ISBN: 978-65-986235-8-6

GERMINATIVE EVALUATION OF SOYBEAN (*Glycine max*) UNDER DIFFERENT WATER LEVELS

https://doi.org/10.63330/aurumpub.008-003

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ABSTRACT

The soybean crop (*Glycine max*) is of great global importance due to its various purposes for both human and animal food industries, as well as raw material for agribusiness. The seed germination stage is one of the crucial phases in the plant's life cycle, directly influencing productivity and crop quality. Therefore, the objective of this study was to evaluate the effect of different water levels on soybean seed germination, aiming to understand how water availability influences this fundamental process for the initial establishment of the crop. The experiment involved evaluating the influence of three water levels (50%, 75%, and 100% of the substrate's field capacity), analyzing total germination rate, germination speed index, and seedling height. For each treatment, four replicates of 50 seeds each were performed. Data collection involved daily counting of germinated seeds over eight days; the total number of germinated seeds divided by the number of days resulted in the germination speed index. Summing the germinated seeds yielded the total germination rate. Measuring the height of 10 seedlings per replicate provided the average height per treatment. Means were compared by Tukey's test at a 5% probability level. The most ideal treatment was Treatment 2, with 75% of field capacity.

Keywords: Field capacity; Germination; Soybean.

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INTRODUCTION

The soybean crop (*Glycine max*) is of great global importance due to its various applications in the human and animal food industries, as well as serving as a raw material for agribusiness. Originating from Northeast Asia, its dissemination occurred through navigation from the East to the West (Chung and Singh, 2008). According to Black (2000), the first reports of soybean in Brazil date back to 1882, initially in the state of Bahia.

According to the National Supply Company (CONAB, 2023), Brazil has consolidated itself as the world's largest soybean producer, with a 2.8% increase in sown areas and an estimated production of 162.4 million tons for the 2023/24 crop. Mato Grosso leads as the country's largest grain-producing state, accounting for 31.3% of total production according to the Brazilian Institute of Geography and Statistics (IBGE, 2023).

To achieve this, the use of seeds with proven quality is essential, ensuring an ideal plant population for a soybean crop. One of the abiotic factors with the greatest influence on seed germination is water availability in the external environment for seed hydration. As reported by Carvalho and Nakagawa (1988), the seed requires a minimum water level to initiate germination, which varies according to its chemical composition and seed coat permeability.

However, early sowing in the Mato Grosso region poses a risk due to water restrictions in the crop's initial phase, placing the plant under water stress. Nevertheless, avoiding late soybean cultivation—typically less productive—allows better utilization of farm machinery due to the broader operational schedule, better selling prices at the beginning of the harvest, and advancement of the second crop (safrinha), benefiting from higher rainfall during its production cycle (Ferrari, 2015).

According to Chagas (2019), there was a reduction in average rainfall in most parts of Brazil between 1980 and 2015, particularly in the Southeast and Cerrado regions, along with increased intervals between rainfall events (drought spells). Given this scenario, studies on the ideal amount of water available for seeds are of great importance, as water is one of the environmental factors with the greatest influence on the germination process. Therefore, this study aimed to evaluate the effect of different water levels on soybean seed germination, aiming to understand how water availability influences this fundamental process for the initial establishment of the crop.

MATERIALS AND METHODS

The research was conducted at the soil laboratory of the Faculty of Applied Social Sciences of Vale do São Lourenço (EDUVALE), in the municipality of Jaciara/MT, Brazil. The faculty is located between parallels 15°57’ south latitude and 54°58’ west longitude, at an altitude of 380 meters.

Soybean seeds (*Glycine max*) of the cultivar SYN2376IPRO (untreated) were used as methodological resources. The seeds were then placed to germinate in plastic trays measuring 35x50x2.5 cm, using commercial Carolina Soil substrate, maintained under normal laboratory conditions (18 to 32°C and 65 to 85% relative humidity)..

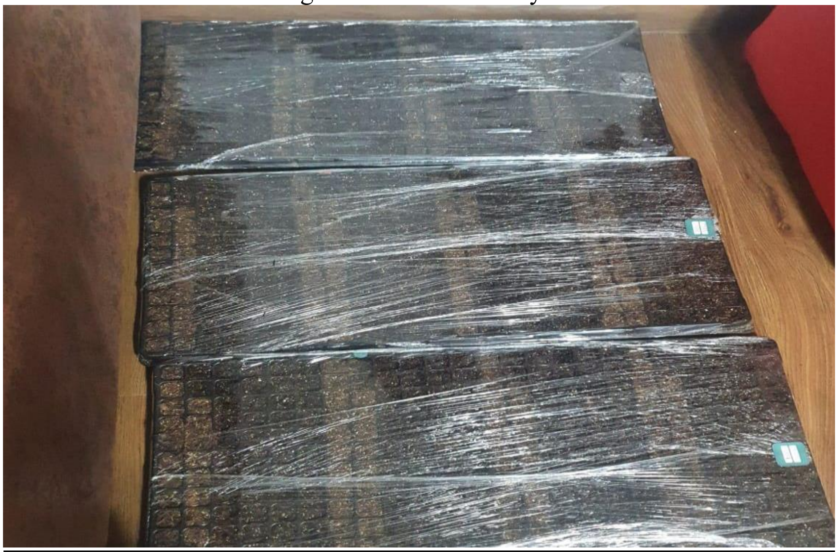
The analyzed substrate water contents were 100%, 75%, and 50% of field capacity. According to the Federal University of Juiz de Fora (2018), determining the substrate's field capacity requires weighing 100 g of substrate, adding 100 mL of water, and waiting 2 hours for the water to percolate through the entire sample. After measuring the amount of water retained in the soil, the following formula is used:

$$\text{Field capacity (\%)} = \frac{\text{Water retained in soil (mL)} \times 100}{\text{Soil volume (mL)}}$$

Seed germination tests were conducted in 4 replicates of 50 seeds for each treatment, with counts performed on the 7th day after sowing. The result was expressed as a percentage, obtained using the following formula according to Pereira *et al. (2007):*

$$\text{Germination rate (\%)} = \frac{\text{Germinated seeds} \times 100}{\text{Total seeds}}.$$

Figure 1 - Plastic trays.



Source: Personal archive.

In the germination speed index (GSI) tests, the number of germinated seedlings (cotyledons completely above the soil) was counted daily over 8 days, with results expressed as a mean percentage

(Maguire, 1962). Seedling height evaluations were conducted on 10 seedlings per plot, measured in centimeters from the soil to the apical meristem growth region (Pelacani et al., 2016).

The experimental design was completely randomized in a 1x3 factorial scheme with one substrate and three water content levels for substrate hydration. Results were compared by Tukey's test at a 5% probability level using the Sisvar statistical software. The steps were divided as follows:

1. Seed preparation: acquiring seeds of the same variety and batch to ensure uniformity, pre-washing seeds in running water to remove surface impurities, and drying them with clean paper towels for uniform distribution on trays with commercial substrate.
2. Substrate preparation: using 4 trays with 200 cells for seed germination, filling cells uniformly with substrate, marking, and identifying each tray according to the different water levels to be applied.
3. Treatment application: determining the different water levels to be tested, representing varying amounts of water applied to each experiment. Pipettes were used to carefully apply the specific water quantity to each cell, as per the established treatments.
4. Seed distribution: uniformly distributing seeds over the substrate-filled cells, ensuring adequate spacing to avoid competition during germination, recording the number of seeds in each tray, and properly identifying the treatments.
5. Experimental unit assembly: arranging trays in controlled humidity and temperature conditions for germination, covering trays with transparent plastic to create a humid environment conducive to germination.
6. Germination monitoring: maintaining trays in suitable conditions for germination, with constant temperature and diffused lighting, and daily monitoring of the germination process over 8 days, recording the number of germinated seeds and observing seedling development over time.

The experiment required the following items: one 9 kg bag of Carolina Soil substrate, 3 plastic trays with 200 cells each (35x50x2.5 cm), 600 untreated soybean seeds (*Glycine max*) of the SYN2376IPRO cultivar, a 5 mL graduated pipette, 21 liters of deionized water, one roll of PVC plastic wrap (0.18 x 100 m), adhesive and pen for treatment identification, a table for tray arrangement, and the soil laboratory at Eduvale.

RESULTS AND DISCUSSIONS

One of the factors most impacting seed germination is the amount of water available in the soil, as water absorption initiates this process. After seed moistening, the seed coat weakens, and the embryo and reserve tissues expand, leading to seed coat rupture, gas diffusion, and primary root emergence.

Consequently, reserve digestion, translocation, and assimilation occur, resulting in embryo growth (Marcos Filho, 2015).

Under favorable moisture conditions, the seed follows a triphasic water uptake pattern. Phase I, known as imbibition, involves a slight water intake due to potential differences between the substrate and the seeds. Phase II shows reduced water absorption, with equilibrium between potentials; various metabolic reactions occur before primary root emergence. In Phase III, active metabolism and formation of osmotically active substances reduce the seed's water potential, prompting slight water uptake from the medium (Bewley and Preto, 2013).

In the total germination rate evaluations (Table 1), there was no statistically significant difference between Treatments 2 and 3. Treatment 2, with 75% of field capacity, was most favorable, with 143 germinated plants, while Treatment 1 (50%) was least favorable, with 57 germinated plants. A similar result was found by Evangelista et al. (2007), where the most efficient field capacity range was 50-65%, with considerable vigor reduction beyond 70%.

According to Taylor and Kwiatkowski (2001), if seeds were coated with SB2000 polymer, the total germination rate would likely increase, as the polymer slows water penetration into the seed, reducing damage caused by imbibition in legumes.

Table 1 – Total Germination Rate

Treatments (Field Capacity)	Germination Percentage (%)
01 (50%)	28,0 B
02 (75%)	71,0 A
03 (100%)	57,0 A
Coefficient of variation (%)	20,27

Source: Miranda, 2024.

According to Jacinto *et al*. (2014), water content influences both total germination rate and germination speed index (GSI), being positively correlated with increased water in blotting paper and negatively in germitest paper. Results obtained with commercial substrate showed that GSI (Table 2) was more favorable at 75% and 100% of field capacity and unfavorable at lower water volumes. According to Sá (1987), water limitation reduces biochemical and physiological process speeds, resulting in poorer soybean seedling development.

These data corroborate the total germination rate results (Table 1) but differ from Moterle *et al.* (2011), where soybean seed germination speed ranged from 2.04 to 2.28 plants/day, depending on variety and treatment. Seeds with higher GSI are more resistant to stress and consequently exhibit better plant development and growth (Dan *et al.*, 2010).

Table 2 – Germination Speed Index (GSI)

Treatments (Field Capacity)	Germination per day (units)
01 (50%)	9,46 B
02 (75%)	20,40 A
03 (100%)	19,12 A
Coefficient of variation (%)	21,81

Fonte: Miranda, 2024.

Regarding seedling height data (Table 3), Treatments 1 and 3 showed no statistical difference, differing from results in other variables (Tables 1 and 2) and equating with Treatment 2, which was most favorable.

Similar results were found by Pelacani *et al*. (2016), with seedling heights varying from 7.1 to 9.3 cm depending on soybean seed vigor, based on an average of 10 seedlings per treatment. According to Vazquez and Assis (2011), soybean seedlings show greater growth with increased water availability.

The most efficient osmotic potential (MPa) for soybean seedling length was 0.0 MPa, reaching 23 cm, while the least efficient was -0.9 MPa, with a length of 1 cm (Braccini *et al*., 1996).

Table 3 – Average Seedling Height

Treatments (Field Capacity)	Seedling Height (cm)
01 (50%)	3,5 B
02 (75%)	9,50 A
03 (100%)	6 B
Coefficient of variation (%)	20,38

Fonte: Miranda, 2024.

Low-moisture imbibition can lead to high pressures, even cotyledon rupture, reducing seedling emergence and field population (Obendorf and Hobbs, 1970). According to Popinigis (1985), low-vigor seeds may have a seed coat more susceptible to water passage, facilitating absorption.

Across all three analyzed variables, Treatment 2 performed best, with Treatment 3 second, differing statistically only in seedling height. Treatment 1 (50% field capacity) was the least advantageous in all variables.

Figure 2: Germinated trays.

Tray with 50% field capacity	Tray with 75% field capacity	Tray with 100% field capacity

Source: Personal archive.

FINAL CONSIDERATIONS

This study allowed for an analysis of how the amount of water available in the soil is critically important for successful seed germination, influencing the final plant stand and, consequently, farm productivity in Brazil and worldwide.

Additionally, it verified the most favorable water amount in this process, with Treatment 2 (75% field capacity) showing the best results in germination rate, germination speed index, and seedling height.

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