, thus, creating undue stress on seed which is placed in the same space. So the problem was essentially a sowing issue associated with planting placement. The challenge was could we address the issue with a seed coating?

We embarked on coating canola seed with different loadings of both lime and talc from 5% through to 30%. Lime and talc were used so that if it was the acidic nature that was doing the damage then the lime should stand out. The result was a 67% improvement in hybrid seed emergence and an 83% improvement in TT (triazine tolerant) varieties. This improvement was only seen once the coating level reached 20% or greater with best results at 30% with both lime and talc. Weather conditions are a factor with these results; cold and damp conditions at time of sowing will increase the intensity of the fertiliser reaction.

Needless to say my interest in what could be achieved was high, when along came Nuffield and the wonderful support of the Grains Research and Development Corporation(GRDC) and I was off around the world to see what everyone else was doing to their seed. My travels were in three parts, as follows:

Contemporary Scholars Conference, in which all the scholars from 2012 met in Rotterdam in the Netherlands then travelled to London for a week.

The Global Focus Program, where I travelled with nine other scholars for seven weeks to the Philippines, Hong Kong, China, California, Washington DC, Canada, Belgium, France and Ireland. I stayed on for a further two weeks and went back to the Netherlands and England.

My Nuffield sponsored research then took me back to China, Italy, Austria, France, Switzerland, Germany, Norway, Canada and the USA.

Since then I have travelled back to China where I investigated seed treatment machinery and also powder manufacturers.

Acknowledgments

I must thank the following people and organizations whose faith, assistance and belief made this opportunity possible.

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Abbreviations

ASF- Australian Seed Federation

ASA- Australian Seed Authority

CAGR- Compound annual growth rate

KG- kilogram

TT- triazine tolerant

MT- Metric tonne

LPG- Liquid Petroleum Gas

OH&S- Occupational Health and Safety

MLA- Meat and Livestock Australia

GRDC- Grains Research and Development Corporation

GM- Genetically Modified

UV- Ultra Violet

Objectives

This report looks at different methods of seed treatment from products to systems and technology and investigate the potential and limitations of each. This led to looking into the following areas:

Chemistry treatment via active ingredients

Physical manipulation of the seed

Mechanical manipulation of the seed bed

Coating processes and the importance of layering

Use of stimulus products and trace element treatments

An understanding of the capabilities of each method should provide a toolbox of available technologies which can be applied to help solve crop emergence and/or establishment issues.

Chapter 1: Introduction

The global seed treatment market is the fastest-growing segment of the crop protection market. This market was valued at over US$2.25 billion by the end of 2010, and is expected to reach $3.43 billion by 2016, growing at a compound annual growth rate of 13.5 percent from 2011 to 2016. The North American market is expected to hold 22 percent of the global market share by 2016, at an estimated compound annual growth rate (CAGR) of 16.4 percent, due to higher acceptance of Genetically Modified (GM) seed for soybeans and corn. The market share of Asia-Pacific is expected to rise from $157.5 million in 2010 to $248.2 million by 2016, at an estimated CAGR of 14.4 percent (%) from 2011 to 2016. The major part of this growth is attributed to the cost effectiveness of seed treatments, the economic and social benefits, and increasing demand for GM seeds (Seed Treatment Market Trends and Global Forecasts (2011-16), 2012).

With 70% of the variation in a cropobal Forepotential being put down to three factors (heat, cold and moisture) which are mostly out of a grower cold and mothere is a lot of research, particularly from Bayer and Syngenta, which is looking at ways of reducing the effect of these three main stresses on the plant, while also improving plant nutrition.. That leaves 30% of available yield potential which is due to the control of disease, nutrient availability and further plant stresses. This is where seed treatments can make the greatest difference. These factors, along with the level of processing seeds are put through to produce the standard and quality we expect, as illustrated below. The aim is to understand how all these factors interact, so that we can measure and optimise the available technologies. (personal communication, B. Hussherr, Syngenta, September 2012; personal communication Dr F. Brandl, Syngenta, September 2012).

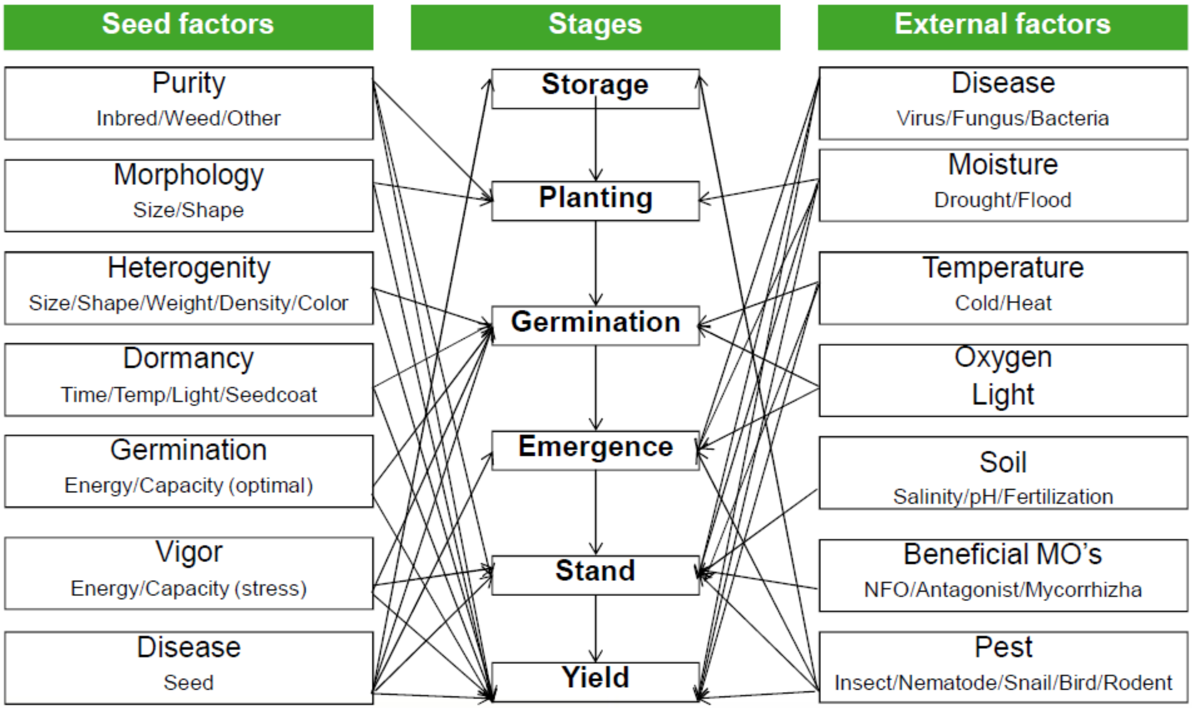


Table 1: Seed Stages and contributing factors

Source: (F. Collee, Incotec, Netherlands, Presentation July 2012.)

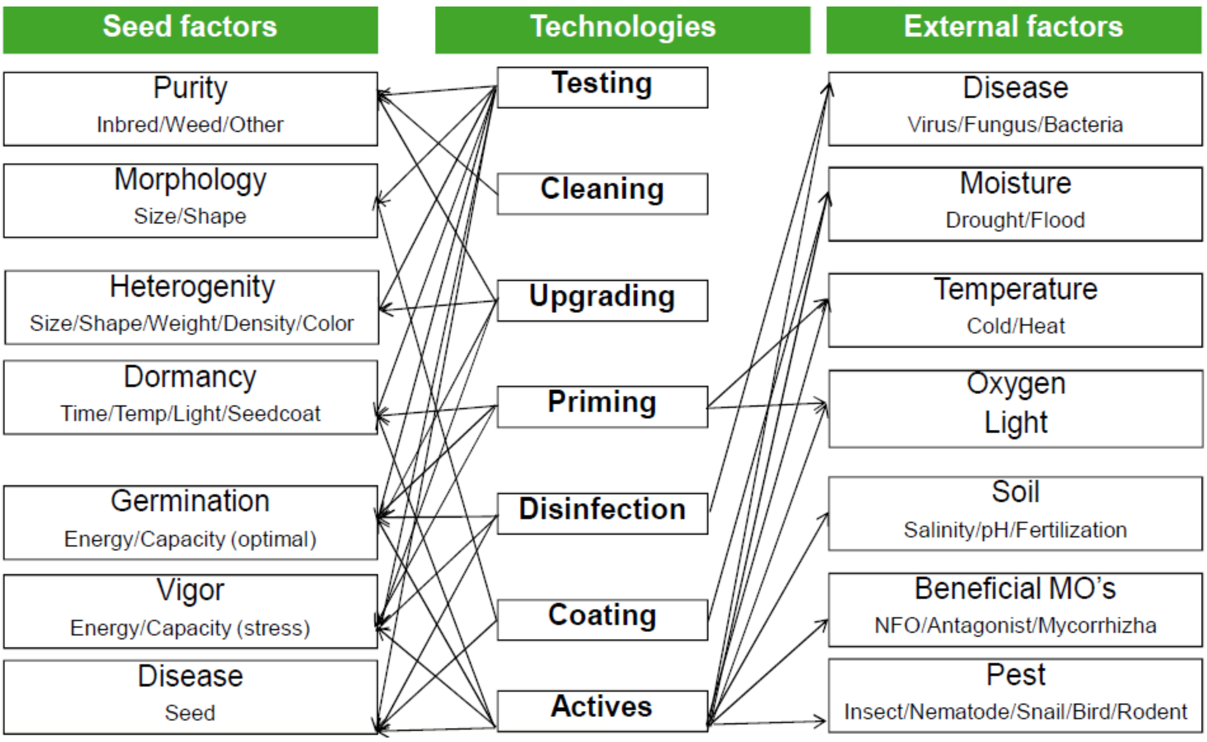


Table 2: Seed Stages and processing procedures

Source: (F. Collee, Incotec, Netherlands, Presentation July 2012.)

Seed treatment can be broken down into the following areas:

Chemistry- Use of ingredients such as fungicides, insecticides, nematicides and biologicals.

Physical alteration of the seed- this report will examine Thermoseed, electro beam technology and catalytic infrared energy.

Mechanical manipulation of the seed bed- looking at the Samco system from Ireland.

The coating process - this report will examine coating machinery, different levels of coating, colourants and powders.

Use of stimulus products such as *Bacillus spp.*, trace element products and their interaction with soil. These products can influence nitrogen and phosphorous fixation, and can change the seed soil wetting characteristics, for such as in non-wetting sands.

Chapter 2: Chemistry

The use of chemicals (or active ingredients) is the most common and widely adapted form of seed treatment around the world. Actives can be either insecticides, fungicides or nematicides and it is only after an exhaustive evaluation process that it will be determined which category each active will fall in to. A herbicide seed treatment is in the pipeline but is still considered to be at least 10 years away from commercial release.

After an active is selected, it is then determined which crop species it will be applied to and what application range will be most effective. Then the mobility, strength, efficacy, Ultra Violet (UV) stability and toxicological effect to humans all need to be determined.

A seed treatment formulation may contain the following components;

Active ingredient

Pigment

Binder

Thickener

Around three surfactants

Antifoam

Antifreeze

Water

Once a formulation is selected it still has to undergo plant safety tests such as germination, vigour tests, cold tests, long term storage effects and flow ability of the formulation. After application, sowing tests and coverage are all measured.

An important test which is being adopted across the world is the Huebach test which measures the level of dust-off. Before this test is conducted the seed must be stored at 20 degrees Celsius and 50% humidity for 48 hours. This test is critical, particularly in the use of insecticides, to eliminate the possibility that insecticide could become airborne during the sowing process, and also for Occupational Health and Safety (OH&S) reasons. This could affect beneficial insects such as bees used for pollination. The need for professional application also comes to the fore in order to meet these minimum standards.

The author found that management of plant stress and protection of environment were leading the concerns of the researchers who were interviewed. These experts saw the future being in helping plants to use water more efficiently, thus combating salinity and improving nutrient availability.

Measurement of the effect of seed treatment chemistry on the plants physiology is relatively easy, by identifying which pathogens are being affected, and where they lie in the plants cell structure. Once this is known, identifying the best mode of action to use is relatively simple. This problem is greater when dealing with soil bacteria where there are far more variables that come in to play. The links between all the variables and the bacteria and mycorrhiza within the rhizosphere are really unknown at this point. Much research is going on in this area, however, publicly available data is very limited.

Fungicides

For control or suppression of fungal diseases like smut, bunt, rust, rhizoctonia, pythium, etc., fungicides typically make up the greatest percentage of film coating, particularly in Australian cereal production. These include current products such as Raxil, Dividend, Veteran, Rancona and Evagol.

Insecticides

Seed treatments containing insecticides are gaining traction in the seed treatment market, with many new actives and formulations coming on to the market over recent years. These actives can be taken up systemically into the plant and carried in the sap stream or are contact insecticides carried on the plant surface. This means that only the insects that attack the plant are targeted. With a targeted approach to pest management beneficial predatory insects are not harmed causing minimal disruption to natural ecosystem. Some of the typical currently used trademark products include, Gaucho, Cosmos, Cruiser Opti, Hombre, Zorro, and Tri-power.

Nematicides

Nematodes come in many forms and can be both beneficial and pest depending what they feed on. Nematodes are therefore divided into their feeding groups:

Bacterial feeding

Fungi (hyphae) feeding

Predacious

Plant pathogen

Plant associated

Omnivores

Management of nematodes in Australia has largely been taken care of by breeding varieties that have a level of tolerance or resistance to nematodes, thus, nematodes historically have not been regarded as a big issue in Australia. However, with the adoption of no-till farming practices, and the decline in the diversity of crop rotations, nematodes have become more prevalent and are affecting productivity. There are now linkages between low levels of nematodes, leading to medium to high levels of crown rot infection. Seed treatment control of nematodes may become more prevalent in the future in Australia.

Chapter 3: Physical seed treatments

Physical seed treatments currently occupy around 2% of the total world market share. Physical treatments operate by disinfecting the seed through use of non-chemical methods. For instance, bacteria can be killed via heat exposure. One of the possible limitations of these technologies is that they work only on the seed born bacteria, while bacterial infections like *Fusarium spp.* and *Ascochyta spp.* are both seed borne and soil borne. That said, the soil borne bacteria causing infection are different strains to that of the seed borne strains, and it is claimed by the manufacturers of these physical treatments, that it is the seed borne bacteria which carry the major risk to the crop.

With all these types of treatments there are some clear advantages in not using chemically-based treatments;

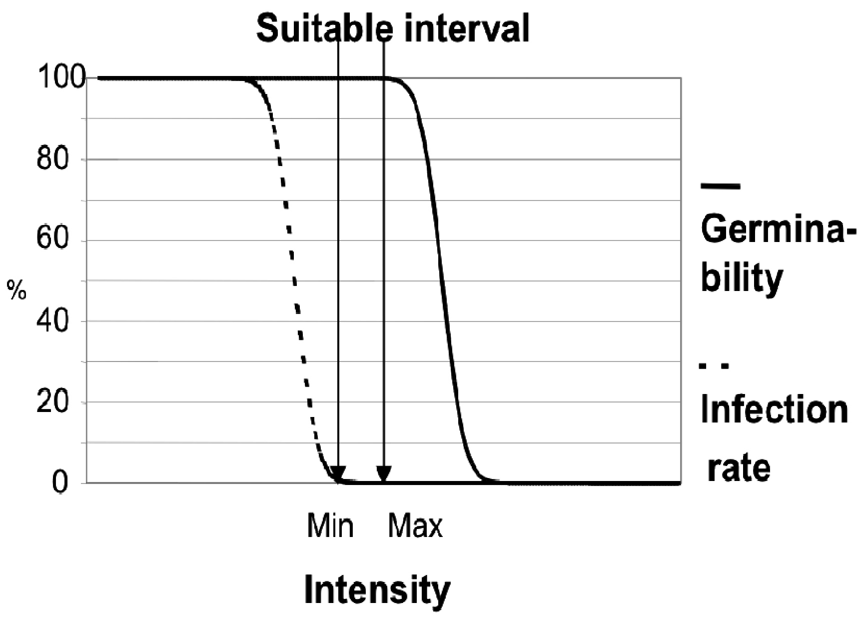
- They provide a solution for organic farming in control of seed borne bacteria.
- Left-over seed can be placed into standard delivery points for use in the supply chain.
- Effective control of insect contamination in stored seed.
- Treatment cost similar to that of chemistry application.
- No OH&S issues for processors and farmers.
- The environmental advantages and “clean green” image can be passed on all the way through the supply chain to the end customer.

ThermoSeed™

Developed in Sweden in 2002, this product is now being commercialized by Incotec (Netherlands). The ThermoSeed™ is basically a pasteurization of the seed with hot humid air for a given time.

The principle is as follows: the seed is tested prior to treatment for the level of infection and germination. The seed is then tested to see what level of heat and humidity over a given time is required to kill as much bacteria as possible without affecting germination. These parameters are then given to the processor to apply to that particular seed lot.

Table 3: Critical control Window



Alness, Kenneth. (presentation, September 2012).

The result is a relatively high capacity (15mt/hr/machine) treatment with high control over seed born bacteria. In Sweden and Norway, because of the co-operative approach to farming and processing right through the value chain, this enables the co-operatives to take the ThermoSeed process to the end consumer by marketing it under slogans such as *"This bread is produced from the cleanest seed in the world"*. This becomes a powerful message, which gives extra weight to the advantages of the ThermoSeed process.

Currently used in Norway on cereal seed this process has worked extremely well., However, because of the large scale of the processing facilities and the immense volume of seed put through this process (approximately 50,000 mt/yr), the cost per metric tonne of seed is very competitive, around \$20-\$30/mt, which is similar to that of a basic chemistry treatment. In Australia, no one supplier handles such volumes which would make it difficult to justify in the current Australian market (Collee, Frans; Alness, Kenneth. (A. Fraser interviewer, September 2012).

Electro Beam

This technology is the use of an electron beam to do a similar job to that of the ThermoSeed™ treatment in that it will attack the bacteria on the surface of the seed and suppress diseases like smut, bunt and seed borne fusarium. This technology has a narrow spectrum of activity and can only control shallow infections, although the strength and depth of penetration can be adjusted. However, embryo damage is a real risk when targeting deep infections.

Catalytic Infrared energy

Catalytic infrared energy is very new to the seed world with the author not knowing of any commercial manufacturers currently. The process uses natural gas or Liquid Petroleum Gas (LPG), passed through a catalytic pad which separates the fuel gas molecule in to hydrogen and oxygen. The hydrogen molecule becomes oxygen scavenging and creates a non-flame infrared heat. By varying the gas and air volumes, the infrared heat wave can be adjusted to varying wavelengths. Research still needs to be done on the exact infrared wavelength required to achieve desired results for maximum bacterial control and minimal germination effect. This technology may be able to be developed to be both an effective control of bacteria, while at the same time, with adjustment of the wavelength, being soft on beneficial bacteria.

Chapter 4: Mechanical manipulation of the seed bed

Samco System

The Samco system has been developed by the brothers, Gordon and Robert Shine, in Ireland. The system is not a seed treatment but is a great example of what can be achieved by manipulation of the seed bed in essence. This is also part of what can be achieved by coating and pelleting seed.

The Samco system uses a specific grade of biodegradable plastic over the seed bed to create a greenhouse effect. This allows for sowing in cold soil temperatures by artificially heating the soil bed and getting crops to grow faster and sooner. There are approx 40,000 hectares in production around the world using this system currently, with the main crops being sugar beet, maize, soybeans and sunflowers. With the Samco system, yield in forage maize typically goes from 40mt/ha at18-20% starch to 50-55mt/ha at 30-32% starch. Grain yield typically is increased from 8mt/ha at 15% moisture to 14mt/ha at 15% moisture. This increase in yield is achieved by extending the effective growing season by one month. The basic principle is to get the crop completely through its vegetative growth stages by the time the plant is ready to set seed so that the plant is able to put all its energy into grain production rather than into producing any further vegetative mass.

Table 4: Differences in growth rates under Samco System

(Samco trial site, Ireland July 2012).

The above photo is the same variety planted on the same day. The difference in growth response due to the Samco treatment is visible on the right-hand side.

Pioneer have partnered with Samco to develop specific varieties which suit the system. The system is sold as a complete package including seed, chemical, plastic and machinery

Shine, Robert and Gordon. (A. Fraser interviewer, July 2012).

Chapter 5: The coating process

The coating process itself can be broken down into three main types; film coating, encrusting (or as it is commonly known “build-up”) and then pelleting. In addition to the coating process there is also seed priming, which is a method of starting the germination process and then stopping it. This is almost exclusively used in the horticulture and ornamental markets. This chapter also looks at machinery used and the different levels of automation and operator input. The role of colours and powders also comprise a vital ingredient, with powder being the largest percentage of a build-up coat. The type of powder used is critical in the process of coating to give the coating both hardness and porosity.

An example of a typical build-up coat might look like the following; fungicide is placed against the seed followed by an insecticide. Next the seed is built up with powder and a binding agent (glue) to around 25%-30%. This is the point where there is complete encapsulation of the seed, which is important because it provides a separation between chemicals and the beneficial bacteria which are applied next. Over the next 20% of the coat, the rizhobia or beneficial bacteria are added bringing the coating level to around 50% of the original weight of the seed. Once the coat reaches this point it is time to seal the coat with a little more powder and binder; this sealing process is also important as it helps keep the ingredients alive for longer, thus, giving the coating a longer shelf life. Typical acceptable shelf life for coatings is regarded as approximately six months, however, this can vary depending on the process undertaken. Any manufacturer of coated product should be able to give their customers an estimated shelf life.

Film Coating

The most basic of all seed treatment applications is film coating, where less than 5% by weight is applied to the seed. Typically, machinery that can be used is as basic as an auger with fungicide applied via a metering system through to highly accurate continuous coating machines from companies such as Petkus and Cimbria. These film coatings typically are fungicide based to control the likes of smuts and bunts; this is typical for on farm applications. Other terms for this may be “pickling” or “treating”.

Basic fungicides for smut and bunt control have a tolerance for a somewhat variable coverage, however, the more specific and most of the latest chemistry available, requires a level of application accuracy better than +/- 10%. Therefore, specialized equipment via professional application is usually used.

More complex forms of film coating include advanced fungicides and insecticides along with binding agents. These coatings are designed to reduce dusting and then powders which restore or improve the flow ability of the seed. These coatings today are typical for most crop species, and are usually supplied on the seed from the seed company. The machinery used is capable of a high standard of control and metering, such as often found in rotary batch style machines.

Encrusting or build-up coating

This is the next level of coating where multiple applications are made to the seed on a timed batch process. Typically lime or talc is used as the build-up medium and a blend of both can be used successfully. Build-up coats generally range from 25% through to 200% by weight of seed, 25% being the lower limit for complete encapsulation of the seed (this can vary depending on the size and or surface area of the seed being coated). Build-up coating or encrusting is designed to improve plant ability and act as a carrier of active ingredients.

A build-up coating can include one or more of the following components:

Fungicide.

Insecticide.

Binding agent or sticker.

Colour.

Rhizobia (beneficial bacteria).

Trace elements.

Sealing agent or top coat.

Build up medium.

Stimulus product.

The order of application can vary greatly depending on purpose, operator, machinery available or customer requirement. The author found that different methods were well matched to different applications and/or seed species and that more public access to research would be required to formulate any accurate data associated with a "best practice" order of application. The author did find the following commonalities:

Separation as much as possible between chemistry such as fungicides and beneficial rhizobia was desirable to limit rhizobia death.

Drying temperature should not exceed 38 degrees Celsius, again to limit rhizobia deaths; temperatures of approximately 30-32 degrees Celsius would be classed as ideal.

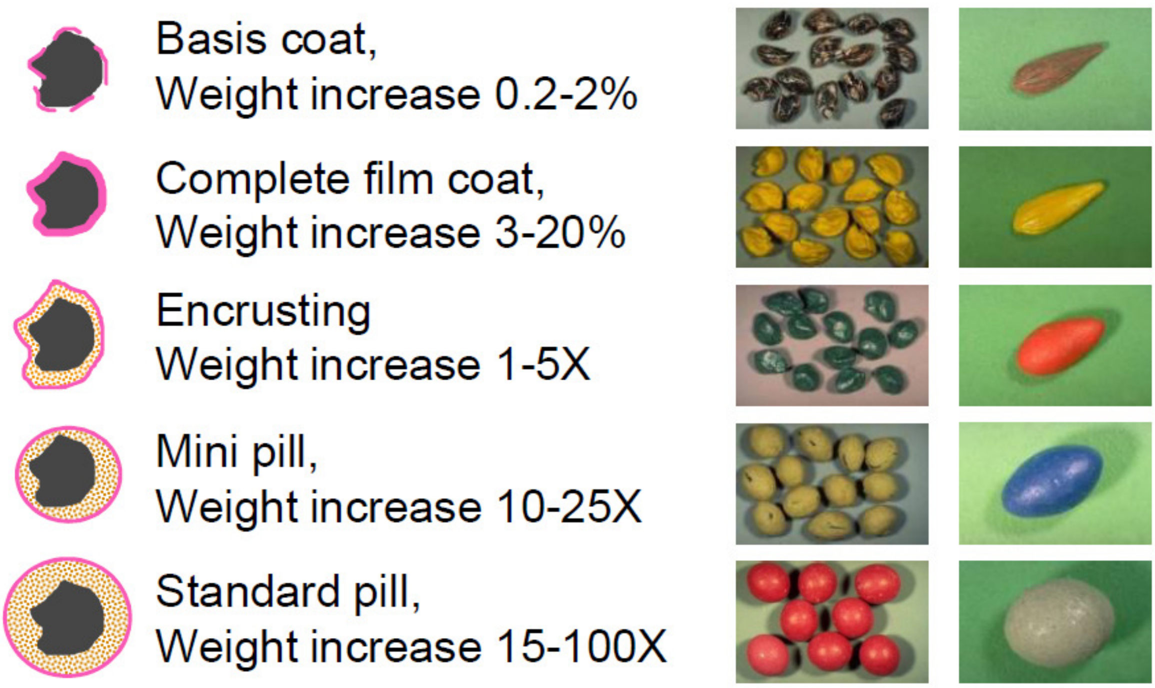
Very accurate balance of binding agent and top coat to powder medium required to limit dusting.

Storage of coated seed post application also had a significant impact on rhizobia life, with extreme fluctuations in temperature having a detrimental effect.

Pelleting

Pelleting is by far the most complex of seed coatings, with the objective to achieve 100% plant establishment with a uniform seed size that is large enough to be handled accurately with 100% accurate placement. Due to the high cost of application, to date pelleting has only been used commercially in the vegetable and ornamental sectors of the seed industry. This is where seeds can be as small as 100,000,000 seeds/kg (finer than ground pepper) and of extremely high value. It is important, therefore, that these seeds are changed into a form that can be handled and sown accurately; this is where the pelleting process comes into effect.

The pellet is designed to split perfectly in half once exposed to moisture in the seed bed. This exposes the seed to vital oxygen and light required to fully germinate and establish as a plant. If the coat does not split correctly and the coat melts around the seed then it can suffocate the seed and prevent the establishment of the plant. Even though the pelleting process has been around for many decades, most pelleting is done in round bowls with ingredients added by hand, requiring highly skilled operators to complete the process. There have been further developments in machinery automation by Bayer, through their machinery arm Gustafson, to develop machinery that can do this on a large scale with full automation.



(Collee, Frans 2012).

Priming

Priming is the process of starting the seed germination process and artificially getting the embryo growth to a certain point before stopping the process in a way that enhances germination in the future. The objectives of priming are as follows:

Improve the uniformity of germination.

Increase the speed of germination.

Overcome all kinds of seed dormancies.

Achieve better germination at non-optimal temperatures.

Give a higher number of good plants.

The priming process is almost exclusively used in the vegetable and ornamental markets or other high value seeds where the highest establishment rate is demanded. Companies such as Incotec and Nunhems are very prominent in the pelleting market. They are professionals in this area and have extensive testing regimes in place to ensure the highest results and quality from their seed and services (Collee, Frans presentation, tour, A. Fraser interviewer, July 2012).

Machinery

There are many levels of seed treatment machinery both in mechanical operation and also level of control. The more complex the seed coat the more critical the machinery and operation are. Seed coating can be a highly skilled, very slow and labour intensive process, using very simple machinery. Alternatively, it can be a highly automated, high capacity process using very sophisticated machinery with a high level of accuracy and control.

With film coating of basic products like pickles and fungicides at a farmer level, machinery can be as simple as a metering system delivered into an auger. Although this is not sophisticated, with a good operator it can provide quite an adequate result at a basic level.

Film coating at a professional processing level should be conducted through a dedicated continuous coating machine or rotary batch coater which is equipped with precise metering equipment to ensure a minimum accuracy of plus or minus 10%. Companies such as Petkus, Gustafson, Nicklas and Cimbria all have a range of these types of machines.

This year Bayer have brought a new approach to the seed sector with their "Seedgrowth" program. The Seedgrowth package includes products, equipment, coatings and service in the one offering, a concept currently not available from any other single company.

Batch-coating machines (or rota-stat machines) all operate by spinning seed into a wave, with an atomized spray application of fluids through the wave of seed. These commercial machines come in batch sizes ranging from 20kg through to 200kg per batch. There are many differences in programmable control and mechanical design, depending largely on the background of the developer who designed the machine.

Large build-up coatings and pelleting processes both involve significant intellectual property. For both these processes designing the machinery is the easy part; the intellectual property behind the process being the valuable component and it is usually held as proprietary property by companies involved in this area.

When choosing any machine it is important the purchaser has a clear understanding of what they are looking to achieve in a machine and what critical control points will make the biggest difference to their business. If the purchaser is unsure then seeking professional help would be appropriate. (Friedrich Schnier, Dr HeinzA. Fraser interviewer, September 2012; Scholz, MarkA. Fraser interviewer, September 2012).

Colourants and powders

Powders are the medium or foundation of seed coatings, with lime and talc being the most common. Other products such as perlite, zeolite, mica and bentonite are also common in a blend of powders used. Particle size and shape will vary between powders, often depending on their source. The particle shape and size can influence the porosity and hardness of the coat and also the likelihood of dusting. Typically powders used in the coating process have a size between five and 12 microns, with the majority in the 5-8 micron range. Some finer or coarser particle sizes can be used in a blended powder application. The shape of the particle will influence how well the particles fit together around the seed surface, with “jagged” type particles not fitting together as well as rounded type particles. The better the fit between particles the lower the level of dusting that may occur, as the coat becomes tighter around the seed.

Pearlescent powders are often used as a finishing compound. They give the seed a lustrous finish and will greatly improve the flow ability of the seed through seeding equipment. Some actives can reduce the flow ability, and the application of a small quantity of mica powder will reverse or improve this affect. Pearlescent powders are a manufactured powder that is ground from mica, filtered and baked.

Coloured finishing powders are available where pigments are added or where titanium dioxide is used to give highly vibrant colours. Seed can also be given a metallic finish which the manufacturers claim can have a bird-repellant effect, however, the author could not find substantial data to back up this claim; it was uncertain if only certain species of birds were repelled.

Colourants are added purely for appearance, and it is a legal requirement that all treated seed be coloured so as to be able to distinguish it from non treated seed. Colourants are usually pigment based and are used for distinguishing different species, with the choice of different coatings depending on requirement. Colourants come in differing strengths and qualities depending on the application machinery being used. Different colourants can behave differently, and the choice of the best type often depends on the type of applicator (Sun, Carrie A. Fraser interviewer June 2013).

Chapter 6. Stimulus and trace element coatings

Stimulus products

These are products that are applied to seed to enhance plant growth, improve yield, improve cell structure of the plant and promote microbial activity in the soil. There are large numbers of these products on the market, all claiming to be better than the other. The author found that evidence of significant improvements in growth and yield were possible, ranging up to100% in some individual cases with these products. However, consistent replication of these results was very difficult due to the large number of variables, such as soil pH, moisture, prominent bacteria in the soil, nutrient base in the soil, sowing depth, seed health, etc. The author found no evidence of clearly defined correlations showing how these stimulus products interacted with all the variables. *Bacillus* products can be more effective than traditional *Rhizobia* products, as *Rhizobia* have a weak cell wall which make it vulnerable to high death rates from external factors.

Trace Element products

Trace element seed treatments or mineral additives like copper, zinc, manganese and molybdenum are used to provide immediate plant availability of these essential elements. These treatments are typically applied in a liquid form as a foliar or seed treatment application. These treatments need to be applied in a chelated form which means that the molecule is in a form whereby the organic chelate molecule is bound to the mineral molecule. Chelates small particle size makes them ideally suited to seed treatment applications as the trace element stays where it is applied. Applying a straight mineral to the soil which already has a deficiency problem or nutrient lock-up issues can reduce the proportion of available nutrient by up to 50-60%. Chelates provide for almost complete plant availability by restricting the amount of the nutrient “locked-up” by the soil.

Soil interaction

Getting the full benefit of the use of stimulus products and trace elements depends on understanding what is going on in the soils and the interaction between all factors involved. To understand the full value of stimulus products and to measure the actual effect of trace element treatments applied, requires an understanding of exactly what is happening at the soil/root interface and between the bacterial components in the mycorrhizal and the rhizosphere. Research still needs to be done to more accurately measure these links and account for the all the variables involved, such as:

Moisture.

Temperature.

Oxygen availability.

Light.

Fungal activity.

Bacterial activity.

Seed dormancy.

Seedling vigour.

Soil structure and health.

Nutrient availability.

Soil pH.

Carbon nitrogen ratio.

There has been a wide adoption of minimum or no-till farming in Australia over the past 20 years, yet soil carbon levels and humus levels are still at critically low levels. Heinz-Friedrich Schier (A. Fraser interviewer, September 2012) stated that, to have effective microbial activity, a carbon to nitrogen ratio of 10-12 is required. Microbes use nitrogen to break down stubble, so in our now widely adapted no-till farming practices with stubble retention, the carbon nitrogen ratio can easily blow out to 60-70. This would mean that additional nitrogen is required to restore the ratio to facilitate effective microbial activity.

Nanotechnology

Nano is the term given to particle sizes smaller than one millionth of a metre in diameter. Nanotechnology is very prevalent in the paint industry and trace element sectors. This technology is new to the seed treatment sector, with products such as zinc now available with a particle size down as low as 10-15 nanometers. The issue with these products is that once particle size becomes this small it can cross the sub-dermal layer in humans; this potentially creates an opportunity for elements to become toxic.

The author found that industry uptake of this technology will be very cautious at best. All researchers interviewed did not want to talk at any length about nanotechnology, other than to say it was on the radar, but until the toxicological effects were properly understood, there would not be development in this area (Brandl, Dr FranzA. Fraser interviewer, September 2012).

Conclusion

Due to the fact that the vast majority of research and development in seed treatments is undertaken by the private sector and mainly the major multinationals such as Bayer, Syngenta, BASF and Incotec, the intellectual property is held very tightly. This makes publicly available data very hard to come by and, as such, advice, recipes and formulations are almost nonexistent to anyone outside of these companies. Representatives of these companies can be useful in providing some assistance on the use of their individual products. However, this still comes back the to the individual's practical experience. Independent service providers of coated seed are left to learn the processes via opinion and by trial and error, rather than from information and confirmed data.

There is a valid argument from industry that research is still ongoing and that confirmed data is not yet available. The seed processing and farming community in Australia would benefit greatly from access to research findings especially at a time when we are struggling with understanding the interactions of coating ingredients and the soil at the soil root interface among all the variables.

Set coating recipes for certain types of coatings are not realistic as every machine behaves differently and there are still different opinions as to what order ingredients are to be applied. Research is vital in providing an understanding of the influence of each variable, such as moisture, temperature, oxygen availability, light, fungal activity, bacterial activity, seed dormancy, vigour, germination, soil health and structure, nutrient availability, soil pH and carbon nitrogen ratio.

When looking at the purchase of a coating machine as much focus should be given to the availability or access to after-sales support and assistance in the coating process; this is lacking in the Australian market as opposed to overseas markets where specialist advice appeared readily available.

Recommendations

The author would recommend that an independent research program be conducted to investigate the effectiveness of different coatings, much like the pasture seed trial program currently being undertaken between the Australian Seed Federation (ASF) and Meat and Livestock Australia (MLA). This would then give farmers and seed companies' good information as to the effectiveness of coatings available and give greater transparency as to what works and what does not. Any trial program should investigate the interaction on all the variables such as coat hardness and porosity, shelf life, moisture, temperature, oxygen availability, light, fungal activity, bacterial activity, seed dormancy, vigour, germination, soil health and structure, nutrient availability, soil pH and carbon nitrogen ratio. This sort of program would carry on very well from the work that the GRDC is currently doing in regard to soil carbon ratios and nutrient interaction. This level of research would be expensive, however, it would provide valuable and usable data to enhance all agricultural sectors, as seed coating is used in pastures, coarse grains, oilseeds and most forms of horticulture. Research into coating technology could vastly enhance productivity, far beyond that of conventional breeding, emphasizing its importance to the supply chain.

Manufacturers or marketers of seed coating equipment should be able to give their customers access to experienced coating specialists to enable the best machine for their application and to provide sound advice on starting points for recipe formulations and how to adapt these recipes to suit the customers individual requirements. Post-coating practices are also something industry should be more aware of, with drying technology and storage conditions significantly affecting the shelf life of many ingredients in the coatings themselves.

The ASF are already addressing the issue of operator education through the formulation of the seed processing training initiative, which has a seed coating unit included. This will go a long way to providing an overall education of industry personnel and addressing OH&S in the coating sector. Government assistance in making this qualification nationally available would be a huge step forward for the seed industry.

References

Alness, Kenneth. CEO, Lantmannen Bio Agri-Sweden-Managing Director Incotec Sweden-(presentation, tour, A. Fraser interviewer, September 2012).

Brandl, Dr Franz. Head Global Seed Care Institute, Syngenta, Switzerland-(A. Fraser interviewer, September 2012).

Collee, Frans. Incotec Netherlands- (presentation, tour, A. Fraser interviewer, July 2012).

Friedrich Schnier, Dr Heinz. Strategy & Business Management & Head of Seed Treatment application centre, Bayer, Monheim, Germany-(Tour, A. Fraser interviewer, September 2012).

Hussherr, Benoit. Global Seed Care Manager Application and Services, Syngenta, Switzerland-(presentation, tour, A. Fraser interviewer, September 2012).

Scholz, Mark. Managing director Petkus Germany -(Presentation, tour, A. Fraser interviewer, September 2012).

Seed Treatment Market Trends and Global Forecasts (2011-16), (2012). Seedweek, 11.1.2012, published by MarketsandMarkets

Shine, Robert and Gordon. Directors, Samco System, Ireland. -(Presentation, tour, A. Fraser interviewer, July 2012).

Sun, Carrie. International Sales, Hangzhou Forward Fine Chemical Company, China.-(presentation, tour, A. Fraser interviewer, June 2013).

Plain English Compendium Summary

Project Title:	**Name of project**
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Objectives	To improve germination, plant vigour and disease resistance, reduce plant stress through healthier plants with better cell development.
Background	Seed coatings and various treatments have become standard practice in Australian farming. With so many options, which recipes of chemistry should we use? What is the best method of coating that will suit? Which application process is the best? Are there non-chemical options available? These are all relevant questions which needed addressing to gain a better understanding of what could be achieved with seed treatments.
Research	Included the Global Focus Program over six weeks, which visited Philippines, Hong Kong, China, USA, Canada, Belgium, France and Ireland, with a further two weeks in England and Netherlands. The remainder of the studies, over 10 weeks, took place in China, Italy, Austria, France, Switzerland, Germany, Norway, Canada and USA. Studies were with research facilities, commercial coating companies, multinational seed technology providers, machinery manufacturers, alternative process providers, powder manufacturers and farmers.
Outcomes	Reference to the report will allow farmers insight into what options are available in seed treatments to overcome establishment issues that arise. Seed coating companies can have patents on processes of their effects on the interaction of components with a coating and understand the limitations of these processes.
Implications	When trying to understand the interaction of plant establishment, soil health and the soil root interface we need to be able to understand and measure many variables which contribute to plant establishment. Many of these questions are still largely unanswered, with research still ongoing.
Publications	