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RESEARCH NOTE

# The influence of seed coating on the vigor and early seedling growth of barley

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## Abstract

**F.M.F. Corlett, C.A. Rufino, J.F. Vieira, L.C. Tavares, L.M. Tunes and A.C.S.A. Barros. The influence of seed coating on the vigor and early seedling growth of barley. Cien. Inv. Agr. 41(1): 129-136.** Seed coating is a process in which a thin and uniform polymer layer is deposited on the surface of a seed. The objective of this study was to evaluate the vigor of barley seed coated with a commercial polymer and various combinations of calcium, silicon and fungicide. In addition to a control with only the polymer coating, a total of 17 seed coating treatments were used in a completely randomized factorial design (18 treatments × 4 replicates per treatment). Calcium and silicon were applied at concentrations of 0, 25 or 50 g kg$^{-1}$ of seed, and 0 or 3.0 mL of fungicide was applied. The means were compared using a Duncan test ($P \leq 0.05$). The results showed that a coating of polymer, fungicide, calcium and silicon did not affect the physiological quality of the barley seed and that the use of these products can protect the seed against pathogens without affecting the rate of emergence of the barley seedlings while ensuring good seed appearance, adhesion, distribution and coloration.

**Key words:** seed protection, physiological quality, seed quality.

## Introduction

The process of seed coating involves the application of finely ground solids or liquids containing dissolved or suspended solids to form a more or less continuous layer covering the natural seed coat (Scott, 1989). Because the coatings are extremely thin, multiple coatings of various ingredients are also possible (John *et al*., 2005). Seed coating is used in conjunction with chemical and biological treatments. The protective material is applied in very precise amounts and with a minimal impact on the environment (Baudet and Peres, 2004).

Seed coating has long been used, especially for the seeds of vegetables, forest plants and ornamentals. It can be employed to increase seed size, to improve seed shape and texture and to facilitate direct sowing. This advanced technology allows the application of combinations of nutrients, fungicides, insecticides,

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herbicides and beneficial microorganisms to seed (Nascimento *et al*., 1993). In addition, it serves to reduce the exposure of agricultural workers to pesticides and improves the contact between seeds and the soil, contributing to the preservation of the environment (Baudet and Peres, 2004; Levien *et al*., 2008). The seed coating should be more or less continuous to eliminate or minimize product dust-off, as low dust-off is an important factor in worker safety (Taylor *et al.,* 2001). Polymer materials are slightly more viscous than most chemicals used as pesticides in seed treatment. Consequently, the application of these polymers requires a machine that can apply the coating with high precision. The treatment of seed with various combinations of polymers, fungicides and insecticides requires only a small financial investment for the farmer but promises an excellent return on this investment. To guarantee that all seeds are coated with an adequate quantity of the chemical product and thereby maximize the potential benefit from the seed treatment, efficient application is essential (Levien *et al*., 2008). Several previous studies have reported satisfactory effects of seed coating on seed germination, seedling growth, root and shoot growth, leaf area, dry biomass and increase in yield (Zelonka *et al*., 2005; Gevrek *et al*., 2012; Tavares *et al*., 2012; Tavares *et al*., 2013). In addition, seed coating improves plantability, reduces the percentage of skips and doubles, reduces the formation of dust from seed and minimizes the leaching of insecticide from treated seed (Avelar *et al.,* 2012). Accordingly, the objective of this study was to evaluate the effect on the seed quality and seedling performance of barley resulting from seed coating with various combinations of calcium, silicon, polymer and fungicide.

## Materials and methods

This study was performed at the Laboratory of Seed Analysis, LDAS, and Faculty of Agronomy Eliseu Maciel at the Federal University of Pelotas. Seed of the barley cultivar Scarlett (2008/2009 season) were supplied by the Company Westermann, located in the city of Pelotas, in the State of Rio Grande do Sul, Brazil.

In this study, barley seeds were coated with various combinations (Table 1) of the following products: fludioxinil + metalaxyl-M (25 g $L^{-1}$ + 10 g $L^{-1}$), trade mark Maxim-XL®, at a dosage of 3 mL $kg^{-1}$ of seed; dolomitic limestone (0, 25 and 50 g $kg^{-1}$ of seed); and aluminum silicate (0, 25 and 50 g $kg^{-1}$ of seed). All seed treatments also included 2 mL CF Clear ® polymer and 4 mL of dye (red). Lastly, 15 mL of water $kg^{-1}$ of seed was added to obtain a concentration of dolomitic limestone or aluminum silicate of 25 g $kg^{-1}$ of seed, whereas 25 mL of water $kg^{-1}$ of seed was added to obtain a concentration of 50 g $kg^{-1}$ of seed. The volume of solution derived from the mixture of solid ingredients (calcium and silicon compounds) and liquid ingredients (fungicide, polymer, dye and water) was 24 mL $kg^{-1}$ of seed and 34 mL $kg^{-1}$ of seed, respectively. The treatments and dosages used are shown in Table 1.

**Table 1.** Description of the treatments evaluated.

| Treatments | Dosages |
|---|---|
| T1 | Ca (25 g) |
| T2 | Si (25 g) |
| T3 | Ca (25 g)+ Si (25 g) |
| T4 | Fungicide (25 g) |
| T5 | Fungicide + Ca (25 g) |
| T6 | Fungicide + Si (25 g) |
| T7 | Fungicide + Si (25 g) + Ca (25 g) |
| T8 | Ca (50 g) |
| T9 | Si (50 g) |
| T10 | Ca (25 g) + Si (50 g) |
| T11 | Ca (50 g) + Si (25 g) |
| T12 | Fungicide + Ca (50 g) |
| T13 | Fungicide + Si (50 g) |
| T14 | Fungicide + Si (50 g) + Ca (25 g) |
| T15 | Fungicide + Si (25 g) + Ca (50 g) |
| T16 | Fungicide + Si (50 g) + Ca (50 g) |
| T17 | Ca (50 g) + Si (50 g) |
| T18 | Uncoated control |

The source of the silicon used was aluminum silicate in the form of a whitish non-toxic dust obtained from ground rock and containing 77.9% $SiO_2$, 23.73% $Al_2O_3$, 0.23% CaO and 0.36% $K_2O$. The source of Ca was dolomitic limestone containing calcium oxide (CaO) and magnesium oxide (MgO) with a Relative Power of Total Neutralization (RPTN) of 75% and a reactivity of 77%.

To coat the seed, the products were applied manually to 0.5 kg of seed in the following order: fungicide + polymer + calcium and silicon. The seed was placed in plastic bags and then agitated until all seeds were completely covered (approximately 5 minutes). The treated seed was then naturally dried for 48 h.

Sowing was conducted on August 29, 2009 in plots measuring 10 m × 1 m in Albaqualf soil under conventional tillage. Each experimental plot consisted of four rows 1 m long with 0.10 m spacing between rows and 50 seeds planted per line. Irrigation was performed daily for a period of 30 days. No other management practices were necessary. The number of emerged seedlings was counted daily until it reached a constant level (a period of 21 days). For each replication, the emergence speed index was calculated by summing the daily ratios of the number of emerged plants to the number of days from sowing (Maguire, 1962) using the following formula:

$$ESI = \frac{E1}{N1} + \frac{E2}{N2} + \ldots + \frac{En}{Nn},$$

where ESI = emergence speed index; E1, E2, En = number of seedlings emerged, computed at the first, second and last counts; N1, N2, Nn = number of days from sowing to the first, second and final counts.

For the determination of leaf area and dry biomass, 10 seedlings were collected weekly; they were cut at ground level on the 10th, 20th and 30th days after emergence (DAE). Measurements of leaf area were performed using a photoelectric device (LI-3100 Area Meter, LI-COR Ltda.) giving a direct reading in $cm^2$. The seedlings were oven dried at 65ºC for 72 hours to obtain the dry biomass. A Burris (s.d.) scale with scores ranging from 0 to 10 was used to evaluate the visual quality of the treated seed. Four replicate subsamples, each containing 500 g of seeds, were used per treatment.

A completely randomized factorial design (18 treatments × 4 replicates per treatment) was used. The study data were analyzed with the ASSISTAT statistical program, version 7.5 (Silva and Azevedo, 2009). The treatment effects were compared using a Duncan test at a 5% significance level.

## Results and discussion

Almost all treatment groups showed an emergence speed index greater than that of the control (Figure 1). Only T9 (50 g Si) was statistically similar to the control treatment. Treatments T1, T5, T7, T8, T13, T14 and T16, which contained (1) fungicide and silicon, (2) calcium applied alone or in combination with fungicide (3), stimulated the rapid growth of barley seedlings, offering the greatest potential for initial vigor. Zorato *et al.* (2001) have shown that seed treatment with fungicide can control important seed-transmitted pathogens. For this reason, the treatment of seed with fungicide is important because it can guarantee adequate populations of plants if the weather and soil conditions are unfavorable. In addition, silicon is an important amendment because it positively influences plant growth and development (Tavares *et al.*, 2012). Tavares *et al.* (2012) observed that a coating containing a silicon source did not affect either the germination of the coated rice seed or the emergence of seedlings from the coated seed in the field; these same authors also observed that a coating of aluminum silicate applied to rice seed promoted a greater leaf area on the plants at 20 days after emergence. In addition, their study showed that dolomitic limestone and aluminum silicate, applied in a seed coating either alone or in combination, produced plants with a higher dry biomass as early as 20 days after emergence.

The values obtained in this study (Table 2) showed that treatments T5 (fungicide + 25 g Ca) and T13 (fungicide + 50 g Si) showed strong and significant effects on the leaf area of the barley seedlings on the 10th, 20th and 30th DAE. At 10 days after emergence, the effects on the seedling leaf area of treatments T2, T4, T7, T8, T10, T11, T13 and T14 do not differ; however, all of these effects on leaf area were higher than the value found for the control treatment. Tavares *et al.* (2012) found that treatments of the rice cultivar IRGA 422 CL with dolomitic limestone and aluminum silicate, either alone or in combination, showed significantly greater values of leaf area than the control treatment. In the current study, only treatments T5 and T13 showed significantly greater values of leaf area than the other treatments at 20 days after emergence. Moreover, no statistically significant differences were found among the effects of treatments T2, T3, T5, T9 and T13 on leaf area at 30 days after emergence.

In general, the seed coating influenced the rate of seedling emergence, as shown by the results for the emergence speed index (Figure 1). According to Tavares *et al.* (2012), the coating of lowland rice seed with dolomitic limestone and aluminum silicate did not negatively affect the physiological quality of the seed. In contrast, the treatments produced increments in the initial growth of seedlings relative to the control treatment.

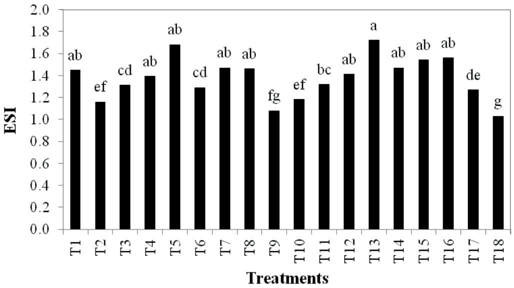

**Figure 1.** Emergence speed index (ESI) of barley seed treated with various doses of calcium and silicon, with and without fungicide. Means followed by the same letter in the same column are not significantly different (Duncan test, 5% significance level). T1: Ca (25 g); T2: Si (25 g); T3: Ca (25 g) + Si (25 g); T4: Fung (25 g); T5: Fung + Ca (25 g); T6: Fung + Si (25 g); T7: Fung + Si (25 g) + Ca (25 g); T8: Ca (50 g); T9: Si (50 g); T10: Ca (25 g) + Si (50 g); T11: Ca (50 g) + Si (25 g); T12: Fung + Ca (50 g); T13: Fung + Si (50 g); T14: Fung + Si (50 g) + Ca (25 g); T15: Fung + Si (25 g) + Ca (50 g); T16: Fung + Si (50 g) + Ca (50 g); T17: Ca (50 g) + Si (50 g); T18: Control.

The production of dry biomass by the barley plants is shown in Table 3. Treatments T5 (fungicide and calcium) and T13 (fungicide and silicon) produced a strong and consistent performance for all three evaluation periods. Tavares *et al.* (2012) have also found that the dry weight of rice plants grown from seed coated with dolomitic limestone and aluminum silicate, either alone or in combination, was significantly greater than the value for the control treatment.

These results document the advantages of seed coating; however, certain authors have stated that coating can negatively affect the physiological quality of seed. Franzin *et al.* (2004) found that germination of lettuce seed was inhibited after coating. Silva and Nakagawa (1998) found that coated seed showed a 20 days delay in germination. Accordingly, small differences in vigor can contribute to the uneven characteristics of the initial population of plants. However, seedlings that have overcome the barrier produced by the coating show equal growth rates. Moreover, both in the laboratory and under natural conditions, the seedlings are uniform in both fresh and dry weight.

From an analysis of methods of production and production technologies such as seed coating, Baudet and Peres (2004) concluded that seed must show a good aggregate value in an increasingly competitive market. Seed that has a high uniformity of germination and emergence and that produces seedlings with a high growth potential are needed for this purpose. The use of artificial materials as seed coatings can help to identify a set of characteristics necessary for the establishment of seedlings. This approach can serve to standardize the early stages

**Table 2.** Leaf area of barley seedlings grown from seed coated with various doses of calcium and silicon, with and without fungicide, at different times of evaluation. Capão do Leão – RS.

| | | Times of evaluation | | |
|---|---|---|---|---|
| | | 10 DAE[1] | 20 DAE | 30 DAE (days) |
| Treatments | | Leaf area (cm$^{-2}$ pl$^{-1}$) | | |
| T1 | Ca (25 g) | 26.60 cd | 78.63 cd | 120.16 gh |
| T2 | Si (25 g) | 29.37 ab | 70.01 fg | 172.33 ab |
| T3 | Ca (25 g) + Si (25 g) | 21.21 f | 62.12 h | 164.70 ab |
| T4 | Fung (25 g) | 30.68 ab | 72.94 ef | 123.66 gh |
| T5 | Fung + Ca (25 g) | 33.76 a[2] | 99.98 a | 188.65 a |
| T6 | Fung + Si (25 g) | 25.10 de | 55.92 i | 136.55 fg |
| T7 | Fung + Si (25 g) + Ca (25 g) | 29.20 ab | 67.53 gh | 159.87 bc |
| T8 | Ca (50 g) | 29.87 ab | 72.94 ef | 136.15 fg |
| T9 | Si (50 g) | 27.00 cd | 80.13 cd | 183.11 ab |
| T10 | Ca (25 g) + Si (50 g) | 28.44 ab | 74.80 de | 138.18 ef |
| T11 | Ca (50 g) + Si (25 g) | 30.06 ab | 66.23 gh | 156.47 cd |
| T12 | Fung + Ca (50 g) | 27.36 bc | 67.52 gh | 119.37 gh |
| T13 | Fung + Si (50 g) | 32.58 ab | 104.74 a | 183.24 a |
| T14 | Fung + Si (50 g) + Ca (25 g) | 30.55 ab | 76.62 de | 138.06 ef |
| T15 | Fung + Si (25 g) + Ca (50 g) | 28.15 bc | 83.16 c | 173.66 ab |
| T16 | Fung + Si (50 g) + Ca (50 g) | 25.24 cd | 65.98 gh | 141.36 de |
| T17 | Ca (50 g) + Si (50 g) | 21.79 ef | 57.12 i | 162.34 bc |
| T18 | Control | 21.03 f | 38.88 j | 114.712 h |

[1]DAE: days after emergence. [2]Means followed by the same letter in the same column are not significantly different (Duncan test, 5% significance level).

**Table 3.** Dry matter production of barley plants grown from seed coated with various doses of calcium and silicon, with and without fungicide, at different times of evaluation. Capão do Leão – RS.

| | | Times of evaluation | | |
|---|---|---|---|---|
| | | 10 DAE[1] | 20 DAE | 30 DAE (days) |
| Treatments | | Dry matter (mg pl$^{-1}$) | | |
| T1 | Ca (25 g) | 0.102 bc | 0.310 de | 0.541 f |
| T2 | Si (25 g) | 0.116 ab | 0.345 cd | 0.780 ab |
| T3 | Ca (25 g) + Si (25 g) | 0.098 bc | 0.279 fg | 0.671 cd |
| T4 | Fung (25 g) | 0.102 bc | 0.315 de | 0.561 f |
| T5 | Fung + Ca (25 g) | 0.139 a[2] | 0.412 ab | 0.843 a |
| T6 | Fung + Si (25 g) | 0.091 c | 0.389 ab | 0.706 bc |
| T7 | Fung + Si (25 g) + Ca (25 g) | 0.107 ab | 0.334 cd | 0.639 de |
| T8 | Ca (50 g) | 0.103 bc | 0.304 ef | 0.567 f |
| T9 | Si (50 g) | 0.111 ab | 0.341 cd | 0.763 ab |
| T10 | Ca (25 g) + Si (50 g) | 0.101 bc | 0.323 de | 0.659 cd |
| T11 | Ca (50 g) + Si (25 g) | 0.110 ab | 0.351 cd | 0.779 ab |
| T12 | Fung + Ca (50 g) | 0.097 bc | 0.370 bc | 0.639 de |
| T13 | Fung + Si (50 g) | 0.142 a | 0.438 a | 0.844 a |
| T14 | Fung + Si (50 g) + Ca (25 g) | 0.107 ab | 0.279 fg | 0.738 ab |
| T15 | Fung + Si (25 g) + Ca (50 g) | 0.095 bc | 0.317 de | 0.741 ab |
| T16 | Fung + Si (50 g) + Ca (50 g) | 0.114 ab | 0.323 de | 0.706 bc |
| T17 | Ca (50 g) + Si (50 g) | 0.094 c | 0.272 g | 0.608 ef |
| T18 | Control | 0.064 d | 0.185 h | 0.317 g |

[1]DAE: days after emergence. [2]Means followed by the same letter in the same column are not significantly different (Duncan test, 5% significance level).

of the plant for seed production. Studies on barley seed coating have been conducted by Pilar *et al.* (2009); Pilar-Izquiedo *et al.* (2012), and Gorim and Asch (2012). However, more information is needed about the effects that these coatings may have on germination and early seedling growth.

An important finding of the current study is that the coated seed showed variation from 9.0 to 10.0 on Burris' scale. This result showed that the treatments produced excellent coverage, an attractive appearance, good adherence and coloration and a desirable distribution of the products used to coat the seed.

The coating of barley seed with calcium, silicon, polymer and fungicide did not affect the emergence rate. Indeed, the coatings increased the initial growth of seedlings relative to the control. The combinations of fungicide with 25 g of a calcium source and fungicide with 50 g of a silicon source (expressed in units of g $kg^{-1}$ of seed) promotes seedling vigor, and the vigor of the seedlings grown from the coated seed was found to be higher than that of the seedlings grown from the control seed. Seed coated with calcium, silicon, polymer and fungicide produced seedlings with a greater leaf area than that of the seedlings grown from the control seed. Barley seed coated with calcium, silicon, polymer and fungicide is desirable in terms of appearance, adhesion, distribution and coloration.

## Resumen

**F.M.F. Corlett, C.A. Rufino, J.F. Vieira, L.C. Tavares, L.M. Tunes y A.C.S.A. Barros. Influencia del recubrimiento de semillas en el vigor y crecimiento temprano de las plántulas de cebada. Cien. Inv. Agr. 41(1): 129-136.** El recubrimiento de semillas consiste en la deposición de una capa delgada y uniforme de un polímero sobre la superficie de la semilla. El objetivo de este estudio fue evaluar el vigor de las semillas de cebada, revestido con calcio y silicio, polímero comercial y fungicida. Los tratamientos consistieron de dos concentraciones de calcio y silicio para el revestimiento de las semillas, con niveles de 0, 25 y 50 g $kg^{-1}$ semilla. Se utilizó 3,0 mL de fungicida y un total de 17 tratamientos y un control, sin ningún tratamiento. El diseño experimental fue completamente al azar en un esquema factorial (18×4) y los resultados fueron analizados a través de la comparación de medias, utilizando la prueba de Duncan ($P \leq 0,05$). Los resultados mostraron que las semillas de cebada recubiertas con fungicida, calcio y silicio, no se vieron afectadas en su calidad fisiológica y, posiblemente, el uso de estos productos protege la semilla contra patógenos, sin afectar su velocidad de aparición, y proporcionan semillas con buena apariencia, adherencia, distribución y coloración.

**Palabras clave:** Calidad fisiológica de semillas, calidad de semillas, protección.

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