Journal of Agricultural Science; Vol. 11, No. 1; 2019
ISSN 1916-9752 E-ISSN 1916-9760
Published by Canadian Center of Science and Education

# Slurry Composition and Physiological Quality of Treated Soybean Seeds Over Storage

Andréia K. Suzukawa[1], Giovanna E. G. Mariucci[1], Lucas C. Pereira[1], Alessandro L. Braccini[1], Raissa M. Ponce[1], Danilo C. V. Marteli[1], Luiz H. S. Lima[1], Priscila Angelotti[1] & Vanessa F. V. Silva[1]

[1] Programa de Pós-graduação em Agronomia, Universidade Estadual de Maringá, Maringá, Brazil

Correspondence: Andréia K. Suzukawa, Programa de Pós-graduação em Agronomia, Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá, Paraná, Brazil. E-mail: kazumi.s@gmail.com

Received: September 25, 2018 Accepted: October 30, 2018 Online Published: December 15, 2018

doi:10.5539/jas.v11n1p376 URL: https://doi.org/10.5539/jas.v11n1p376

**Abstract**

Industrial seed treatment assures uniform coverage of seeds with insecticides, fungicides, micronutrients and bioestimulant at precise dose, however often resulting in higher slurry volume. Furthermore, seeds are coated long periods of time prior sowing and may influence germination and vigor. Thus, the aim of this work was to evaluate the influence of seven industrial seed treatments and their respective slurry volumes on the physiological potential of soybean seeds at 0, 15, 30, 45, 60 and 90 days of storage. In each storage period, the variables germination, accelerated aging test and emergency speed index were evaluated and studied in the repeated measures in time model. The products used were: fungicide (thiabendazole, fludioxonil and mefenoxam), insecticide (thiametoxam), insecticide/nematicide (abamectin), micronutrients (cobalt and molybdenum), bioregulator, drying powder and polymer. High volumes of seed-coating mixtures reduce the physiological quality of soybean seeds over storage. However, the slurry composition also influenced on the maintenance of the seed germination and vigor throughout the storage.

**Keywords:** germination, *Glycine max* (L.) Merrill, repeated measures in time, slurry volume, vigor

## 1. Introduction

The use of seeds of high physiological and sanitary quality plays a crucial role in plant stand and, thus, in crop yield. However, not often sowing takes place in areas free of pathogens or insect threats, therefore, treating seeds with agrochemicals prior sowing is a way to guarantee seedling development, either by controlling early pests or diseases or by reducing the risk of their establishment in intact areas (Balardin et al., 2011; Pereira et al., 2011).

In this context, in Brazil, the second-largest soybean [*Glycine max* (L.) Merrill] producer worldwide (Organisation for Economic Co-operation and Development [OECD]-FAO, 2017), the market of treated soybean seeds reaches more than 95% of the sown area, with the industrial seed treatment (IST) comprising about 66 % of the total market-share (Henning, França-Neto, Krzyzanowski, & Lorini, 2010).

By using specific equipment, besides insecticides and fungicides, the IST enables uniformly treating seeds with other seed-coating products such as micronutrients and bioestimulant at the precise dose. Therefore, since several products can be employed, often the IST result in higher slurry volumes than that performed on farm. Furthermore, unlike the treatment performed, in the IST seeds are coated weeks or months prior sowing (Strieder et al., 2014), which may influence germination and vigor, particularly over storage.

In this way, the objective of this work was to evaluate the physiological potential of soybean seeds in different periods of storage after the addition of micronutrient, biostimulant, and nematicide in a commercial slurry of IST based.

## 2. Method

### *2.1 Seed Treatments and Storage Periods*

Soybean seeds cultivar BMX Alvo RR were submitted to combinations of products: fungicide (F) (thiabendazole, fludioxonil and mefenoxam—Maxim Advanced®, dose: 100 mL 100 $kg^{-1}$), insecticide (I) (thiametoxam—Cruiser®, dose: 200 and 250 mL 100 $kg^{-1}$), insecticide/nematicide (N) (abamectin—Avicta®, dose: 100 mL 100 $kg^{-1}$), micronutrients (M) (Cobalt [Co] and Molybdenum [Mo] as CoMo Platinum®, dose: 200

mL 100 kg$^{-1}$), bioregulator (B) (Stimulate®, dose: 500 mL 100 kg$^{-1}$), drying powder (D) (Fluidus, dose: 150 and 400 g 100 kg$^{-1}$) and polymer (POL) (Disco Ag Green, dose: 100 mL 100 kg$^{-1}$) (Table 1). For calculation of slurry volume, the drying powder is not added as it is a product that quickly dries and does not interfere in the volume.

Table 1. Detailed scheme of the industrial soybean seeds treatments with their respective storage periods

| Treatments[1] | | Slurry Volume (mL 100 kg$^{-1}$) | Storage Periods (days) |
|---|---|---|---|
| T1 | Control (without treatment) | - | |
| T2 | F+I+D | 350 | |
| T3 | F+I+M+D | 550 | |
| T4 | F+I+M+B+D | 1050 | 0, 15, 30, 45, 60 and 90 |
| T5 | F+I+N+D+POL | 500 | |
| T6 | F+I+N+M+D+POL | 700 | |
| T7 | F+I +N+M+B+D+POL | 1200 | |

*Note*. [1]F = fungicide; I = insecticide; D = drying powder; M = micronutrient; B = bioregulator; POL = polymer; N = insecticide/nematicide.

Seeds were treated in a continuous lot seed-coating device and were then placed in kraft paper bags and kept in laboratory ambient conditions. The physiological potential of the seeds was evaluated in five storage periods after treatments (0, 15, 30, 45, 60 and 90) by means of the tests described below.

*2.2 Response-Variables Analyzed*

*Germination*: four replicates of 50 seeds were used, for each treatment, according to the Brazilian Rules for Seed Testing (MAPA, 2013). Count was assessed on the eighth day after the test.

*Accelerated aging*: four replicates of 50 seeds were used, which were arranged on a stainless-steel screen, inserted inside boxes (gerbox type) containing 40 mL of distilled water. Boxes were taken to a jacketed chamber of water, regulated at 41 ºC for 48 hours (Marcos Filho, 1999). Seeds were later submitted to the germination test.

*Emergence speed index*: it was performed on sand substrate and conducted with four subsamples of 50 seeds for each treatment. In this test, the sand used was first washed and placed in plastic trays under greenhouse conditions and moisture was maintained with moderate irrigations. Daily notations were made of the number of normal emerged seedlings up to 15 days after sowing, according to Nakagawa (1999). The results were expressed as proposed by Maguire (1962).

*2.3 Statistical Analysis*

The experiment was conducted using a completely randomized design in the model of repeated measures in time. Data were analyzed using the Mixed procedure (SAS 9.4, SAS Institute Inc., Carey, NC). For pairwise mean comparisons, the macro developed by Piepho (2012) was used to generate letters between significantly different means, by the t test at $\alpha = 0.05$.

## 3. Results

Up to 15 days of storage superior results of germination were found in treatments T2, T3 and T5 (Table 2). Treatment T2 further stood out in germination immediately after seed treatment (0 days) and remained equivalent to untreated seeds (T1) at 30, 45 and 90 days of storage. However, from the 15 days of storage, treatments T4 and T7 presented the lowest percentage of normal seedlings in the germination test, which may be related to their high slurry volume due to the addition of 500 mL 100 kg$^{-1}$ of bioestimulant (1050 and 1200 mL 100 kg$^{-1}$ of seeds for T4 and T7, respectively).

Table 2. Mean percentages of normal seedlings in the germination test of industrial seed treatments in six storage periods

| Treatments[1] | Storage periods (days) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 90 |
| | ---------- % ---------- | | | | | |
| T1: Control | 99.5 aA | 91.5 aBC | 78.5 aD | 89.0 aCD | 97.0 aAB | 90.0 aBC |
| T2: F+I+D | 99.5 aA | 85.5 abBC | 78.0 aC | 85.5 aBC | 90.5 bB | 80.5 aBC |
| T3: F+I+M+D | 99.0 aA | 85.5 abB | 63.5 bC | 82.0 abB | 87.5 bcB | 66.0 bC |
| T4: F+I+M+B+D | 96.0 bA | 72.5 cB | 28.5 dC | 69.0 cB | 65.5 eB | 31.5 cdC |
| T5: F+I+N+D+POL | 98.0 abA | 82.5 bB | 68.0 abC | 88.0 aB | 83.0 cB | 63.0 bC |
| T6: F+I+N+M+D+POL | 99.5 aA | 74.0 cC | 62.5 bD | 83.5 abBC | 84.0 cB | 41.5 cE |
| T7: F+I +N+M+B+D+POL | 98.0 abA | 71.5 cB | 41.0 cC | 74.0 bcB | 73.5 dB | 21.5 dD |

*Note.* [1]F = fungicide; I = insecticide; D = drying powder; M = micronutrient; B = bioregulator; POL = polymer; N = insecticide/nematicide.

Means followed by the same letter do not differ significantly from each other, upper case on the line and lower case in column, by t test at 5% probability.

Regarding the accelerated aging test (Table 3), except the control (T1) normal seedlings values decreased over storage (Table 3). At period zero, the highest values were observed in T2 as well as in the control (T1); on the other hand, at 15 days of storage no significant difference was seen between T2, T3 and T5. Concerning treatment, T5 it was considered as equivalent to control (T1) at both 30 and 45 days, demonstrating its aptitude in maintaining seed viability under the conditions of high humidity and temperature. At 90 days, however, treatment T2 surpassed all others, including, thus, the control (T1).

Table 3. Mean percentages of normal seedlings in the accelerated aging test of industrial seed treatments in six storage periods

| Treatments[1] | Storage periods (days) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 90 |
| | ---------- % ---------- | | | | | |
| T1: Control | 79.5 aA | 45.5 abB | 30.0 abD | 46.0 aBC | 38.5 aCD | 4.0 bE |
| T2: F+I+P | 77.0 aA | 56.0 aB | 27.0 bC | 27.0 bC | 18.0 bCD | 16.5 aD |
| T3: F+I+M+P | 54.5 cA | 55.0 aA | 29.5 bB | 18.0 bcC | 8.5 bcCD | 5.5 bD |
| T4: F+I+M+B+P | 36.0 dA | 18.5 dB | 10.5 cBC | 4.0 dCD | 2.0 cCD | 0.0 bD |
| T5: F+I+N+P+POL | 66.5 bA | 51.0 abB | 40.0 aC | 37.5 aC | 10.0 bcD | 9.5 abD |
| T6: F+I+N+M+P+POL | 58.5 bcA | 43.0 bcB | 31.0 abC | 16.5 cD | 6.0 cE | 2.0 bE |
| T7: F+I +N+M+B+P+POL | 59.5 bcA | 35.0 cB | 13.0 cC | 10.0 cdCD | 0.5 cD | 0.0 bD |

*Note.* [1]F = fungicide; I = insecticide; D = drying powder; M = micronutrient; B = bioregulator; POL = polymer; N = insecticide/nematicide.

Means followed by the same letter do not differ significantly from each other, upper case on the line and lower case in column, by t test at 5% probability.

In respect of the emergency speed index (Table 4), up to 15 days of storage higher vigor levels were observed in treatment T2, which was significant different than T5 at the first storage time of this work. Also, although T3 was inferior than all other treatments at 15 days, from the 30 days it presented superior results at 30, 60 and 90 days (Table 4), surpassing, moreover the control (T1). At the 30 days, treatments T3, T4, T5, T6 and T7 did not present significant differences among themselves, whereas at 45 days, treatments T3, T4 and T5 were superior to others (Table 4).

Table 4. Means of emergence speed index of industrial seed treatments in six storage periods

| Treatments[1] | Storage periods (days) | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 15 | 30 | 45 | 60 | 90 |
| | ---------- % ---------- | | | | | |
| T1: Control | 9.3 abA | 9.8 bA | 4.7 bB | 6.1 abB | 3.9 bB | 0.0 cC |
| T2: F+I+P | 9.6 aB | 11.1 aA | 5.0 bC | 4.7 bCD | 2.8 bDE | 2.4 bE |
| T3: F+I+M+P | 9.1 abA | 6.1 cC | 7.6 aB | 8.8 aAB | 6.0 aC | 6.9 aBC |
| T4: F+I+M+B+P | 8.6 bB | 10.8 abA | 8.8 aB | 7.7 aB | 3.3 bC | 0.1 cD |
| T5: F+I+N+P+POL | 9.6 aAB | 10.3 abA | 7.6 aC | 7.5 aBC | 4.3 abD | 0.4 cE |
| T6: F+I+N+M+P+POL | 8.9 abB | 10.0 abA | 7.8 aB | 3.9 bC | 4.4 abC | 3.5 bC |
| T7: F+I +N+M+B+P+POL | 7.64 cB | 10.7 abA | 7.6 aB | 3.8 bC | 0.7 cD | 3.1 bC |

*Note.* [1]F = fungicide; I = insecticide; D = drying powder; M = micronutrient; B = bioregulator; POL = polymer; N = insecticide/nematicide.

Means followed by the same letter do not differ significantly from each other, upper case on the line and lower case in column, by t test at 5% probability.

## 4. Discussion

Regarding to Koizumi et al. (2008), the first step in the reactivation of metabolic processes that lead to germination is a slow and controlled water uptake. For this reason, the final volume for soybean seed treatment should not surpass 600 mL 100 $kg^{-1}$, the limit of aqueous solution tolerated in which injury to the cell membranes does not occur (Embrapa, 2011). However, recently volumes of up to 1400 mL 100 $kg^{-1}$ have been tested and did not compromise seed germination immediately after treatment (Segalin et al., 2013) and even up to 45 days (Matera et al., 2018), 90 days (Pereira et al., 2018) or 180 days of storage (Schons, C. M. Silva, Pavan, A. V. Silva, & Mielezrski, 2018).

It is important to point out that, besides the storage conditions and the active ingredients, the different performance of soybean seeds above-mentioned regarding slurry volume may be related to the initial level of vigor and germination of the lot prior IST, so that seeds of higher initial physiological quality are potentially more tolerated to the prejudicial effects that a fast imbibition process may have on seed membranes (Brzezinski et al., 2017).

Immediately after seed coating (time zero), none of the treatments used compromised the sales potential of the seeds, since values of normal seedlings in the germination test were above 80%, the value established in the Brazilian legislation as the minimum assurance for sale of soybean seeds (MAPA, 2013). On the other hand, while at 15 days of storage only the T4, T6 and T7 did not reach this minimum level, at 45 and 60 days, apart from T4 and T7, all treatments provided seed lots suitable for commercialization.

These results corroborate Zambon (2013) and Strieder et al. (2014), who recommend performing seed treatment shortly prior sowing to minimize any toxic effects of slurries on germination and seedling establishment. However, regarding the use of thiabendazole, fludioxonil, mefenoxam + thiametoxam, which are the active ingredients employed in this work, while Pereira et al. (2018) found germination below 80% only from 90 days of storage, Matera et al. (2018) pointed out gemination below it already at 45 days after treatment.

In the present work the untreated control firstly showed a germination decrease at 30 days, followed by an increase of it at 45 days. E. R. Carvalho, Mavaieie, Oliveira, M. V. Carvalho, and Vieira (2014) and Santos, Carvalho, Rocha and Nascimento (2018) also reported this same performance in the first periods of storage for untreated seeds, a fact that, according to the authors, may be inherent to the reduction of field fungi incidence during storage. However, differently than reported by L. Dan, H. Dan, Barroso, and Braccini (2010), L. Dan, H. Dan, Albrecht, Ricci, and Piccinin (2011) and Pereira et al. (2018), this same fluctuation was observed in all other treatments, despite the use of agrochemicals. Although it has also been reported in the literature, this is still a subject that demands additional investigations (Pires, Bragantini, & Costa, 2004; Krueger, Goggi, Mullen, & Mallarino, 2012; Mbofung, Goggi, Leandro, & Mullen, 2013).

In the accelerated aging test, as seen for germination, treatments with the highest slurry volumes (T4 and T7) presented the lowest percentages of normal seedlings (Table 3) over storage. This result corroborates those of Matera et al. (2018), Pereira et al. (2016) and Silva et al. (2008), who also found vigor reduction in treated corn or soybean seeds with the bioregulator, particularly over storage.

The results seen in the speed index partially differ from those of germination and accelerated aging tests (Table 2 and 3), in which T4 and T7 had the lowest values. Higher vigor results in the speed index for both treatments may be explained by the fact that the sand reduces the concentration of active ingredients near the seeds, minimizing, thus, a possible phytotoxic effect of the used slurries (Taylor & Salanenka, 2012). It should be noted, nevertheless, that at 0, 45 and 60 days of storage, the lowest values of speed index were observed in T7, which may be related, as mentioned, to the high slurry volume adopted in this treatment.

## 5. Conclusion

High volumes of seed-coating mixtures reduce the physiological quality of soybean seeds over storage. However, the slurry composition also influence the seed germination and vigor maintenance throughout the storage.

**Acknowledgements**

The research had financial support from CNPq (Brazilian National Council for Scientific and Technological Development).

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