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Impact of adhesive adjuvants addition into seed treatments on the flowability of cereal crop seeds

Einfluss der Zugabe adhäsiver Additive in Beizlösungen auf das Fließverhalten von Getreidesaatgut

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Abstract

Flow behavior of bulk material is influenced by surface material. The application of different seed treatment slurries indicate a change of boundary friction between the grains as a result of contact. A comparison between adjuvant added and single treated cereal seed was conducted in the present study to evaluate the impact on flowability. Related to the chemical components of the used adjuvants different impacts were detected. The use of plant oil based adjuvants Kantor® and Inteco® reduced the value of released energy compared to single use of seed treatments Efa® and Rubin®TT in crop seeds wheat, barley, rye, oat and triticale at 80% of treatments. Contrary to this, the addition of a polysiloxane based adjuvant MaximalFlow® increased the value of released energy representing flowability in 70% of treatments compared to single use of preparation

Key words: adjuvant, bulk material, flowability, seed treatment

Zusammenfassung

Das Fließverhalten von Schüttgütern wird durch das Material der Oberfläche beeinflusst. Die Applikation von Saatgutbehandlungsmitteln führt zu einer Änderung der Grenzreibung zwischen einzelnen Getreidekörnern als Folge von Kontakt. In der vorliegenden Studie wurde ein Vergleich zwischen verschiedenen Beizlösungen, mit und ohne Additiv in Bezug auf die Fließfähigkeit durchgeführt. Es konnten, abhängig von den eingesetzten Zusatzpräpa-

raten unterschiedliche Effekte detektiert werden. Die Verwendung von pflanzenölbasierten Adjuvantien Kantor® und Inteco® in Kombination mit den Saatgutbehandlungsmitteln Efa® und Rubin®TT reduzierte die Energiefreisetzung, verglichen mit der jeweiligen Varianten ohne Additiv, anhand der Verwendung von Weizen-, Gerste-, Roggen-, Hafer und Triticalesaatgut. Im Gegensatz dazu erhöhte die Zugabe des Polysiloxan-basierten Additivs MaximalFlow® die Energiefreisetzung in 70% aller Vergleiche, relativ zur Variante ohne Zusatz.

Stichwörter: Additiv, Fließfähigkeit, Saatgutbehandlungsmittel, Schüttgut

Introduction

More than 90% of the field crops grown worldwide are sown on the basis of seeds (SCHWINN, 1994). The chemical treatment of seeds is a basic process for conventional farming to allow a safe emergence of crops. Substantial seed treatment applications are conducted on small grain cereals, which comprises more than 50% of the world market for fungicide use as seed dressing (KNOWLES, 2008). Slurry treatment forms the predominant application technique for chemical substances.

Adjuvants can contribute to effectiveness of chemical applications. Bioenhancement due to the use of adjuvants is a well described process in field applications with respect to the functionality, based on the purpose of each adjuvant. Stabilisation, de- and antifoaming, buffering, wetting, spreading or sticking are factors that might be influenced by the addition of adjuvants (Foy, 1989;

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HAZEN, 2000). Seed treatments have different requirements than field applications. According to pelleting and coating techniques, which include high amounts of polymers, liquid dressings can be combined with certain adhesives in order to increase the adhesion to the individual seed grain. These components include stickers and binder as a basic part of the seed treatment process (HALMER, 1988). This importance of an addition of adhesives for seed dressings differs obviously, depending on the application area of liquid components. ROBINSON and MAYBERRY (1976) already compared different seed treatment application systems and declared the treatment of cereal crop seeds as the simplest form of application. This is due to the fact that the application is proceeded in a single process and generally conducted without any sticker or binder use. However, different studies prove the importance of stickers as a contribution to reduce abrasion and dust drift during sowing (PISTORIUS et al., 2010; RUDELDT et al., 2017). An addition of substances into the slurry production can thus be declared as enhancement of any characteristics but not as need. Therefore the addition of substances for cereal crop seed treatment can be compared to “tank mix additives”, also called “adjuvants” from field applications (TANN, 2010; HOCHBERG, 1996).

Besides the holding capacity of polymers, there are more important aspects that might be influenced by an addition of adjuvants regarding seed treatments. Due to the fact that the treatment process differs in time and space from sowing process, the focus might be on some technical claims such as adhesion and flowability. The contribution of adhesive adjuvants concerning adhesive strength has already been mentioned (SCHNIER et al., 2003). Seed bagging after treatment process is basically determined by its flow behavior. Thus, flowability has a main influence on the efficacy of seed treatment plants to allow a steady flow and prevent blockages. It is generally accepted that surface coating leads to a change of internal friction between single particles such as grains. A change from dry friction towards boundary layer friction is obtained (SOMMER et al., 2014). Concerning seeds, no investigation regarding flowability have been reported for cereal seed treatments, comparing different slurry mixtures.

In this study a laboratory seed treatment trial was carried out using single liquid seed dressings and mixtures with different adjuvants at a defined application rate in different cereal crops. An analysis regarding flowability was conducted to estimate the contribution of adhesive adjuvants.

Material and Methods

Seed

Certified cereal crop seed from winter wheat (cultivar: Potenzial, Breeder: Deutsche Saatgutveredelung AG, Lippstadt GER), winter barley (cultivar: KWS Kosmos, Breeder: KWS Lochow GmbH, Bergen GER), winter rye

(cultivar: Brasetto, Breeder: KWS Lochow GmbH, Bergen GER), oats (cultivar: Bison, Breeder: Saaten-Union GmbH, Isernhagen GER) and winter triticale (cultivar: Cosinus, Breeder: KWS Lochow GmbH, Bergen GER) was used in the trial.

Seed dressings and adjuvants

Two universal suspension concentrates (SC) EfA® (Fluoxastrobin 37.5 g l⁻¹, Prothioconazole 25.0 g l⁻¹, Triazoxide 10.0 g l⁻¹, Tebuconazole 3.75 g l⁻¹; company: BayerCropScience, Mohnheim, GER) and Rubin®TT (Pyrimethanile 42.0 g l⁻¹, Triticonazol 25.0 g l⁻¹, Prochloraz 38.6 g l⁻¹; company: BASF Crop Protection, Limburgerhof, GER) were used for seed treatment. Further three different adhesive adjuvants were partly added. Two emulsifiable concentrate (EC) seed treatment adjuvants, Kantor® (company: Agroplanta GmbH & Co. KG, Langenpreising-Zustorf, GER) and Inteco® (company: BayerCropScience, Mohnheim, GER) based on proportions of plant oil (Soybean oil) and one suspension concentrate (SC) seed treatment adjuvant MaximalFlow® (company: BASF Crop Protection, Limburgerhof, GER), containing a proportion of silicon oil, were also included. Slurry solution was mixed in a 15 ml centrifuge tube according to the approved quantity of seed dressings for the crops winterwheat, -barley, rye, -triticale and oat. Additionally a fixed input of 40 µl 100g⁻¹ was added, when using adjuvants. Slurry was filled up with tap water to a defined level of 1000 µl solution, representative to a constant application rate of 1000 µl 100g⁻¹.

Approved quantity of seed dressings.

EfA®	160 µl 100g ⁻¹ (winterwheat and -barley); 120 µl 100g ⁻¹ (winterrye and -triticale); 100 µl 100g ⁻¹ (oat)
Rubin®TT	200 µl 100g ⁻¹ (winterwheat and -barley); 150 µl 100g ⁻¹ (winterrye, -triticale and oat)

Mixtures.

Amounts of seed dressings	(100, 120, 150, 160, 200 µl 100g ⁻¹)
+ tap water without adjuvant	(900, 880, 850, 840, 800 µl 100g ⁻¹)
+ addition of adjuvants	(40 µl 100g ⁻¹)
+ tap water with adjuvant	(860, 840, 810, 800, 760 µl 100g ⁻¹)

Seed treatment process

A laboratory batch seed treater Hege 11 (Wintersteiger) was used to conduct the seed treatment process. Technical settings were fixed for application time (12 sec) and mixing time (4 sec). A 5 ml syringes (Braun) with an application rate of 1000 µl treatment solution per 100 g seeds was used for application. The seed batches contained 400 g seeds. Seed storage was conducted in 1.5 kg paper bags for two days at room temperature (20 ± 2°C with a relative humidity of 50 ± 10%) according to the

methodology of the Julius Kühn-Institut from the Heubach-Dustmeter test (HEIMBACH, 2011).

Seed flowability measurement

Seed flowability was measured by capturing the dynamic flow behavior of the dry seed mass using a *Revolution Powder Analyser*. Released energy of avalanches was measured in a rotating drum by image capturing. An amount of 100 ml treated seeds was necessary for analysis. Duration (100 revolutions), rotation speed (0.5 rpm) and frequency of image capturing (10 images per second) were fixed as instrumental settings. Measurement was carried out with three replicates per variant. The average forms the flowability in kJ kg^{-1} , representing the amount of released energy. The smaller the energy, the better is the flowability.

The statistical software R (2015) was used to evaluate the data. The analysis of variance (ANOVA) indicates significant evidence to all single factors and to all two- and three-fold interactions. Multiple contrast tests (BRETZ et al., 2010) were conducted in order to compare the different slurry mixtures.

Results

The different seed dressings EfA[®] and Rubin[®]TT, used in the five crop seeds wheat, barley, rye, oat and triticale, showed individual heights of released energy. The columns in Figure 1 represent the different mixtures depending on the use of adhesive adjuvants. A selective change of flowability was measured when using adjuvants compared to single application. Specific interactions of seed treatment agent and adjuvant were found in wheat. For both seed treatments EfA[®] and Rubin[®]TT the combination with MaximalFlow[®] resulted in higher values of released energy compared to single use. In contrast to this the combination with the adjuvants Kantor[®] and Inteco[®] indicated lower values of released energy. Uniform significant differences were found between the mixture with MaximalFlow[®] and single use, as between single use and Kantor[®] or Inteco[®] mixtures. No difference was found between energy values for variants with Kantor[®] and Inteco[®]. This was also found when slurries were applied in triticale. In Barley this relation was found when using seed dressing EfA[®]. Different interactions were found for the mixture of Rubin[®]TT with the adjuvant Inteco[®]. Values of released energy were higher than by single use and just slightly lower than by the mixture with MaximalFlow[®], so that there was no significant difference to any of both. Significant lowest values of released energy were related to Kantor[®] included mixtures. Using both products EfA[®] and Rubin[®]TT in rye resulted in significant higher energy values for single use and the mixture with MaximalFlow[®] compared to Kantor[®] and Inteco[®] included mixtures. The use of EfA[®] in oat resulted in the same relation of mixtures as in wheat barley and triticale. When using Rubin[®]TT, lowest values of released energy were measured from single application. Values from Inteco[®] included variants were significant higher, whereas there was no significance related to the remaining mixtures.

Discussion

The application of different coatings to a surface area indicate a change of boundary friction, in this case between the grains, as a result of contact that is defined as a change of friction (HOLMBERG et al., 2007). The addition of the various adjuvants led to a change in the flow behavior. For plant oil based adjuvants Kantor[®] and Inteco[®] the resulting avalanches were smaller than from single use of seed dressing and the bulk material could flow more evenly. SCHULZE (2014) explained the effect of flow aids with a reduction of the adhesive forces between the individual particles. The chemical effect of oils used as flow aids was defined by VAN DE MARK and SANDEFUR (2005) as coalescence from particle interaction, regarding surface coatings. Early studies from IRANI et al. (1959) indicate an effective impact of adjuvants with a smaller particle size, relative to that of the application agent (seed dressing). Fuller filling of spaces and evenness on surfaces result in less friction (PELEG and HOLLENACH, 1984). The differences of released energy values between seeds treated with adjuvants Kantor[®] and Inteco[®] compared to seeds treated with MaximalFlow[®] in almost every crop seeds and seed dressings in the trial indicate, that the impact of flow aids is due to their chemical composition. Plant oil based polymers have very commonly been used for surface coating techniques (DUTTON and SCHONFIELD, 1963). Different components such as double bonds, epoxies, hydroxyls or esters due to the triacylglycerols of fatty acids, can undergo several chemical reactions (ALAM et al., 2014). The drying of the wetting surface is a plant oil-specific phenomenon which is attributable to the individual fatty acid patterns and especially to the content of unsaturated fatty acids. This leads to a polymerization between single unsaturated fatty acids that results in a stable layer (MEIR et al., 2007; LU and LAROCK, 2009; TUMOSA and MECKLENBURG, 2013). This is in contrast to the alternative oil that is part of the adjuvant MaximalFlow[®]. In 70% of the comparisons between single used seed dressing and mixtures with MaximalFlow[®] there was a significant higher amount of released energy relative to single use. The co-polymer, which consists of polysiloxanes (silicone), is characterized exclusively by saturated fatty acids. The influence on the drying of the surface is significantly slower (LU and LAROCK, 2009). The incomplete drying process might be an explanation of a remaining cohesive potential between single particles (kernels). This phenomenon has already been described by SCHULZE (2014) as a relation between liquid quantity and bonding force due to liquid bridges between individual particles.

Conclusion

The use of different adhesive adjuvants led to changes in the flowability of seeds. The chemical mixtures of the used adjuvants are crucial for suitability as flow aids. This aspect seems to be an additional benefit beside the reduction of abrasion and dust drift. A good

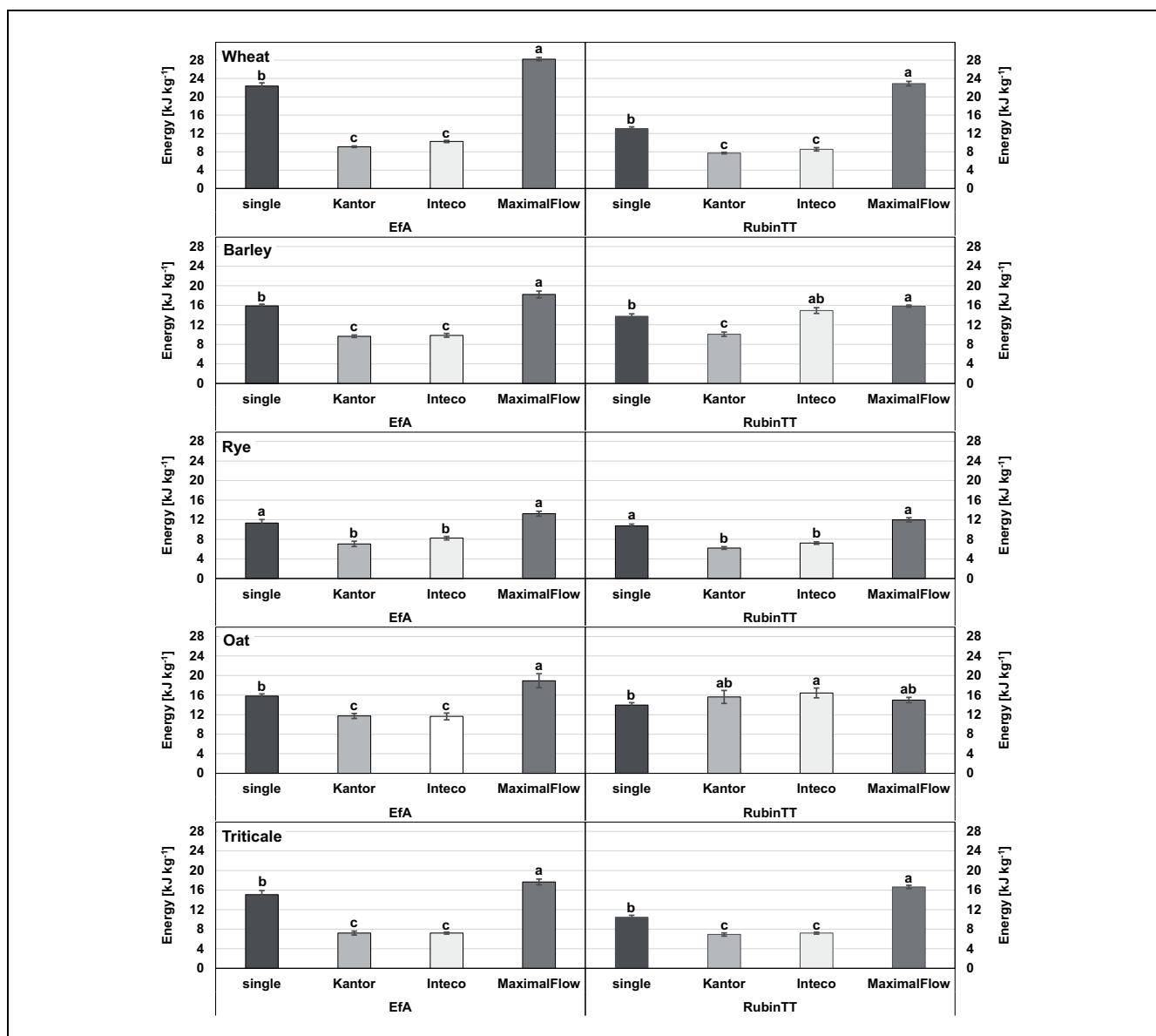


Fig. 1. Released energy [kJ kg⁻¹] representing flow behavior of Efa[®] and Rubin[®]TT treated seeds using the Revolution Powder Analyser in four seed dressing mixtures for both seed dressing (single, +Kantor[®], +Inteco[®] and +MaximalFlow[®]), in crop seeds of wheat, barley, rye, oat and triticale.

choice to improve flow behavior of cereal crop seeds might be using plant oils due to their natural phenomenon termed as drying.

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