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Meeting requirements for sustainable, high performance seed treatment solutions

Comparing the performance of plant-based formulations from Roquette with synthetic alternatives

Seed treatment helps to provide optimal conditions for germination, emergence and early plant growth directly supporting the attainment of high yields. By precisely delivering small amounts of ingredients such as fungicides, insecticides, inoculants, plant growth regulators, fertilizers, and biostimulants, it protects crops at their most vulnerable, while minimising environmental impact. Other important benefits include easier, safer seed handling with processes such as coating, encrusting and pelleting, reducing dusting and improving seed flowability, for more consistent drilling. These advantages provide significant motivation for application with the global market for seed coating materials alone forecast to reach $3 billion by 2025[1].

Roquette, a global leader in the manufacture of plant-based ingredients, has developed a range of solutions for plant nutrition and protection that includes a portfolio of products for seed treatment. Initiatives such as the European Green Deal[2] along with the associated Farm-to-Fork Strategy[3] and the USDA Agriculture Innovation Agenda[4] intensify the need for seed treatment formulations that can match the performance of traditional solutions while lowering environmental impact. Roquette provides effective, biodegradable and sustainable products to meet these evolving needs. This paper presents experimental data illustrating their performance in the treatment of both cereal and vegetable seeds.

Changing requirements for seed treatment formulations

Seed treatment can be traced back to the use of onion sap and cypress extracts in ancient Egypt and Rome[5] and, by the 1800s, relatively sophisticated techniques were in use, such as immersion in copper sulphate solution as a treatment for bunt, a fungal grain disease[1]. Fast forward 200 years and in developed countries seed treatment is now standard for most crops, prized for its ability to deliver:

- Protection against pests, diseases and abiotic stress
- Optimal nutrition for germination and early plant growth
- Reduced exposure to dust
- Precise, even, uninterrupted seed distribution.

With seed treatment, inputs work harder as a result of precision targeting at the earliest stages of plant growth, when small quantities have a major impact. Effective seed treatment means less reliance on broadcast agrochemical applications, lowering active ingredient loadings in the environment. In particular, seed treatment has an important role to play in Integrated Pest Management strategies keeping pesticide levels to a minimum, and predominantly within the soil rather than airborne[5].

When it comes to seed handling, studies of, for example, the impact of grain dust, have conclusively confirmed its potential to harm lung function[6], highlighting the need for protective measures. Seed treatment can substantially reduce dust levels thereby improving safety. Heubach dust analysis quantifies the free floating dust associated with treated seeds and there are European Seed Treatment Assurance (ESTA) reference values defined for specific crops, for example, 4g/100kg for cereals[7], to help ensure consistent safety standards.

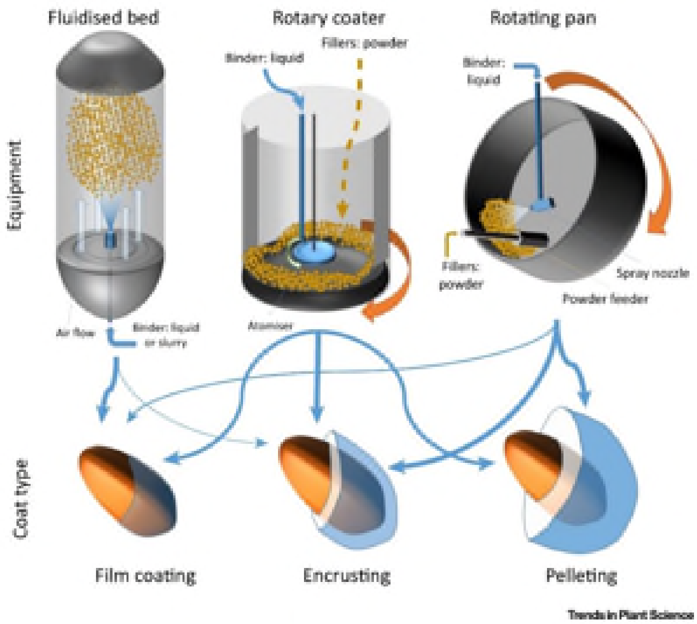


Figure 1: Examples of processes used for seed treatment and the resulting products[8]

Processes used routinely for seed treatment are shown in Figure 1, along with the different types of coating applied. Film coatings typically account for just 1 – 3% of total seed mass. They protect from moisture and can be used for coloration, making seed easier to see on the ground. Encrusting applies a thicker layer, typically up to 30% of the seed mass, offering additional scope to add nutrients and microrganisms while still preserving the shape of the seed. Pelleting adds most mass to the seed, increasing it by between 15 and 100 times, and transforming seed shape[5]. It offers even more scope to include a range of ingredients for seed protection and growth and the resulting regularly-shaped pellets flow easily from the drill enabling uninterrupted, closely controlled sowing at the required density. Processing technology for any seed treatment is selected on the basis of coating requirements, practical concerns such as throughput, and the ability to efficiently achieve a uniform product, with minimal seed damage.

Seed treatment formulations include a number of excipients, in addition to active ingredients, to ensure on the one hand that the product is stable and on the other that it disintegrates in a timely way, within the ground, releasing active ingredients as required. Example ingredients include:

- Wetting agents
- Colorants
- Coatings
- Binders
- Fillers
- Processing aids
- Disintegrants.

Across the industry, reformulation is commonplace in the drive to lighten the environmental footprint associated with seed treatment, particularly with respect to synthetic polymer usage. Seed coatings are an identified source of microplastic pollution and binders are often fossil-fuel derived, synthetic polymers. Plans for EU-wide restrictions on the use of microplastics are likely to directly impact the materials used for seed coating[9]. And while the US Microbead-Free Waters Act of 2015 is much more limited in scope it has been widely criticised with respect to microplastics left untackled[10]. Going forward increasing scrutiny of the source, fate and impact of microplastics will increase demand for less harmful, biodegradable alternatives.

Roquette processes feedstocks such as peas, potatoes and cereals to produce a portfolio of plant-based ingredients for seed treatment, via steps such as:

- Solubles extraction, via steeping (extended contact with water)
- Fermentation
- Enzymatic hydrolysis
- Separation, including filtration and centrifugation
- Concentration, notably low temperature drying.

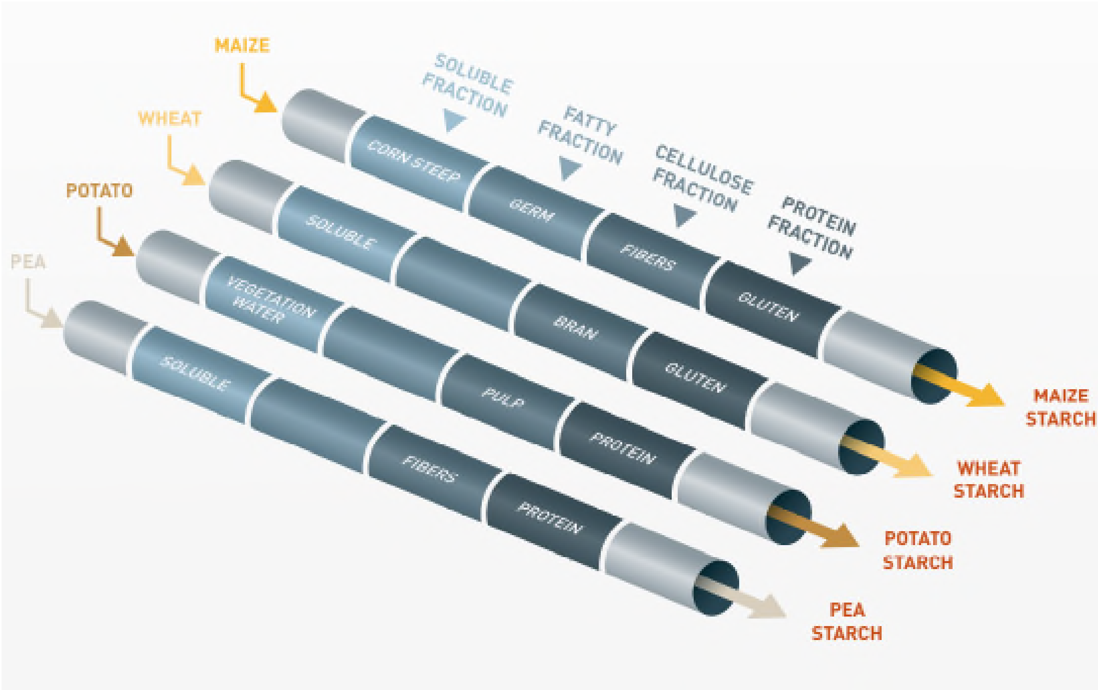


Figure 1: Roquette creates a range of plant care solutions from plants such as maize, wheat, potato and pea via a process of progressive refining that extracts starch, proteins and other valuable ingredients.

These well-controlled processes operate under relatively benign operating conditions, use no solvents and produce highly consistent, stable, biodegradable materials with a low carbon footprint. Feedstocks are of known provenance enabling Roquette to offer a number of OMRI (Organic Materials Review Institute) compliant materials for growers that need them. Progressive refining of the different fractions enables the isolation and formulation of products tailored to specific seed treatment functionalities with starch derivatives and modified starches forming the backbone of the product offering.

Using Roquette products it is possible to reformulate problematic seed treatments to deliver equally dependable and high performance, but with a much improved environmental profile. The following case studies illustrate the efficacy of these products and demonstrate what can be achieved.

Case study 1: Assessing the performance of Roquette coatings for wheat, tomato and onion seeds

Figure 2 shows data from experiments assessing the performance of two Roquette products - ROQUETTE® PC COAT FP-01 and Product A – as binders in film coating formulations for onion, tomato and wheat seeds. Data for untreated seeds and for seeds coated with a formulation containing a commercial, synthetic polymeric binder are included for reference. Coatings were made up as aqueous solutions and applied using a lab-scale rotary coater.

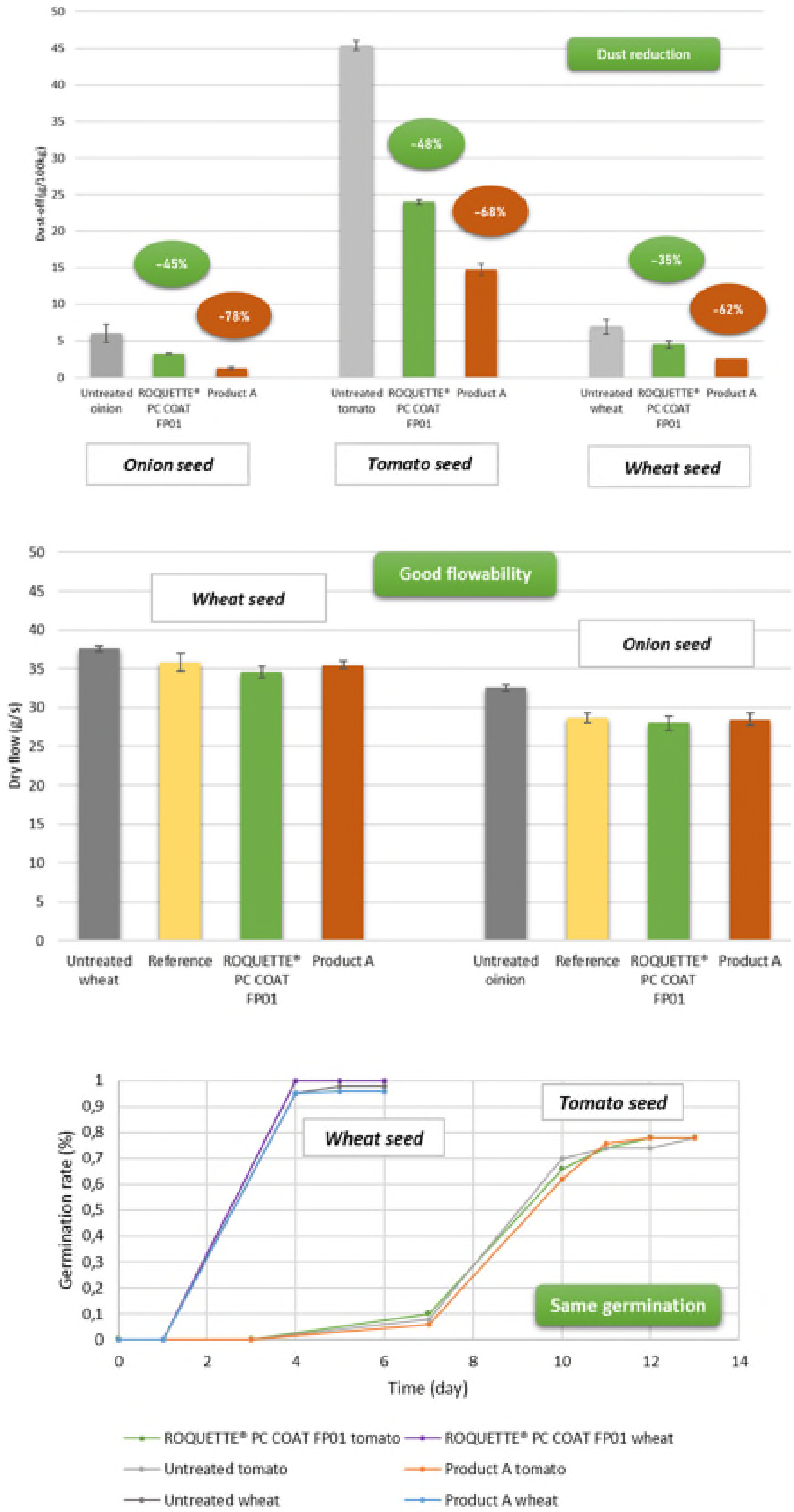
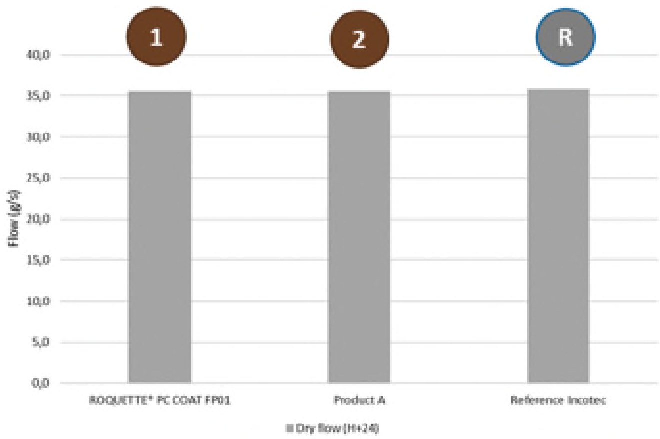


Figure 2: Dust reduction, flowability and germination data for seeds coated with ROQUETTE® PC COAT FP-01 and Product A solutions confirm their suitability for seed coating; performance is comparable to a commercial synthetic binder (where assessed).

Dust off was measured with a Heubach dustmeter using the ESTA reference method[11]. The results show that coating onion, tomato and wheat seed with either Roquette product substantially reduces dusting, relative to the untreated seed. Onion and wheat seeds both meet the ESTA reference values of 0.2g of dust per 100,000 seeds and 4g of dust per 100kg of seed respectively; there are no published values for tomato seed[7].

Flowability was measured using a flow through a funnel method that detects bridging and poor flow from measurements of the mass of seed exiting a hopper outlet in a defined time period. Both wheat and onion seed have good flowability when untreated which was minimally impacted by coating. All tomato seeds, treated and untreated gave a 'null' result with the flowability apparatus used due to their light weight. Crucially both Roquette products resulted in closely comparable performance to the reference binder.

In a third and final test, germination rates were determined by dispersing 50 seeds on moist blotting paper and then leaving the samples in moist, dark conditions. Germination rate is defined as the ratio of germinated seeds (as ascertained from daily checks) to the total number of seeds multiplied by 100. Results for wheat and tomato seeds, coated with either of the Roquette products, show that germination is unaffected by the coating process. All onion seeds, treated and untreated, proved unviable (failed to germinate) possibly due to age.



Equivalent flowability
vs market reference

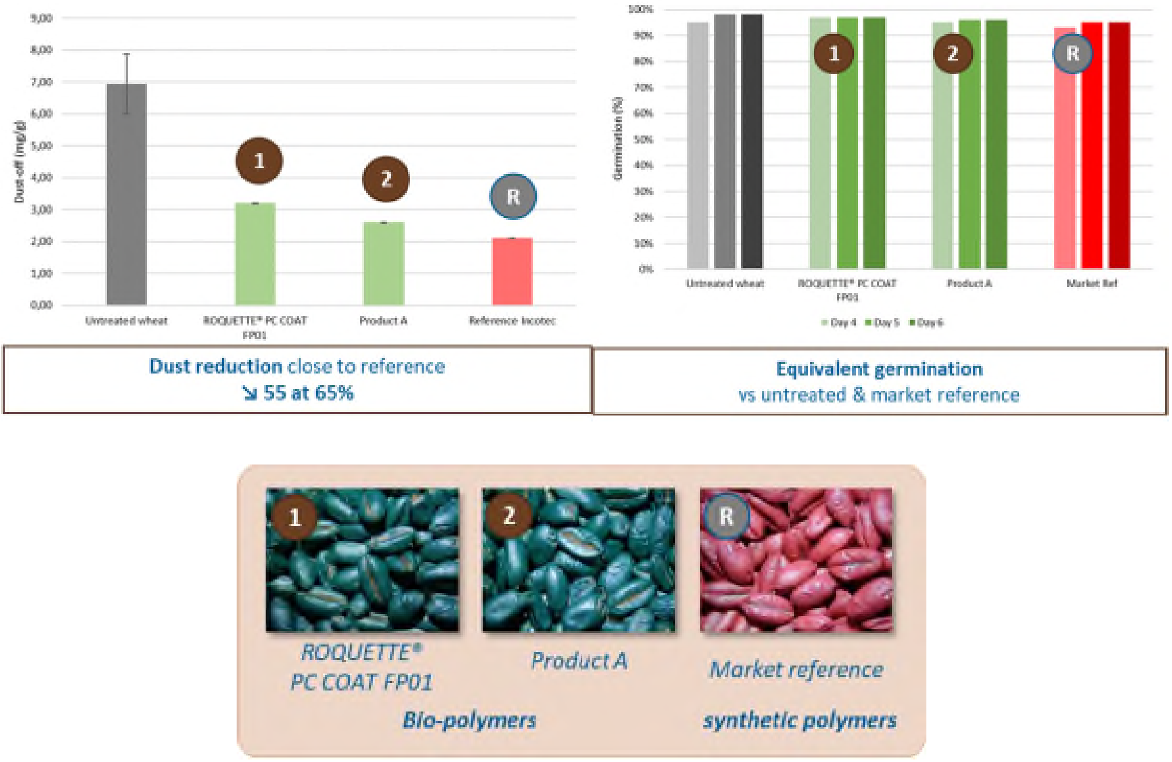


Figure 3: Dust reduction, flowability and germination data for wheat seeds coated with ROQUETTE® PC COAT FP-01 and Product A solutions show that both are successful in delivering performance comparable to that of a commercial synthetic polymeric coating

Figure 3 shows data from a second set of experiments comparing the performance of coating solutions formulated with ROQUETTE® PC COAT FP-01 and Product A (as before) with that of a commercial formulation containing a synthetic polymeric binder, for the coating of wheat seeds. As before, coatings were made up as aqueous solutions and applied using a lab-scale rotary coater; the reference coating was different to that in the first series of experiments. Flow, dust-off and germination were all measured for untreated and coated seeds as previously described.

The results show that all coatings reduce dust off by a minimum of around 50% with the two Roquette products delivering performance approaching that of the reference formulation. As in the first set of experiments Product A performs slightly better than ROQUETTE® PC COAT FP-01 but crucially dust levels are reduced below the 4g of dust per 100kg of seed reference value for cereals. All three coatings exhibit closely similar flowability and germination rate with no loss of germination relative to the untreated seed.

In summary, both data sets provide encouraging evidence of the good performance of ROQUETTE® PC COAT FP-01 and Product A as seed coating materials. Both have the ability to substantially reduce dusting while minimally impacting germination and performance compares well with currently used formulations where tested.

Case study 2: Reformulating for dust reduction with a Roquette binder

In a second case study, reformulation work was carried out to assess the feasibility of replacing a synthetic polymeric binder in an existing corn seed coating formulation with Roquette Product B,. Table 1 provides details of the reference formulation and the alternatives assessed. The reference formulation is applied at a level of 12 g/kg of seed, 10.85 g/kg of proprietary formulation and 1.15g/kg of a phytosanitary product, for disease control. Reformulated coatings were made up as aqueous solutions containing either 9 or 15 % Product B and identical levels of phytosanitary product and filler (relative to the reference formulation). These were applied at a dosage rate of 12, 16 or 20 g/kg using a lab-scale rotary coater. Dust-off values were measured using the Heubach dustmeter, as previously described.

Formulas

Product	Dose
Binder	9-15%
Phytosanitary	1.15g/Kg
Fillers	1g/Kg
Water	qs
Total	12-16-20g/Kg

Reference Formula

Product	Dose
Customer formulation	10,85g/Kg
Phytosanitary	1.15g/Kg
Total	12g/Kg

Table 1: Conventional seed coatings can be reformulated with plant-based binders such as Product B.

Figure 4 shows how the dust-off performance of the formulations compares with untreated seed, with one another, and with the regulatory levels for corn; the customer also applies an alert level to provide an indication of sub-optimal seed coating performance. Increasing Product B concentration reduces dust-off, as does increasing dosing levels. Performance equivalent to the reference formulation can therefore be achieved with either a binder concentration of 9% and a dosing level of 20g/kg or a binder concentration of 15% and a dosing level of 16g/kg. The reformulated coatings easily reduce dusting to below the ESTA reference values.

While these dosing levels are somewhat higher than those required for the reference formulation they clearly illustrate the potential to use Product B to move away from a synthetic formulation with no loss of performance. Furthermore, there may be scope to further reduce dosage levels through process optimization and/or by using alternative coating equipment.

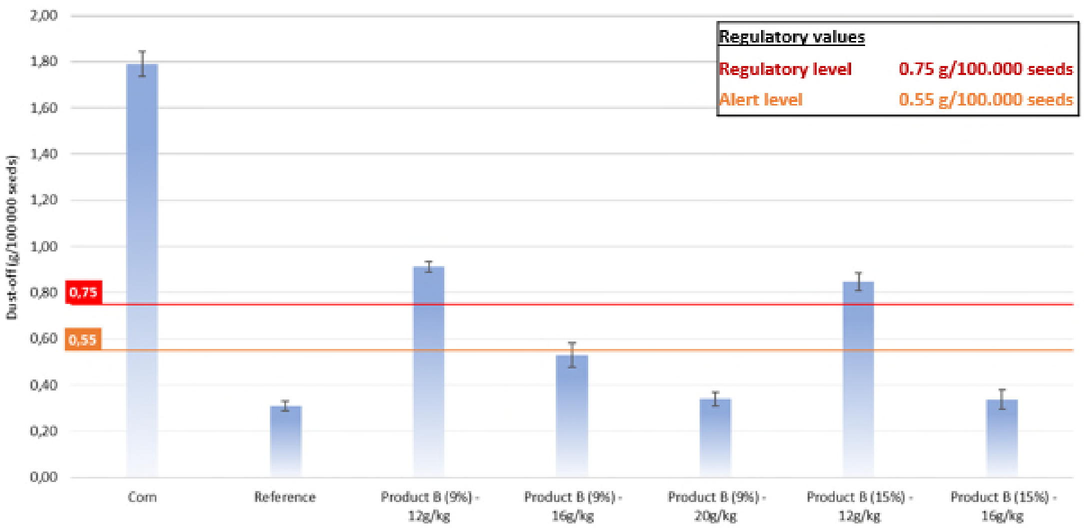


Figure 4: Product B --based formulations can deliver identical dust-off performance to commercial synthetic formulations for corn coating.

Case study 3: Assessing the performance of Roquette products for alfafa encrustation.

In a final study, experiments were carried out to assess the performance of Roquette products for encrusting alfafa seeds. Firstly, tests were carried out using Roquette Product C which was added at different concentrations in the range 30 – 60% (w/w dry) with the aim of determining the level required to maximise coverage. The balance of the encrusting mix was filler and the encrusting process was carried out in a rotary coater, sequentially adding dry ingredients and water to produce a stable coating.

Unsurprisingly, increasing Product C concentration increases coverage (see figure 5) but even at high loadings coverage is incomplete. A surfactant/dispersant was therefore added with the aim of decreasing the surface tension of the encrusting mixture and improving coverage. Figure 5 shows the impact of the dispersant in terms of number of covered particles (green line), partially covered particles (amber line) and agglomerated particles (red line). Just 1% dispersant gives optimal performance in combination with a Product C concentration of 40%; higher binder concentrations result in agglomeration.

20% 30% 50%

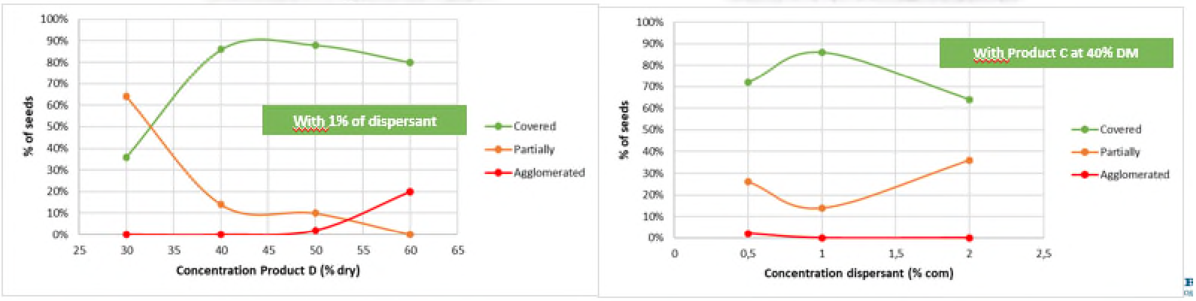
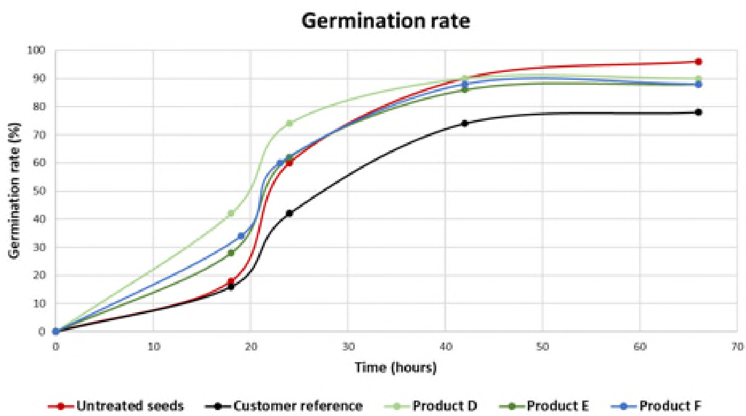


Figure 5: Addition of a dispersant improves coverage. Maximum coverage is achieved with a 1% dispersant level in combination with a 40% Product C concentration.

Three other Roquette products, Products D, E, and F, were also assessed for this encrusting application. Product D gives good coverage at both 20 and 30% but the viscosity of the encrusting solution becomes too high for successful processing at 40%; Product F exhibits good coverage at 30%.



Binder	Non treated alfalfa	Customer reference	Product D (15%)	Product E (70%)	Product F (30%)
TGW	1,98	3,00	2,85	2,92	3,13
H_2O (%)	/	6,1	5,8	6,2	5,6
Abrasion (%)	/	0,46	0,27	0,00	0,09
Germination (%)*	96	78	90	88	88
Observations			Presence of dust Regular shape Full seed coverage	No dust Lower seed coverage	Low dust Good seed coverage

Figure 6 shows summary data for seeds encrusted using the Roquette product formulations (D,E and F), the customer reference formulation and for untreated seeds.

Germination data show that the Roquette solutions accelerate germination relative to the reference as well as ultimately delivering germination rates closer to those of the untreated seeds, far higher than those of the reference. The tabulated data show that by switching to Roquette products it is feasible to make encrusted seeds of comparable weight and water content to the reference, but with lower abrasion (as measured with the Heubach dustmeter), minimal dusting, and with significantly higher germination rates. These are beneficial gains to set alongside the better environmental credentials of the Roquette products.

In conclusion

Seed treatment provides protection against pests and diseases and a beneficial nutritional environment to get plants off to the great start needed for high yields even as crop inputs are progressively reduced. It is therefore an important element of efforts to maintain or even increase land productivity while improving sustainability. However, conventional seed treatment formulations often contain ingredients that are environmentally problematic, notably synthetic, fossil fuel derived polymers and microplastics. Roquette offers a portfolio of plant-based products for seed treatment that deliver comparable performance to conventional alternatives but with a much lighter environmental footprint. Experimental data illustrates the potential of these products and how they can help to make seeds that are safer to use and safer for the planet.

A comprehensive plant-derived portfolio for seed coating

Roquette has an established portfolio for plant protection and seed treatment, predominantly derived from starches, proteins and cellulose. The full range extends to attractants, binders, bulking agents and diluents, seed coatings, disintegrants, emulsifiers, encapsulation agents, granulation agents, growth factors and humectants. These ingredients help customers to formulate active ingredients into safe, effective, easy-to-use products with excellent biodegradability and a low environmental footprint. Take a closer look at some of the most popular options for seed treatment:

ROQUETTE® PC COAT is a range of fully biodegradable solutions for seed coating and encrusting. Use to apply a viscoelastic film coating that will leave no trace of microplastics in the soil or to ensure an appropriate level of tack in an encrusting formulation.

We have other solutions and developed several mixes adapted to different technologies.

To find out more about these products and how they can help you develop an optimized seed treatment formulation visit our website and/or contact us.

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