# Soybean seed cover with solid phosphate fertilizer

# Revestimento de sementes de soja com fertilizante fosfatado sólido

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## ABSTRACT
The use of seeders that only deposit seeds in the soil results in the phosphate fertilization to be realized at the surface of the soil, demanding new techniques to the localized phosphate fertilization as the seed covering with solid phosphate fertilizers. The aim of this work was to evaluate the seed cover with supertriple phosphate in granulometries and fertilizer doses. The experiment was a 4x4 factorial (granulometries x doses), which tested the 6, 12, 24 and 48% of fertilizer added in the seed covering, relative to the seeds mass. The fertilizers granulometries were defined by sieves Mesh-Tyler 35, 60, 115 and 270. Seed of soybean variety TMG 7063 were covered using Likoseed polymer (1 ml $kg^{-1}$). It was evaluated the visual quality of seeds cover, the seeds germination on paper roll, the emergence in sandbox and the growth of aerial part and radicle of the seedlings. The finer granulometries combined with the higher doses showed better visual quality of covering however, as the fertilizer doses were higher, the seeds germination, the emergence and the radicle growth were lower. The seed covering is technically viable to supply the fertilizer trough seeds.

**Keywords:** Emergence, Germination, *Glycine max*, Seeding, Triple superphosphate.

**RESUMO**
O uso de semeadora que depositam somente as sementes no solo resulta na fertilização fosfatada realizada a lanço na superfície do solo, demandando novas técnicas para posicionar o fertilizante fosfatado como o revestimento de sementes com fertilizantes fosfatados sólidos. O objetivo deste trabalho foi avaliar o revestimento de sementes com superfosfato triplo em granulometrias e doses. O experimento foi um fatorial 4x4 (granulometria x doses), que testou 6, 12, 24 e 48% do fertilizante adicionado no revestimento, em relação à massa de sementes. As granulometrias foram definidas pelas peneiras Mesh-Tyler 35, 60, 115 e 270. Sementes de soja da variedade TMG 7063 foram revestidas utilizando o polímero Likoseed (1 ml $kg^{-1}$). Avaliou-se a qualidade visual do recobrimento, a germinação no papel toalha, a emergência em caixa de areia e o crescimento da parte aérea e da radícula das plântulas. As granulometrias mais finas combinadas com as maiores doses de fertilizantes resultaram em melhor qualidade visual do revestimento, no entanto, a medida em que se elevou as doses, a germinação, a emergência e o crescimento da radícula foi menor. O revestimento é tecnicamente viável como veículo do fertilizante fosfatado ao solo.

**Palavras-chave:** Emergência, Germinação, *Glycine max*, Semeadura, Superfosfato triplo.

## 1 INTRODUCTION

The soybean's cultivation is expanding trough all Brazilian regions, specially to the Cerrado biome, which presents weathered soils with reduced natural phosphorus content, due to its original material (BRANQUINHO et al., 2014; MARTINS et al., 2015; MATIAS et al., 2015; FONTANA et al., 2016). The phosphorus is an element that is important to final yield of soybeans (VIEIRA et al., 2015; FERNANDES et al., 2020), contributing to the oil content of the grains (FAQUIN, 2005).

Production systems that fertilize the soil without revolving it, as the direct seedling, doesn't incorporate the phosphorus in higher depths, making the element concentrated on the surface of the soil (NUNES et al., 2011; LEITE et al., 2014). That concentration is due to phosphorou's limited mobility in the soil, due to its adsorption by the soil's components, especially iron and aluminum oxides, which are very common in the Brazilian tropical soil (RAIJ, 2004).

Following the world's machinery development, the Brazilian farmers are adopting the use of seeding machines without fertilizer deposition, mostly to reduce the cost of the seeding process (BARBOSA et al., 2015). However, these machines require the phosphorus fertilization to be made on the soil surface without incorporate the element at soil, concentrating this element at the soil surface (NUNES et al., 2011), reducing the plants root development (MALAVOLTA, 2004) and exposing those plants to climatic risks.

Trough that, the phosphorus fertilization must be reviewed, locating it as nearest as possible to the seeds, which reduces the negative effects. In order to that, the seed covering with phosphate fertilizers can be an alternative, as this technic can cover vegetable seeds with diverse products (TANADA-PALMU, 2005; OLIVEIRA et al., 2014), that can enhance the initial development of seedlings (SHARMA et al., 2015).

At covering process, one polymer is used to make the glue process possible, after that, the covering product is added. This product can be produced with active or inactive elements and, after added, it creates an external layer in the seed that protects it and can transform its form into another. However, the technics that are available to produce these covered seeds are private patented and its materials and process, kept under industrial secret laws (SHARMA et al., 2015).

As its exposed, the objective of this work is to evaluate the cover of soybeans seeds with solid phosphate fertilizer (Triple superphosphate) at different doses and particle sizes.

## 2 MATERIAL AND METHODS

The experiment was conducted in Umuarama's Campus in the seed analysis laboratory of the State University of Maringá, State of Paraná, Brazil. A completely randomized design was used to compose a 4x4 factorial arrangement (weight of fertilizer utilized x fertilizer particle size).

Soybean seeds of variety TMG 7063 (93% original germination) were covered with superphosphate (41% $P_2O_5$), adding the LIKOSEED as a polymer. The superphosphate was grinded by a knife's mill. After grinding it was sifted with four sieves (Mesh-Tyler 35, 60, 115 and 270).

The covering was performed spraying the polymer (1 ml per kg of seeds) over the seeds and adding the treatment's volume of fertilizer into a recipient with the seed and shaking it to homogenize it.

The evaluated treatments were: four volumes of fertilizers in the covering, testing the percentages 6, 12, 24 and 48% of fertilizer used in the covering in relation to the mass of seeds used, combined with four fertilizer granulometries and determined by the sieves used for their separation, admitting the sieves Mesh-Tyler 35 (> 0.425 mm), 60 (0.425 -

0.250 mm), 115 (0.250 - 0.125 mm) and 270 (0.125 - 0.053 mm) as tested granulometry intervals.

After coating, the seeds were air-dried for 30 minutes and subsequently submitted to the following tests:

**Visual evaluation of the coating efficiency**

Using four repetitions of 50 seeds each, the treatments were subjected to a visual analysis of the coating efficiency with scores from 0 to 5 indicating the final quality of the coating obtained by the treatment; in which 0 indicates total covering inefficiency, which meant incapability to observe the fertilizer's attachment to the seed and 5, indicates total covering efficiency of, in which the entire surface of the seed gets covered by the fertilizer. The intermediate values (2, 3 and 4) represent the evolution of 20% in the covering surface of each note.

**Germination test on paper roll**

Using four repetitions of 50 seeds each, which were packed in filter paper using the paper roll mode and adding the volume of distilled and deionized water corresponding to 2.5 times the mass of the paper. After the rollers were formed, they were placed in a B.O.D. with a controlled temperature of 25ºC ± 2ºC, with a 12-hour photoperiod. Two counts were performed five and eight days after the beginning of the test, counting the normal germinated seedlings (BRASIL, 2011).

**Emergence test at sandbox**

Using four replicates of 50 seeds of each treatment, that were packed in a plastic box with 5 cm of sand and followed by the distribution of the seeds, another layer of 1 cm of sand was applied for the seed's coverage. The boxes were moistened daily and at the end of the 10th test day, the number of normal seedlings emerged was counted (MARCOS FILHO et al., 2009).

**Germination speed index (GSI)**

Using the experiment set up for the sandbox emergence test, the number of normal seedlings emerged was counted daily. The average value of germination speed was calculated by the weighted average between the number of normal seedlings emerged on each date and the number of days of test duration until the date of evaluation (MAGUIRE, 1962).

### Growth and seedling mass

Using four repetitions of 10 seeds of each treatment, which were packed in filter paper adding the volume of distilled and deionized water corresponding to 2.5 times the mass of the paper. The seeds were positioned in the upper portion of the paper, which in the form of rolls, were placed in a germination chamber type B.O.D. with a controlled temperature of 25ºC ± 2ºC, with a 12-hour photoperiod. After eight days, t was measured the length of the hypocotyl and the largest root present with a graduated ruler. Then, the seedling portions (hypocotyl and radicle) were packed in paper bags and taken to the greenhouse with forced air circulation for 24 hours at 80ºC, to obtain the dry mass of radicle and hypocotyl, which were expressed in mg seedling$^{-1}$ (NAKAGAWA, 1999).

The data obtained were subjected to analysis of variance to test the interaction between factors and the influence of them solely, when the results were significant, the treatments were compared by linear and nonlinear regression models.

## 3 RESULTS AND DISCUSSION

The covering of soybean seeds with phosphate fertilizer significantly influenced the germination in sand and filter paper, the germination speed index, the growth and seedling root's mass and resulted in different visual efficiencies of the covering, according to the percentage of fertilizer and particle sizes of the triple superphosphate used (Table 1).

The visual evaluation of the efficiency of seed covering resulted in better values as the percentage of fertilizer used in the covering increased and the granulometry of the fertilizer used was reduced (Figure 1).

The chemical and physical characteristics of the coating material directly interfere with the process result, in which thicker particles reduce the mechanical integrity and resistance of the coating (PEDRINI et al., 2017). This is due to the better organization of the particles and, consequently, better adhesion of the material when smaller particle diameters are used (ZONG et al., 2017).

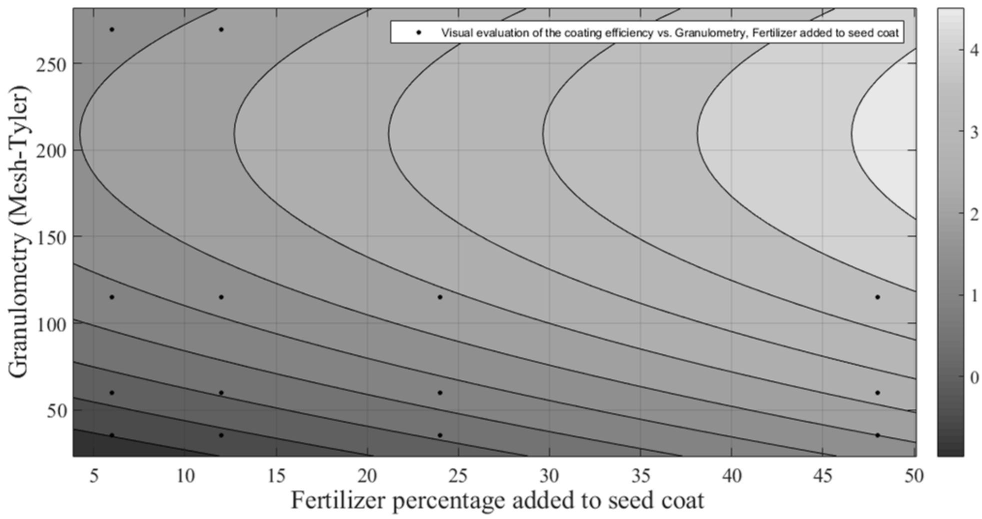
Table 1 – Summary table of the analysis of variance for results of soybean seed coverage due to percentage of fertilizer utilized and triple superphosphate granulometry.

| | ------------------- Mean square | ------------------ | | | C.V. (%) | Mean |
|---|---|---|---|---|---|---|
| | Fertilizer percentual (P) | Granulometry (G) | PxG | Residue | | |
| Visual evaluation of the coating efficiency | 20.92**(1) | 18.92** | 0.69** | 0.00 | 0.00 | 1.69 |
| Germination test on paper roll | 80.06*(2) | 340.76** | 17.00ns(3) | 26.12 | 14.04 | 72.80 |
| Emergence in sandbox | 159.46** | 14.38ns | 10.06ns | 12.17 | 8.89 | 39.25 |
| Germination speed index | 8.49** | 0.46ns | 0.24ns | 0.31 | 9.13 | 6.07 |
| Radicle length | 9.80** | 1.48ns | 0.85ns | 0.81 | 7.64 | 11.76 |
| Radicle dried mass | 15.83* | 1.97ns | 0.26ns | 5.22 | 13.65 | 16.74 |
| Hypocotyl length | 0.94ns | 1.28ns | 0.28ns | 1.19 | 12.37 | 8.83 |
| Hypocotyl dried mass | 10.38ns | 2.12ns | 2.13ns | 14.43 | 16.91 | 22.46 |

(1) Significant according to F test $p<0,05$; (2) Significant according to F test $p<0,01$; (3) Non significant according to F test $p<0,05$. Font: The authors.

The highest visual notes observed in the experiment were found as the granulometry increased above Mesh-Tyler 115, combined with the covering percentages above 24%, which indicate that smaller granulometries enable the adhesion of the largest volume of fertilizers to the seeds with better visual quality of covering.

Figure 1 – Visual evaluation of the coating efficiency due to the interaction of fertilizer granulometry and fertilizer percentage used in the seed covering process. Equation: $Z = -1.985 + 0.05906x + 0.03567y - 8.515e^{-05}y^2$. $R^2 = 0.8744^{**}$

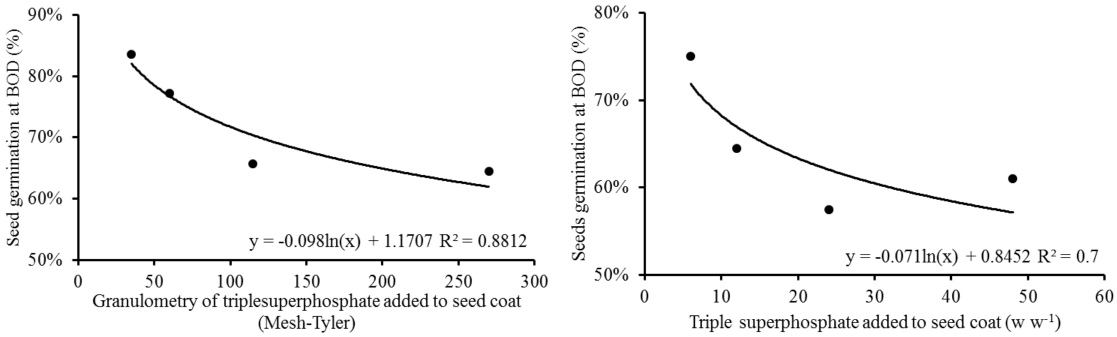



However, the coarser granulometries and the lower percentage of coverage provided the lowest values in the visual evaluation of the results, indicating that the fertilizer volume was insufficient for the total covering of the seeds and that the coarse grain sizes are not able to provide enough particle agglomeration in the seeds for satisfactory coating.

Analyzing the percentage of coated seeds germination in the paper roll, the granulometry and the percentage of triple superphosphate used on the seed covering significantly influenced the results, reducing the germination as the granulometry was reduced and the percentage was raised (Figure 2).

Finer particle sizes provide better organization of the particles (ZONG et al., 2017), creating a physical barrier to emergence that can reduce the permeability of gases and water through the covering layer (GRELIER et al., 1999). In the present study, the thicker grain sizes (Mesh-Tyler 35 and 60) showed the best germination percentages compared to the finer grain sizes. Comparing the results with the initial germination of the seeds (93%), there is a reduction in the germination power when they were submitted to the coating process, reducing the germination of seeds by 10, 15, 18 and 29% using the Mesh-Tyer granulometry 35, 60, 115 and 270, respectively. That effect must be studied a little further, because the minimal percentage allowed to commercialize seeds is 80% (MAPA, 2013) and only the initial two grain sizes reached that level, compromising the use of the seed coat on soybeans. The finer particle sizes (Mesh-Tyler 115 and 270) did not show sufficient germination index for the seed's commercialization.

Figure 2 – Soybeans seeds germination percentage at BOD due to granulometry and percentage of triple superphosphate added to the seed coat

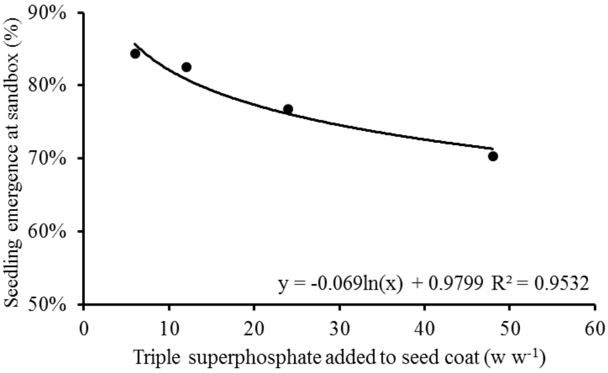



The visual evaluation of seed germination showed that the coating process reduced the emerging power of the seed's embryo because it had to break the physical barrier created by the seed coating process and not every seed has enough reserves to transform into germination power to break it. The use of greater seeds, with more reserves can reduce this negative effect of the seed coating. Other polymers and better technics of coating can also help improving the coated seeds germination.

However, when the coated seeds were submitted to the emergence test in the sandbox, the result of the influence of the percentages of fertilizer used was different from the germination on a paper roll, showing significant difference solely in the percentage of fertilizer used in the seed coating process, in which the highest percentage of fertilizers obtained the lowest percentage of seedling emergence (Figure 3).

The difference between the results of germination and emergence observed is probably due to the fact that in the sand substrate the fertilizer used in the covering of the seeds was dissolved and dissipated through the sand, which did not occur in the substrate paper roll, where the dissolved fertilizer remained in contact with the seed; giving that the diffusion coefficient of the chemical elements is distinct between different matrices (SHACKELFORD and DANIEL, 1991), which can result in excess of the element in direct contact with the seed coat on the paper, impairing the process of soaking and seed emergence.

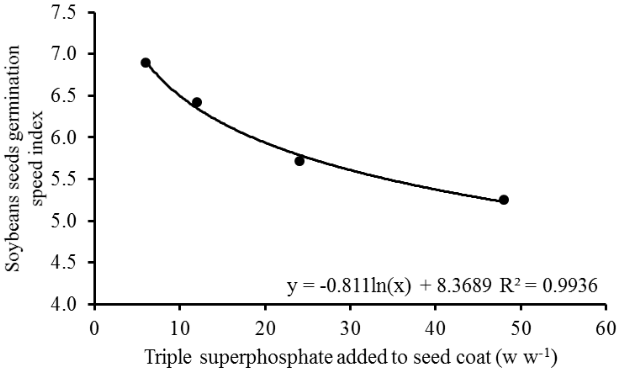
Figure 3 – Soybeans seedling emergence percentage in the sandbox due to fertilizer percentage added during the seed covering process. Font: The authors.




The emergence results in the sandbox demonstrate that as the percentage of fertilizer used in the coating increased, the seedling emergence decreased, in which the highest percentage tested (48%) was responsible for the 14% reduction in the number of seedlings emerged, comparing to the lowest percentage tested (6%). This reduction demonstrates the need to fine-tune the doses of nutrients applied via seed coating, which can cause damage to the seeds (SHARMA et al., 2015).

The results for the germination speed index of the coated soybean seeds showed that the higher percentages of fertilizers used resulted in a lower germination speed, indicating a longer time for seed germination (Figure 4).

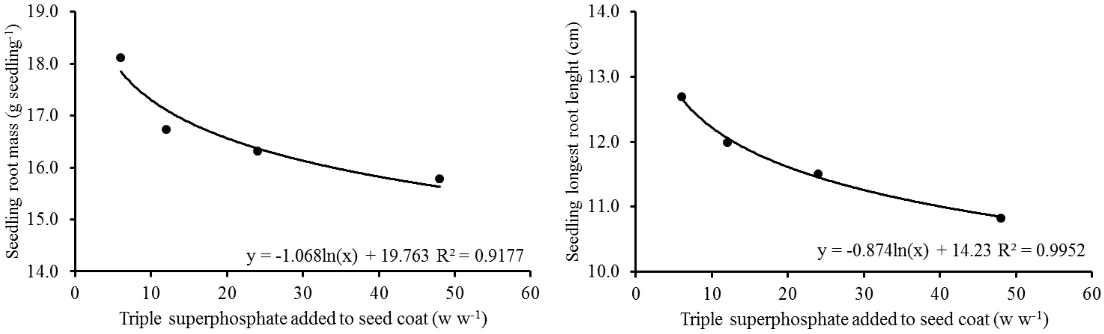
Figure 4 – Soybean's seeds germination speed index due to fertilizer percentage added during the seed covering process. Font: The authors.




The reduction at germination speed may be the result of a reduction in the physiological quality of the seeds tested by storage (SMANIOTTO et al., 2014) or in the shorter period of seed soaking (SALES et al., 2015), caused by the physical barrier of the coating applied, especially in the highest percentages of fertilizer used in the experiment.

The seedling growth results of the evaluated seeds indicate a longer root length and root's dry matter weight with the use of the lowest percentages of fertilizer in the coating (Figure 5), indicating some damage to the initial seedling development when using the highest percentages of tested fertilizers.

Figure 5 – Soybean seedling root mass and longest root length due to fertilizer percentage added during the seed covering process. Font: The authors.




However, as there was more phosphorus available at the higher fertilizer percentage used, there was less need for the root's growth to reach the phosphorus element; that is because the root growth tends to be heavily directed by the phosphorus availability at the environment. The plants even generate additional lateral roots, in the search for better root contact with the element (PÉRET et al., 2014).

That demonstrates the greater availability of fertilizer close to the root results in a lower energy use of the plant in the production of long roots in search of contact with the fertilizer. That can be a very nice acknowledgment of the soybean seed's coating, illustrating that there was no need to use high coating doses, that depresses the seeds germination and emergence, to enhance the initial development of plants by the use of seeding machines without fertilizer deposition.

## 4 CONCLUSIONS

The covering of soybean seeds with triple superphosphate shows better visual quality as it uses higher doses and smaller granulometry of the fertilizer.

The highest doses of fertilizer impaired the physiological quality of the seeds, which reduced the percentage of germination and emergence, the rate of germination speed and the initial growth of seedling roots.

The covering of soybean seeds with triple superphosphate presents itself as a technically viable alternative as vehicle of phosphorus to the soil, requiring fine adjustment of the dose and granulometry of the fertilizer used to avoid the loss of germination and emergence power of the seeds.

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