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IMPACT OF PATHOGENS ON THE GERMINATION AND INITIAL GROWTH OF WHEAT CULTIVARS: EVALUATION OF THE SEED DISINFESTATION METHOD

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Abstract

Wheat (*Triticum aestivum* L.) production faces challenges caused by abiotic and biotic factors, with diseases transmitted by contaminated seeds being a risk for pathogen-free areas. This study assessed the presence of pathogens in five wheat cultivars: Tbio Sinuelo, Tbio Toruk, ORS Madreperola, Tbio Ponteiro and LG Cromo. The “blotter test” method was used to assess the influence of these pathogens using the Hiltner test. The following variables were analyzed in seeds disinfected and not disinfected with 1% hypochlorite: germination (%), seed-to-seedling transmission, mean root length (MRL), mean shoot length (SPL), root fresh mass (RRM), root dry mass (RSM), shoot fresh mass (SPF) and shoot dry mass (SPD). The experiment, conducted at the Plant Physiology Laboratory of the Federal University of the Southern Frontier, followed a completely randomized design in a 5x2 factorial scheme. The sanitary analysis revealed the presence of the genera *Fusarium*, *Aspergillus*, *Penicillium*, *Rhizopus and Alternaria*. Although germination and seed-to-seedling transmission showed no significant difference between disinfected and non-disinfected seeds, there were statistical differences in the ARL, SPL, FRM, DRM, FRM and DSM components, with disinfected seeds showing higher averages.

Keywords: Seeds; health; length; dry mass; fresh mass.

Impacto de patógenos na germinação e crescimento inicial de cultivares de trigo: avaliação do método de desinfestação de sementes

Resumo

A produção de trigo (*Triticum aestivum* L.) enfrenta desafios causados por fatores abióticos e bióticos, sendo as doenças transmitidas por sementes contaminadas um risco para áreas livres de patógenos. Este estudo avaliou a presença de patógenos em cinco cultivares de trigo, sendo elas

Tbio Sinuelo, Tbio Toruk, ORS Madreperola, Tbio Ponteiro e LG Cromo. Foi utilizado o método "blotter test", que avaliou a influência desses patógenos por meio do teste de Hiltner. Foram analisadas as seguintes variáveis em sementes desinfestadas e não desinfestadas com hipoclorito a 1%: germinação (%), transmissibilidade semente-plântula, comprimento médio das raízes (CMR), comprimento médio da parte aérea (CMPA), massa fresca das raízes (MFR), massa seca das raízes (MSR), massa fresca da parte aérea (MFPA) e massa seca da parte aérea (MSPA). O experimento, conduzido no Laboratório de Fisiologia Vegetal da Universidade Federal da Fronteira Sul, seguiu um delineamento inteiramente casualizado em esquema fatorial 5x2. A análise sanitária revelou a presença dos gêneros *Fusarium*, *Aspergillus*, *Penicillium*, *Rhizopus e Alternaria*. Embora a germinação e a transmissão semente-plântula não tenham mostrado diferença significativa entre sementes desinfestadas e não desinfestadas, houve diferenças estatísticas nos componentes CMR, CMPA, MFR, MSR, MFPA e MSPA, sendo que as sementes desinfestadas apresentaram maiores médias.

Palavras-chave: Sementes; sanidade; comprimento; massa seca; massa fresca.

Introduction

The wheat crop (*Triticum aestivum* L.) has great historical and economic importance, having been the food base for the development of several civilizations (Venske *et al.*, 2019). The first records of cultivation date back approximately 9,500 years, in the Fertile Crescent region, which corresponds to the present-day Middle East (Sousa *et al.*, 2021). Wheat is the second most cultivated crop globally, accounting for approximately 30% of global grain production, second only to corn in terms of volume produced (Park *et al.*, 2023). Brazil ranks 16th in the world, with the southern region of the country accounting for over 90% of all production (CONAB, 2022). This is because the crop is better adapted to the lower temperatures found in the region (Qaseem *et al.*, 2019). As such, wheat has established itself as a key crop for global food security and job creation throughout the production chain, from cultivation to industrial processing, enabling the production of a wide variety of foods**.**

In Brazil, wheat cultivation is subject to variations due to environmental and biological factors (Alves *et al.*, 2022). Among the biological factors that affect wheat productivity, fungal diseases are particularly specific, as they attack plants and seeds, reducing yields by up to 20% per year and increasing production costs, given the need to use inputs to control pathogens (Figueroa *et al.*, 2018; Garg *et al.*, 2023). Currently, around 70% to 80% of the diseases that affect agricultural crops are caused by fungi, representing a significant threat to global food security, which is aggravated by climate change, which promotes ideal conditions for the proliferation and spread of fungal pathogens due to rising temperatures, droughts and floods, conditions that favor the development of diseases and expand the affected areas, intensifying crop damage and compromising agricultural productivity (Zhou *et al.*, 2024).

Seed health analysis is therefore an essential tool for identifying pathogens that can compromise plant development. The author Choudhury, back in 1982, already reported that, in the case of wheat, the use of infected seeds harms the development of the crop, leading to a reduction in the dry mass of the aerial part and impaired initial growth of the seedlings. Seeds are influenced by biotic and abiotic factors, such as the action of pests and microorganisms, as well as by environmental and storage conditions, causing deterioration and reducing viability, especially when they reach their peak ripeness (Krzyzanowski *et al.*, 2022).

The initial stages of the processes that revolve around seeds are extremely important for conservation and can subsequently interfere with the quality and development of seedlings, and are intrinsically linked to their collection, selection, processing and storage (Medeiros *et al.*, 2024). Another relevant issue is that sanitary analysis is fundamental for management decisions that can guarantee the health of seed lots before planting, preventing economic and environmental losses (Rey *et al.*, 2009; Oliveira *et al.*, 2012).

The aim of this study is to assess the seed health of different wheat cultivars, identify the pathogenic fungi present in the seeds and examine how these pathogens affect seedling development. These results contribute to the development of management practices that promote plant health and the sustainable productivity of wheat cultivars.

Material and methods

The experiment was perfomed at the Plant Physiology Laboratory of the Federal University of the Southern Frontier (UFFS) - Cerro Largo Campus, Rio Grande do Sul (coordinates 28.1511° S, 54.7385° O). The wheat seed samples, of the cultivars Tbio Sinuelo, Tbio Toruk, ORS Madreperola, Tbio Ponteiro and LG Cromo, were obtained from COOPATRIGO's Seed Analysis Laboratory in São Luiz Gonzaga, Rio Grande do Sul. These samples, collected and stored during the 2018 harvest, were initially packed in paper boxes and then transferred to duly identified paper bags. The seeds were then sent to the Plant Physiology Laboratory at UFFS - Cerro Largo Campus, where they were stored until the experiments were set up.

The laboratory experiments were conducted in two stages. The first involved seed health analysis, in accordance with the Seed Health Analysis Manual (Brasil, 2009). The second stage consisted of carrying out tests to assess the influence of the pathogens on the development of the seedlings of the different cultivars.

Seed Health Test

The seed health test was carried out using the incubation method on paper substrate (Blotter

Test), which was chosen because it is a simple, effective and inexpensive method, as well as being the standard and widely accepted method for seed health analysis, recommended by ISTA (*International Seed Testing Association*). This method allows the identification of fungi and other pathogens, providing an ideal environment for the development of microorganisms present in seeds without the interference of complex substrates (FAO; ISTA, 2023).

For this test, 400 seeds per cultivar were used, divided into 50-seed subsamples, totaling eight replicates for each genotype. The substrate used was filter paper moistened with distilled water and placed in gerboxes. The seeds were arranged 1-2 cm apart, in five rows of 10 seeds each, and incubated in a B.O.D. (Biochemical Oxygen Demand) chamber at 20 ºC, with a 12-hour photoperiod, for a period of eight days.

After incubation, the health of the seeds was assessed using a stereoscopic microscope to identify the type of fungus based on the fruiting structures. This process is carried out using the agar plate method, in which the seeds were disinfected on the surface with 1% sodium hypochlorite and then placed in plates (10 seeds/plate) in a Petri dish containing agar medium (3%). All the plated seeds were incubated for 5 to 7 days at 22 °C ± 3 °C, under a 12-hour photoperiod. At the end of the incubation period, the fungi that had grown from the seeds on the agar medium were examined and identified. Identification was based on the characteristics of the colony and the morphology of the sporulation structures under a compound microscope. Once the identification had been made, the colonies were given names and their acronyms were written on the back of the plate (Sreenu *et al.*, 2019).

Germination test

The germination test followed the Rules for Seed Analysis (Brasil, 2009), using 400 seeds of each cultivar, divided into four replicates of 100 seeds. To assess the influence of pathogens, the seeds were divided into two treatments: without surface disinfestation and with surface disinfestation (1% sodium hypochlorite for three minutes). Sodium hypochlorite was selected as the disinfectant agent due to its effectiveness in removing surface pathogens without damaging the seeds' internal structures. Its use is common in seed disinfection procedures because it is a low-cost agent, with good efficiency against fungi and bacteria, and because it minimizes residual toxicity compared to other disinfectants.

The substrate used was Germitest paper moistened with distilled water. The seeds were placed in paper rolls containing 100 seeds each and incubated in a B.O.D. chamber at 20 ºC, with a 12-hour photoperiod, for eight days. At the end of this period, the number of germinated seeds was counted, and seeds that had produced a radicle with at least 2 mm of protrusion were considered to have germinated, and the results were expressed as a percentage.

Seed-to-seedling transmission test

The seed-to-seedling pathogen transmissibility test was carried out according to the Hiltner method, adapted by Henning (1994). The substrate used was medium-grained expansive vermiculite, sterilized in an oven at 105 ºC for four hours. After sterilization, the substrate was moistened and placed in 50 mL disposable cups, in which one seed per cup was placed, covered by an additional layer of substrate. For each cultivar, 40 disinfected and non-disinfected seeds were used, divided into four replicates of 10 seeds, totaling 400 cups. The seeds were incubated in a B.O.D. chamber for 12 days, after which the seedlings were assessed for the presence of symptoms or signs of pathogens.

Complementary evaluations

On the twelfth day, the Average Radicle Length (ARL) of the wheat seedlings was measured, from the base of the coleoptile to the lower tip of the radicles, using a ruler. The values were added up and divided by the number of seedlings to obtain the average value in centimeters.

The Mean Length of the Aerial Part (MLAP) was also measured, considering the distance between the base of the coleoptile and the apex of the aerial part. After the length measurements, the Fresh Radicle Mass (FRM) and the Fresh Aerial Part Mass (FFP) were determined using a 0.001 g precision scale. The seedlings were then dried in an oven at 65 ºC for 48 hours to obtain a constant dry mass. The results were expressed in milligrams (mg) and the average per seedling was calculated.

For the statistical analysis of the data, ANOVA was carried out at a 5% probability of error. If there were significant effects, the means were compared using the Tukey test, with a significance level of 5%. The analyses were carried out using SISVAR software.

Results and discussions

During the sanitary analysis of the seeds of the wheat cultivars, five groups of fungi were identified, corresponding to the genera *Fusarium*, *Aspergillus*, *Penicillium*, *Rhizopus* and *Alternaria*. Previous studies have also reported the presence of these pathogens, as well as others, in batches of wheat seeds from various regions of Brazil (Goulart, 1998; Bertagnolli, 2015). There was also a significant variation in the incidence of pathogens between the different cultivars, as shown in Table 1.

Table 1. Incidence (%) of pathogens in different wheat cultivars.

Cultivars	Pathogens				
	***Aspergillus* spp.**	***Alternaria* spp.**	***Fusarium* spp.**	***Penicillium* spp.**	***Rhizopus* spp.**
	Incidence of fungi (%)				
ORS Madreperola	5,8	0,8	3,0	5,5	38,8
TBIO Ponteiro	7,3	2,5	5,5	5,3	8,0
TBIO Sinuelo	6,8	2,8	3,8	6,3	9,8
TBIO Toruk	7,8	1,5	2,8	4,8	25,5
LG Cromo	6,5	2,8	4,3	5,3	9,8

Source: Prepared by the authors.

The presence of the *Rhizopus* spp. fungus stands out, with an incidence of 38.8% in the ORS Madreperola cultivar. The fungus *Penicillium* spp. had the highest incidence in the cultivar TBio Sinuelo, reaching 6.3%. *Fusarium* spp. was more prevalent in cultivar TBio Ponteiro, with 5.5% of contaminated seeds. In the TBio Toruk cultivar, the pathogen *Aspergillus* spp. was found in 7.8% of the seeds analyzed. The fungus *Alternaria* spp. was also detected by the "blotter test" incubation method, although with a lower incidence of occurrence when compared to the other cultivars.

Among the seeds of the cultivars analyzed, the presence of the *Fusarium*, *Aspergillus* and *Penicillium* genera stands out. These groups of fungi have the potential to produce mycotoxins, secondary metabolites that can cause serious damage to human and animal health (Freire *et al.*, 2007) as well as plant diseases (Lo Presti *et al.*, 2015). These mycotoxins accumulate in grains and can cause severe chronic problems in humans, including immunosuppression and carcinogenic potential, and can be classified as teratogenic, carcinogenic and even allergenic (Godoy, 2018; Gozzi *et al.*, 2023). In addition, the *Fusarium* spp. genus can cause diseases such as gibberella and root rot, which result in plants that are shorter in stature compared to healthy ones (Santana *et al.*, 2012; Fabre *et al.*, 2019).

However, an analysis of the germination of the cultivars' seeds, carried out using the paper roll method, showed no significant impact of the presence of the pathogens detected in the sanitary analysis on seed germination. The following table (Table 2) shows that no statistically significant differences were found between seeds disinfected with 1% hypochlorite and non-disinfected seeds in terms of germination variables.

Table 2. Germination percentage of the different cultivars, subjected or not to disinfestation with 1% sodium hypochlorite.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	Germination (%)				
NDS	94,50 a	97,50 a	96,25 a	94,75 a	95,75 a
DS	95,50 a	97,25 a	96,75 a	95,25 a	95,50 a
CV (%) = 2,12					

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

The pathogens that affect wheat, fungi stand out as some of the most aggressive, due to their ability to penetrate plant tissues and establish themselves internally (Tunali *et al.*, 2019). Wheat seeds are responsible for transporting fungal inoculum, whether in the form of mycelium, spores or both. However, the transmission rate of the pathogen depends largely on the location and quantity of the inoculum present in the seeds. The deeper the pathogen is in the seed tissues, the greater the likelihood of infection in emerging seedlings, increasing the risk of disease establishment from the earliest stages of development (Lo Presti *et al.*, 2015). The most effective way for the seedling to become infected is through the presence of the pathogen in the seed embryo (Neergaard, 1979; Menten, 1991; Yahaya; Yakasai, 2022).

Other factors can influence the infection of pathogens in seeds, such as the genotype, the practices used in crop management, the severity of the infection in the parent plant as well as the stage of infection in the plant, insect infestation and the way the seeds are handled during processing (Machado, 2012; Yahaya; Yakasai, 2022).

Mihovilović *et al.* (2024) showed that disinfesting wheat seeds with 4% sodium hypochlorite in combination with an additive in the seed growth medium was effective in completely suppressing different genera of fungi commonly found in the crop. The Mean Radicle Length (MRL) test showed that the seeds that had been disinfected in 1% sodium hypochlorite had higher mean values than those that had not been surface disinfected. The results can be seen in Table 3.

Table 3. Average radicle length (ARL) of wheat cultivar seedlings.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	CMR (cm/plântula)				
NDS	14,63 b	16,67 b	17,20 b	16,78 b	20,18 b
DS	18,79 a	18,98 a	19,85 a	19,47 a	22,68 a
CV (%) = 7,75					

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

Disinfecting the seeds with sodium hypochlorite helps to suppress possible fungal pathogens present on the surface of the seeds. These microorganisms can damage the initial establishment of germination and the growth of wheat seedlings (Castro; Sena, 2020). By eliminating or suppressing these pathogens by disinfecting the seeds, a healthier environment is created for root growth, which allows the seedlings to develop longer and more vigorous rootlets. This favors the absorption of nutrients and water (Silva *et al.*, 2021).

For the analysis of the mean shoot length (SPL), the results show that the disinfestation treatment with sodium hypochlorite provided significant increases in the initial growth of wheat seedlings in all the cultivars tested, as can be seen in Table 4.

Table 4. Mean shoot length (SPL) of wheat cultivar seedlings.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	SPL (cm/seedling)				
NDS	11,82 b	14,37 b	14,79 b	13,44 b	15,34 b
DS	14,55 a	16,58 a	16,37 a	16,61 a	16,94 a
CV (%) = 7,75					

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

These results corroborate previous research that indicates disinfestation as a relevant factor in improving germination and initial plant vigor, removing pathogens that can compete with the host plant or cause biotic stresses (Silva, 2018). The literature points out that the elimination of microorganisms can favor the absorption of essential nutrients in the initial growth phase (Rodrigues *et al.*, 2020), reflected in greater shoot length, as observed in the Tbio and LG cultivars.

In addition, the positive effect of disinfestation is related to the reduction of oxidative stress caused by pathogens, decreasing the production of reactive oxygen species (Hu *et al.*, 2020). This protects the plant cells from damage, allowing for healthier growth, since hypochlorite suppresses microorganisms on the surface of the seed, benefiting the development of the aerial part (Pereira, 2019). With this process, it is possible for the plant to increase photosynthesis rates, enabling greater production of carbohydrates, which ultimately stimulates the growth of the aerial part (Torres-Neto *et al.*, 2009; Hu *et al.*, 2020). This practice can therefore be seen as an important strategy for managing changes to improve the initial establishment of plants in field conditions.

The analysis of the fresh radicle mass (FRM) of the seedlings shows significant differences between the disinfected and non-disinfected seeds, demonstrating the effectiveness of the disinfestation treatment in promoting the initial growth of wheat seedlings. The seeds that underwent the sodium hypochlorite disinfestation process showed higher fresh mass averages, with values ranging from 50.23 mg/seedling to 110.55 mg/seedling, while the non-disinfested seeds showed lower averages, ranging from 45.80 mg/seedling to 85.85 mg/seedling. It can therefore be said that all the cultivars that underwent disinfestation showed a greater increase in biomass. The results can be seen in Table 5.

Table 5 - Fresh Radicle Mass (FRM) of the seedlings of wheat cultivars.

Treatment	**Cultivars**				
	ORS	Tbio P	Tbio S	Tbio T	LG
	FRM (mg/seedling)				
NDS	48,73 b	85,85 b	78,18 b	66,58 b	45,80 b
DS	81,76 a	110,55 a	80,55 a	78,20 a	50,23 a
CV (%) = 0,73					

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

These results are in line with studies showing that seed disinfestation is an effective practice for improving root growth, since the presence of pathogens and fungi can inhibit seedling development (Giubert *et al.*, 2023). In one study, Pereira *et al.* (2019) found that disinfested seeds showed a significant increase in the fresh mass of the rootlets, attributing this to the elimination of contaminants that can harm initial growth. Other studies, such as Rodrigues *et al.* (2020), reinforce the importance of disinfestation by reporting that seeds treated with sodium hypochlorite not only resulted in plants with greater fresh mass, but also with better overall performance in growth parameters.

These results highlight the importance of proper seed management in agriculture, contributing to a more vigorous start for crops, which can have direct implications for final productivity. Thus, the practice of disinfestation is not only beneficial for the initial development of seedlings, but can also have a significant impact on the productive efficiency of wheat cultivars, justifying its adoption in cultivation systems.

The analysis of the radicle dry mass (RSM) of the seedlings showed significant results between the disinfected and non-disinfected seeds, with the disinfected seeds showing higher averages, ranging from 10.45 mg/seedling to 11.32 mg/seedling, compared to the non-disinfected seeds, whose averages ranged from 8.70 mg/seedling to 10.40 mg/seedling (Table 6). These data demonstrate the effectiveness of the disinfestation process in promoting more robust root growth.

Table 6. Radicle dry mass (RSM) of the seedlings of wheat cultivars.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	RSM (mg/seedling)				
NDS	8,70 b	10,40 b	9,12 b	9,45 b	9,65 b
DS	10,52 a	11,32 a	10,45 a	10,66 a	10,45 a
	CV (%) = 3,75				

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

These results are in line with what has been observed in the literature, where seed disinfestation has been associated with an increase in seedling dry mass, as a result of reduced competition for nutrients and the incidence of pathogens that can compromise root development (Gomes, 2021).

Silva *et al.* (2021) reported that the application of sodium hypochlorite to seeds of other cultivars resulted in significant increases in dry mass, indicating that disinfestation not only improves seed health, but also contributes to more vigorous seedling development. Rodrigues *et al.* (2020) observed that the dry mass of the rootlets is an important indicator of the overall health of the seedlings, suggesting that seeds treated with sodium hypochlorite can establish stronger and healthier roots, which are essential for the efficient absorption of water and nutrients in the soil. This improvement in root characteristics is reflected in a potential increase in crop productivity throughout the cycle (Martinko *et al.*, 2024).

In this way, seed disinfestation, by favoring the dry mass of the rootlets, proves to be a beneficial and recommended practice for growing wheat, as it contributes to the vigorous initial development of the seedlings and, consequently, can have a positive impact on final productivity.

Analysis of the shoot fresh mass (SPF) of seedlings revealed significant differences between the disinfected and non-disinfected seeds. The seeds that underwent the hypochlorite disinfestation process had higher fresh mass averages, ranging from 70.88 mg/seedling to 95,18 mg/seedling, compared to the non-disinfested seeds, whose averages ranged from 58,20 mg/seedling to 76,03 mg/seedling. This variation highlights the importance of disinfestation in the initial development of seedlings and the results can be seen in the table below (Table 7).

Table 7. Shoot fresh mass (SPF) of the cultivars' seedlings.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	SPF (mg/seedling)				
NDS	58,20 b	76,03 b	70,68 b	73,60 b	64,65 b
DS	79,63 a	95,18 a	73,33 a	80,83 a	70,88 a
	CV (%) = 1,09				

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance

Santos *et al.,* (2021) observed in their experiments that treating seeds with sodium hypochlorite results in a significant increase in SPF, since eliminating pathogens and reducing root diseases favors vegetative growth (Silva *et al*., 2021). Rodrigues and Almeida (2022) point out that disinfected seeds not only have a higher fresh mass, but also a better performance in terms of growth and development, which can be attributed to their greater efficiency in absorbing nutrients.

Another study by Lima (2019) points out that SPF is a fundamental indicator of the general health of seedlings, and that disinfested seeds have greater potential to achieve more robust initial growth. Improving vegetative characteristics is vital, as healthy vegetative development can directly impact the competitive capacity of plants in the field and, consequently, crop productivity.

The analysis of the shoot dry mass (SPD) of the seedlings indicates that the disinfested seeds showed significantly higher averages compared to the non-disinfested seeds, ranging from 9.22 mg/seedling to 10.80 mg/seedling for the disinfested seeds, while the non-disinfested seeds showed averages between 7.33 and 9.45 mg/seedling. The results can be seen in Table 8.

Table 8. Shoot dry mass (SPD) of the seedlings of the wheat cultivars.

Treatment	Cultivars				
	ORS	Tbio P	Tbio S	Tbio T	LG
	SPD (mg/seedling)				
NDS	7,33 b	8,88 b	8,82 b	8,98 b	9,45 b
DS	9,22 a	10,48 a	9,48 a	10,8 a	10,33 a
	CV (%) = 2,75				

DS: Disinfested seed. NDS: Non-disinfested seed. ORS: ORS Madrepérola. Tbio P: Tbio Ponteiro. Tbio S: Tbio Sinuelo. Tbio T: Tbio Toruk. LG: LG Chrome. *Means not followed by the same letter differ in the column by Tukey's test at 5% significance.

This result reaffirms the importance of the disinfestation process in promoting healthy seedling growth. In a study carried out by Costa (2021), it was found that treated seeds showed a significant increase in dry mass, reflecting better vegetative development and greater nutrient storage capacity (Martins, 2019). In another study, Lima (2020) observed that the dry mass of the aerial part is a direct indicator of seedling health, since more robust seedlings tend to establish stronger and more resilient roots. These results highlight the responsiveness of seed disinfestation with sodium hypochlorite for both wheat and other plant species (Gilbert *et al.*, 2023; Mihovilović *et al.*, 2024).

The improvement in SPD in seedlings that come from disinfected seeds can be attributed to the reduction in competition for resources, such as water and nutrients, which is generally imposed by pathogens present on the surface of the seeds. A paper by Almeida and Silva (2022) also addresses this discussion. The authors point out that the use of disinfected seeds not only contributes to an increase in dry mass, but also to better resistance to environmental adversities such as water stress and disease. Thus, the data shown in Table 8 highlights the importance of seed disinfestation as an essential practice for optimizing the initial development of wheat cultivars, increasing their dry mass and, potentially, their productivity in the field.

The difference can be seen in the fungal growth of the genera Aspergillus, Rhizopus and Penicillium on the epicarp of the seeds and in the substrate, which did not cause damage to the seedling tissues, but did lead to a reduction in the length of the roots and aerial part. The results obtained by evaluating the ARL, SPL, FRM, DRM, FRM and DSM components showed that pathogens interfered with the development of the cultivars' seedlings, making the seeds that were not disinfected less vigorous when compared to the seeds that were disinfected in 1% sodium hypochlorite.

Conclusion

The sanitary analysis carried out using the blotter test method revealed the presence of fungi from the genera Fusarium, Aspergillus, Penicillium, Rhizopus and Alternaria in the seeds of different wheat cultivars. Although the presence of these pathogens did not significantly affect the germination rate and seed-to-seedling transmission, there was a negative impact on the initial development of seedlings, which can be seen in the reduction in growth components in non-disinfested seeds.

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